Abstract book of the XVIII National Meeting of the Portuguese Society of Chemistry

Sociedade Portuguesa de Química

universidade de aveiro

Chemistry A European Journal | EurJOC | Chemistry Europe

Com o alto Patrocínio de Sua Excelência

Under the High Patronage of the President of the Portuguese Republic

O Presidente da República

Title

Abstract book of the XVIII National Meeting of the Portuguese Society of Chemistry

Editors

Diana C. G. A. Pinto, Artur M. S. Silva, João Rocha

Committees

Scientific Committee

Artur Silva (UA) - Chair
João Rocha (UA) - Vice-Chair
Ana Isabel Ricardo (FCT UNL)
Baltazar Manuel Romão de Castro (FC UP)
Carlos Afonso (FF UL)
Cristina Freire (FC UP)
Fernanda Proença (UMinho)
Joaquim Faria (SPQ & FE UP)
Lillian Barros (IPB)
Mário Nuno Berberan e Santos (IST UL)
Rui Fausto (FCT UC)
Verónica Cortés de Zea Bermudez (UTAD)

Organizing Committee

Artur Silva - Chair
João Rocha - Vice-Chair
Amparo Faustino
Anabela Valente
Cláudia Lopes
Diana Cláudia Pinto
Filipe A. Almeida Paz
Jorge Saraiva
Manuel Coimbra
Pedro Carvalho
Rita Ferreira
Vânia Calisto

Secretary

Cristina Campos (SPQ)
Leonardo Mendes (SPQ)
Tânia Coelho - Centro de Formação da SPQ
Sociedade Portuguesa de Química
Av. República nº 45, 3º Esq., 1050-187 Lisboa, Portugal

National Organizing Committee

SPQ executives

Joaquim Faria (UP) - SPQ president
Luísa Martins (UL) - SPQ vice-president
Jorge Parola (UNL) - SPQ General Secretary

Goups

Isabel Malaquias (UA)
Maria do Rosário Bronze (UL)
Eduardo Marques (UP)
Celso Reis (IPATIMUP)
Luís Carlos (UA)
Cláudia Silva (UP)
Manuel Fernando Pereira (UP)
Maria Teresa Duarte (UL)
Pedro Vidinha (GQEst)
Ana Carolina Freitas de Jesus (GQJ)
Alexandre Magalhães (UP)
Helena Florêncio (UL)

Delegations

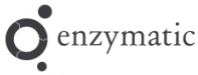
Susana Costa (UMinho) - Braga delegation coordinator
Vasco Bonifácio (UL) - Lisboa delegation coordinator
Amparo Faustino (UA) - Aveiro delegation coordinator
Sara Pinto (UC) - Coimbra delegation coordinator
Victor Freitas (UP) - Porto delegation coordinator

Divisions

Maria Teresa Conceição (UL)
Carlos Afonso (UL)
Manuel Minas da Piedade (UL)
Luísa Maia (UNL)
Maria Amparo Faustino (UA)
Mário Calvete (UC)
Christopher Brett (UC)
Ana Isabel Ramos Novo Amorim de Barros (UTAD)

Acknowledgements and Sponsors

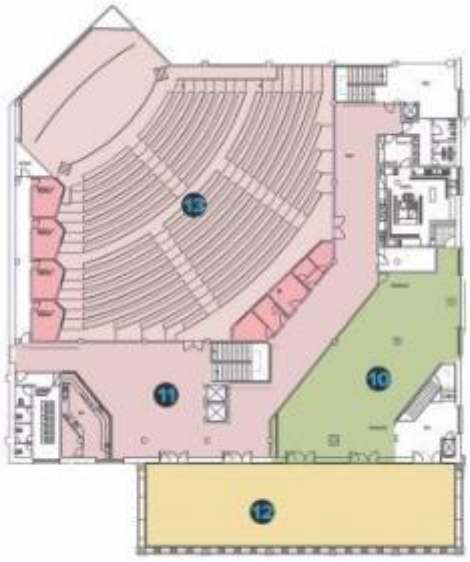
Com o alto Patrocínio
de Sua Excelência
Under the High Patronage of the
President of the Portuguese Republic



Conference Venue

Piso 0

Piso 1



Piso 2

1 | Foyer de entrada
2 | Sala 1
3 | Sala 2
4 | Sala 3
5 | Sala 4
6 | Sala 5
7 | Foyer do Piso 1
8 | Pequeno Auditório
9 | Foyer do Pequeno Auditório
10 | Restaurante
11 | Foyer do Grande Auditório
12 | Terraço
13 | Grande Auditório

Index

Welcome Message

Dear Colleagues,

The XVIII National Meeting of the Portuguese Society of Chemistry will take place at the congress centre of Aveiro from 24 to 26 July 2023. The theme of the congress will be "Chemistry Without Borders With Diversity". As a Central Science, chemistry is a disciplinary area that promotes the dialogue of knowledge between mathematics, physics, biology, medicine, earth and environmental sciences, and the arts. In doing so, it blurs or nullifies the supposedly established disciplinary boundaries and adopts the construction of holistic knowledge.

In chemistry, knowledge is built on the diversity of theory and praxis; in the variety of gender, social organization, age, culture, religion and places; in the diversity of actors, scientists, industrialists, medical personnel, cultural agents, rulers and citizens. In chemistry, knowledge is built in freedom.

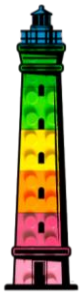
The meeting will, as usual, feature the presentation of the Ferreira da Silva Prize and Vicente Seabra Medal, along with the newly established Fraústo da Silva Prize. This year is particularly significant as it commemorates the centenary of the passing of SPQ's founder, the celebrated Chemist Ferreira da Silva, and the ninetieth birth anniversary of the notable Chemist Fraústo da Silva. In honour of these remarkable milestones, we will dedicate two sessions to celebrating these two giants of Portuguese Chemistry.

The XVIII National Meeting of the Portuguese Society of Chemistry event provides a splendid opportunity for scientists from the academia and industry to share and discuss scientific progress and to embark on interdisciplinary collaborations. This gathering also offers a crucial opportunity for engaging with early-career researchers and students, fostering an environment conducive to nurturing the next generation of interdisciplinary scientists.

The Scientific program comprises plenary and keynote lectures from renowned national and international scientists from academia and industry, selected oral communications, and poster communications, covering a broad range of important topics for a diverse audience.

We hope that you enjoy the XVIII National Meeting of the Portuguese Society of Chemistry. Our aspiration is to meet and surpass the expectations of all attendees.

Artur M. S. Silva & João Rocha
Conference Chairpersons



Scientific Programme

Programme Overview

Monday, 24 July 2023					
Time (h)	Centro Cultural e de Congressos de Aveiro				
9:00-10:30	**Registration – Foyer de entrada**				
Room	**Grande Auditório**				
10:30-10:50	**Opening Ceremony** ***Artur M. S. Silva*** - Vice-Rector of the University of Aveiro - Chair of the XXVIII Encontro Nacional da SPQ ***João Rocha*** - Department of Chemistry, University of Aveiro – Vice-Chair of the XXVIII Encontro Nacional da SPQ ***Joaquim Faria*** - Faculty of Engineering, University of Porto, President of the Sociedade Portuguesa de Química ***Armando Silvestre*** - Director of the Department of Chemistry, University of Aveiro				
CHAIRS:	*Artur M. S. Silva, Univ. Aveiro and Joaquim Faria, Univ. Porto*				
10:50-11:40	PL1 - *Embracing metals with proteins - a personal history*; Ferreira da Silva award José João Galhardas de Moura, New University of Lisbon, Portugal				
11:40-12:30	PL2 - *Lanthanide nuclear paramagnetic shift and relaxation in structural NMR and MRI - a personal experience*; Fraústo da Silva award Carlos Frederico de Gusmão Campos Geraldes, University of Coimbra, Portugal				
12:30-14:00	**Lunch Break**				
Room	**Grande Auditório**				
CHAIR:	*Artur M. S. Silva, Univ. Aveiro*				
14:00-14:50	PL3 - *Transition metal catalysis in biological habitats* Jose Luis Mascareñas, Universidade de Santiago, Spain				
Room: Grande Auditório	***Chair:*** *Fernanda Proença, Univ. Minho*	**Room**: Pequeno Auditório	***Chair:*** *Mário Nuno Berberan e Santos, IST, Univ. Lisboa*	**Room**: 5	***Chair:*** *Diana C. G. A. Pinto, Univ. Aveiro*
14:55-15:25	KN1 - *The physics and chemistry of directional freezing: implications in biofabrication and cryobiology* Francisco M. Fernandes, Sorbonne Université, France	14:55-15:25	KN2 - *Coordination polymers: From self-assembly to functional (bio)materials* Alexander Kirillov, *Universidade de Lisboa, Portugal*	14:55-15:25	KN3 - *Wine industry's untapped goldmine: Unlocking the potential of by-products in the Circular Economy* Ana Novo Barros, University of Trás-os-Montes e Alto Douro, Portugal
15:25-15.40	OC1 - *Enhanced biomass processing using a ternary deep eutectic solvent* André M. da Costa Lopes, University of Aveiro, Portugal	15:25-15.40	OC3 - *DPA fluorescent sensors: "walking" towards the NIR* Artur J. Moro, Universidade NOVA de Lisboa, Portugal	15:25-15.40	OC5 - *Improved functional excipients for high value pharmaceuticals* Cláudia Bento, Hovione Farmaciência S.A., Portugal
15:40-15:55	OC2 - *Understanding the chemistry behind the Kigali Amendment to the Montreal Protocol: an accurate computational protocol* Luís P. Viegas, University of Coimbra, Portugal	15:40-15:55	OC4 - *Addressing drug resistance in methicillin-resistant Staphylococcus aureus through mass spectrometry multiple omics* Pedro C. Rosado, Instituto Superior Técnico, Universidade de Lisboa, Portugal	15:40-15:55	OC6 – *Nitro group-containing compounds as histone deacetylase inhibitors* Joana L. C. Sousa, University of Aveiro, Portugal
15:55-17:15	**Coffee break & Poster discussion (1-120) - CCA**				
17:15-17:45	KN4 - *Manipulation of organic molecules by infrared vibrational excitation* Cláudio Manaia Nunes, *University of Coimbra, Portugal*	17:15-17:45	KN5 - *Photoresponsive host-guest systems with potential biological applications* Nuno Basílio, *Universidade NOVA de Lisboa, Portugal*	17:15-17:45	KN6 - *Semifluorinated soft-matter* Eduardo Filipe, *Instituto Superior Técnico, Universidade Lisboa, Portugal*

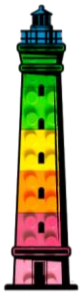
17:45-18:00	OC7 - *The extraction residues as a promising source of fiber and proteins* Tatiane C. G. Oliveira, Instituto Politécnico de Bragança, Portugal	17:45-18:00	OC9 - *Unlocking the potential of chromeno[3,4-b]xanthones as multifunctional compounds for Alzheimer's disease* Daniela Malafaia, University of Aveiro, Portugal	17:45-18:00	OC11 - *Innovation in cork: A cork-Chemistry relationship* Raquel Nunes da Silva, *Cork Technological Centre, Portugal*
18:00-18:15	OC8 - *Electrostatics on biomolecules-based drug delivery systems* Sandra C. C. Nunes, University of Coimbra, Portugal	18:00-18:15	OC10 - *Recovery of palladium by solvent extraction – A contribution for the recycling of PGMs from end-of-life devices* Ana P. Paiva, Universidade de Lisboa, Portugal	18:00-18:15	OC12 - *Featuring hyperbaric storage for Clostridium perfringens endospores' inactivation – a novel breakthrough on food safety?* Carlos Pinto, University of Aveiro, Portugal
Room: Grande Auditório	***Chair:*** *Cláudia Lopes, Univ. Aveiro*	**Room**: Pequeno Auditório	***Chair:*** *Eduarda Pereira, Univ. Aveiro*	**Room**: 5	***Chair:*** *Vânia Calisto, Univ. Aveiro*
18:15-19:00	**Flash 1-7**	18:15-19:00	**Flash 8-14**	18:15-19:00	**Flash 15-21**
19:00	**Porto de Honra - CCA**				
Tuesday, 25 July 2023					
Time (h)	Centro Cultural e de Congressos de Aveiro				
Room	**Grande Auditório**				
CHAIR:	*João Rocha, Univ. Aveiro*				
9:00-9:50	PL4 - *Catalytic amination of bio-based compounds* Karine de Oliveira Vigier, Institut de Chimie des Milieux et Matériaux de Poitiers (IC2MP), France				
Room: Grande Auditório	***Chair:*** *Victor Freitas, FC, Univ. Porto*	**Room**: Pequeno Auditório	***Chair:*** *Verónica de Zea Bermudez, UTAD*	**Room**: 5	***Chair:*** *Filipe Almeida Paz, Univ. Aveiro*
9:50-10:20	***Ferreira da Silva - Tribute Session*** OC13 - *O Laboratório Ferreira da Silva: crónica de uma reconstrução desejada* Marisa Monteiro, Museu de História Natural e da Ciência da Universidade do Porto, Portugal	9:50-10:20	KN7 - *Engineering of silk-based materials: a quest for eco-sustainable resources* Rui F.P. Pereira, University of Minho, Portugal	9:50-10:20	KN8 - *Exploring the use of metals and metallic salts in the synthesis of flavonoids* Raquel Soengas, University of Oviedo, Spain
10:20-10:50	OC14 - *Os zoilos e os templos das ciências* Manuel João Monte, Universidade do Porto, Portugal	10:20-10:35	OC15 - *Photoreduction of carbon dioxide using a novel Re(I) complex* Marcos A. Bento, University of Aveiro, Portugal	10:20-10:35	OC17 - *Effect of alkylsilane and alkylsiloxane chains on the thermophysical properties of ionic liquids* Rodrigo M. A. Silva, University of Porto, Portugal
		10:35-10:50	OC16 - *Hydrogen production via electrocatalytic ammonia conversion using metal-organic frameworks films* Duarte Borralho, Universidade de Lisboa, Portugal	10:35-10:50	OC18 - *New 4-(N-cinnamoylbutyl)amino-acridines as potential multi-stage antiplasmodial leads* Mélanie Fonte, University of Porto, Portugal
10:50-11:15	**Coffee break - CCA**				
11:15-11:30	OC19 - *Os alcalóides de Ferreira da Silva: Evolução do conhecimento da sua toxicologia* Fernando Remião, Universidade do Porto, Portugal	11:15-11:45	KN9 - *Theoretical insight into hole-transporting materials for perovskite solar cells* Enrique Orti, Universidad de Valencia, Spain	11:15-11:45	KN10 - Computing your way out of experimental problems, from nanocarbon to covalent organic frameworks and beyond

11:30-11:45	OC20 - *Carbon materials for advanced water treatment* Vânia Calisto, University of Aveiro, Portugal				Manuel Melle-Franco, University of Aveiro, Portugal
11:45-12:00	OC21 - *Qualidade, autenticidade e segurança alimentar: o valioso contributo do Professor Ferreira da Silva* Isabel M.P.L.V.O. Ferreira, Universidade do Porto, Portugal	11:45-12:00	OC24 - *Development of new analogs with anticancer activity from metabolic products of marine bioluminescent reactions* Luís Pinto da Silva, University of Porto, Portugal	11:45-12:00	OC27 - *Pharmaceuticals detection by LC-MS/MS to test materials for (bio)sensors* Mª João Nunes, Nova University Lisbon, Portugal
12:00-12:15	OC22 - *A avaliação da autenticidade do Vinho do Porto ao longo dos tempos* Manuel Lima Ferreira, Instituto dos Vinhos do Douro e do Porto, Portugal	12:00-12:15	OC25 - *Development and evaluation of o-nitrophenethyl photocaged prodrugs for glioblastoma* João Vaz, Universidade de Lisboa, Portugal	12:00-12:15	OC28 - *Ionic systems as additives for energy applications* Luis C. Branco, Nova University Lisbon, Portugal
12:15-12:30	OC23 - *O passado como conhecimento para o futuro* Vicente Ferreira da Silva	12:15-12:30	OC26 - *Indicator displacement assays using water-soluble deep cavity cavitands for the detection of benzodiazepines* Beatriz Raimundo, Universidade Nova de Lisboa, Portugal	12:15-12:30	OC29 - *Pharmaceutical organic salts and ionic liquids based on Streptomycin and Cefuroxime antibiotics* Francisco Faísca, Nova University Lisbon, Portugal
12:30-14:00	**Lunch Break**				
Room	**Grande Auditório**				
CHAIR:	*Luís Belchior Santos, FC, Univ. Porto*				
14:00-14:50	PL5 - *Tormented polycyclic aromatic compounds* Robert Pascal, Bernard Villars Baus Chair in Chemistry, School of Science & Engineering, Tulane University, New Orleans, LA, USA				
Room: Grande Auditório	***Chair:*** *Amparo Faustino, Univ. Aveiro*	**Room**: Pequeno Auditório	***Chair:*** *Pedro Carvalho, Univ. Aveiro*	**Room**: 5	***Chair:*** *Jorge Saraiva, Univ. Aveiro*
14:55-15:25	KN11 - *Metalloprotein chaperones: regulating protein aggregation and metal ion dyshomeostasis in Alzheimer's disease* Cláudio M. Gomes, Universidade de Lisboa, Portugal	14:55-15:25	KN12 - *Insights on the design of highly stable noble metal-free carbon electrocatalysts for oxygen reduction reaction* Rui S. Ribeiro, University of Porto, Portugal	14:55-15:25	KN13 - *The whereabouts of iron in the human body: insights from blood serum chemistry* André M.N. Silva, Universidade do Porto, Portugal
15:25-15:40	OC30 - *Host-guest complexes based on p-sulfonatocalix[n]arenes and a pyranoflavylium-type dye for dynamic capture of biogenic amines* Ana Sofia Pires, Nova University Lisbon, Portugal	15:25-15:40	OC32 - *Realizing the machine learning power for catalysis: the role of small open data* Pedro S. F. Mendes, Instituto Superior Técnico, Portugal	15:25-15:40	OC34 - *Dynamic G-quadruplex based perfusable supramolecular hydrogels embedded in photo-cross-linkable matrices for bioapplications* João Borges, University of Aveiro, Portugal
15:40-15:55	OC31 - *Exploring photocatalytic properties of titanate hybrid nanotubular materials for sustainable applications* Olinda C. Monteiro, University Lisbon, Portugal	15:40-15:55	OC33 - *Extraction, identification, and antioxidant potential of phenolic compounds from stone pine cone* Cláudia M. B. Neves, Polytechnic Institute of Viseu, Portugal	15:40-15:55	OC35 - *BASHY platform: Bioimaging and therapeutics* Fábio M. F. Santos, Universidade de Lisboa, Portugal
15:55-17:30	**Coffee break & Poster discussion (121 - 230)- CCA**				
17:30-18:00	KN14 - *Near infrared light absorbing nanomaterials for cancer photothermal therapy* Ilídio J. Correia, Universidade de Coimbra, Portugal	17:30-18:00	KN15 - *Advanced treatment technologies for wastewater resources recovery* Vítor Vilar, University of Porto, Portugal	17:30-18:00	KN16 - *Rethinking C-N and S-N bond formation* Mª Manuel B. Marques, Universidade Nova de Lisboa, Portugal

18:00-18:15	OC36 - *New chitin derived furanic platforms as bio-based synthons* Rafael F. A. Gomes, Universidade de Lisboa, Portugal	18:00-18:15	OC37 - *C_2 Hydrocarbons production via oxidative coupling of methane over ABO_3 perovskites (A = La, Pr, Sm, Dy, Yb and B = Mo, Mn, Ga and In)* Joana F. Martinho, Instituto Superior Técnico, Portugal	18:00-18:15	OC38 - *Extracting zeolite preparation data from scientific papers in PDF automatically* Daniel P. Costa, Instituto Superior Técnico, Portugal
Room	**Grande Auditório**				
CHAIR:	*António Jorge Parola, Univ. Nova de Lisboa*				
18:15-19:05	PL6 - *New directions for artificial molecular machines and motors* Alberto Credi, Departmenht of Industrial Chemistry, Università di Bologna, Bologna, Italy				
18:15	**Assembleia Geral da SPQ**				
19:45	**Congress Dinner – Restaurante Universitário, Univ. Aveiro**				
Wednesday, 26 July 2023					
Time (h)	Centro Cultural e de Congressos de Aveiro				
Room	**Grande Auditório**				
CHAIRS:	*Artur M. S. Silva, Univ. Aveiro and Joaquim Faria, Univ. Porto*				
9:00-9:50	PL7 - *From anisotropic to asymmetric nanoparticle growth, Portuguese-Spanish award "Madinaveitia-Lourenço"* Luis Manuel Liz-Marzan, Bionanoplasmonics Lab, CIC biomaGUNE, Donostia/San Sebastián, Spain				
Room: Grande Auditório	***Chair:*** *Armando Pombeiro, IST, Univ. Lisboa and José Moura, Univ. Nova de Lisboa*	**Room**: Pequeno Auditório	***Chair:*** *Armando Silvestre, Univ. Aveiro*	**Room**: 5	***Chair:*** *Manuel Coimbra, Univ. Aveiro*
9:50-10:05	***Fraústo da Silva - Tribute Session*** OC39 - *Fraústo da Silva and the two Cultures: Biographic note* Armando Pombeiro, Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa	9:50-10:20	KN17 - *Molecular design of nitroprusside-based hybrid functional materials* Wei-Jian Xu, University of Aveiro, Portugal	9:50-10:20	KN18 - *Augmenting the reactions' portfolio of quinic acid* Nuno R. Candeias, *University of Aveiro, Portugal*
10:05-10.20	OC40 - *Remembering Fraústo da Silva* José J. G. Moura, Departamento de Química, FCT, Universidade Nova de Lisboa				
10:20-10:35	OC41 - *Metal complexes in biological media. Relevance of assessing their speciation* João Pessoa, Centro de Química Estrutural, Institute of Molecular Sciences and Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa	10:20-10:35	OC43 - *Natural deep eutectic solvents from fundamentals to applications* Andreia S. F. Farinha, King Abdullah University of Science and Technology, Saudi Arabia	10:20-10:35	OC45 - *Titanium-catalysed synthesis of imineureas* César P. Reis, Instituto Superior Técnico, Portugal
10:35-10:50	OC42 - *O Sudário de Turim, fonte de extraordinária informação científica* Victor M. M. Lobo, Departamento de Química, FCT, Universidade de Coimbra	10:35-10:50	OC44 - *Biorecovery of critical elements from fluorescent lamp wastes using the marine macroalga Ulva sp.* João Pinto, University of Aveiro, Portugal	10:35-10:50	OC46 - *The meso-tetrakis(pentafluorophenyl)--porphyrin: a platform for heterogeneous catalysts* Mário M. Q. Simões, University of Aveiro, Portugal
10:50-11:15	**Coffee break - CCA**				

11:15-11:30	OC47 - *The undiscovered world of Werner complexes* Maria José Calhorda, Departamento de Química e Bioquímica, FCT, Universidade de Lisboa	11:15-11:45	KN19 - *The 12 Labours of HERCULES…or from mythology to the frontiers of Chemistry and Art…or chronicle of a ready-made* António Candeias, City University of Macau Chair in Sustainable Heritage, Portugal	11:15-11:45	KN20 - *Endoperoxide–based hybrids as tools to fight infectious diseases; synthesis, structure and properties.* Maria L. S. Cristiano, University of Algarve, Portugal
11:30-11:45	OC48 - *A praise for denitrification* Isabel Moura, Departamento de Química, FCT, Universidade Nova de Lisboa				
11:45-12:00	OC49 - *O Triunfo do azul na Natureza e no antropoceno. Sobre a evolução (Química) dos sistemas de cor nas plantas. O Caso das hortênsias* Fernando Pina, Departamento de Química, FCT, Universidade Nova de Lisboa	11:45-12:00	OC52 - *meso-Aryl-1,3,5,7-tetramethyl BODIPY dyes revisited: A systematic approach for synthetic optimization* Alexandre P. Felgueiras, University of Coimbra, Portugal	11:45-12:00	OC55 - *Detection of mutations in epidermal growth factor receptor using gold nanoparticle aggregation* Anupong Nuekaew, Universidade do Porto, Portugal
12:00-12:15	OC50 - *Ligações de hidrogénio e outras interações não-covalentes em química de coordenação* M. Fátima Guedes da Silva, Departamento de Eng. Química, IST, Universidade de Lisboa	12:00-12:15	OC53 - *Influence of proton transfer on the luminescence of organic dyes* Samuel Guieu, University of Aveiro, Portugal	12:00-12:15	OC56 - *How to reduce the problematic CO_2? Lessons from Biology* Luisa Maia, Universidade Nova de Lisboa, Portugal
12:15-12:30	OC51 - *Living with Chemistry in a virtual world-"A Química na era da desmaterialização do conhecimento"* Clementina Teixeira, Departamento de Eng. Química, IST, Universidade de Lisboa	12:15-12:30	OC54 - *Metalloproteins from pathogenic bacteria - targets for new antibiotics* Sofia Pauleta, Universidade Nova de Lisboa, Portugal	12:15-12:30	OC57 - *Contribution of non-ionic interactions on bile salt binding by chitooligosaccharides: potential hypocholesterolemic activity* Filipe Coreta-Gomes, University of Aveiro, Portugal
12:30-14:00	**Lunch Break**				
Room	**Grande Auditório**				
CHAIR:	*Baltazar de Castro, FC, Univ. Porto*				
14:00-14:50	PL8 - *Development of solar photoreactors for water treatment* Sixto Malato, Water Solar Treatment Unit, Plataforma Solar de Almería, Almería, Spain				
Room: Grande Auditório	***Chair:*** *Mário Simões, Univ. Aveiro*	**Room**: Pequeno Auditório	***Chair:*** *Rita Ferreira, Univ. Aveiro*	**Room**: 5	***Chair:*** *Anabela Valente, Univ. Aveiro*
14:55-15:25	KN21 - *Synthesis and end-of-life tailoring of furan-based polymers: in the pathway to sustainable polymers* Andreia F. Sousa, University of Aveiro, Portugal	14:55-15:25	KN22 - *Brown algae metabolites: the catalysts for biomass valuing* Susana M. Cardoso, University of Aveiro, Portugal	14:55-15:25	KN23 - *Discovery of dual inhibitors of PD-L1 and TGF-BRI leveraged by in silico methods* Rita Guedes, Universidade de Lisboa, Portugal
15:25-15:40	OC58 - *Red color stabilization of anthocyanins with lignosulfonates from the pulp industry* Joana Oliveira, Universidade do Porto, Portugal	15:25-15:40	OC60 - *Hafnium-containing modified zeolites or silicates for catalytic transfer hydrogenation of furfural to useful bioproducts* Mª Margarida Antunes, *University of Aveiro, Portugal*	15:25-15:40	OC62 - *Synthesis of β-functionalized porphyrin-Ir(III) complexes as photosensitizer agents towards cancer cells* Nuno M. M. Moura, University of Aveiro, Portugal
15:40-15:55	OC59 - *Self-assembled binary structures of Mn(III), Fe(III) and metal-free porphyrins in catalytic hydrogenation assisted by sunlight* Gabriela A. Corrêa, Universidade do Porto, Portugal	15:40-15:55	OC61 - *(Photo)Oxidative transformation of biomass derived molecules into valuable products* Iwona Kuzniarska-Biernacka, Universidade do Porto, Portugal	15:40-15:55	OC63 - *Validation of a methodology to quantify several elements in fruits according to ISO 17025* Mª Eduarda Pereira, University of Aveiro, Portugal

15:55-16:15	**Coffee break - CCA**				
16:15-16:45	KN24 - *Analytical challenges in the detection of plant food supplements adulteration* Joana S. Amaral, Instituto Politécnico de Bragança, Portugal	16:15-16:45	KN25 - *Automation of molecular recognition strategies for enhanced analytical methods* Marcela A. Segundo, University of Porto, Portugal	16:15-16:45	KN26 - *Building chemical strategies to expand flavylium-based dyes applications* Luís Cruz, University of Porto, Portugal
16:45-17:00	OC64 - *Exploiting the versatility of electroactive organic building blocks for the construction of functional framework materials* Manuel Souto, University of Aveiro, Portugal	16:45-17:00	OC65 - *All-solid-state thermally-chargeable textile supercapacitors based on CNTs and PEDOT:PSS-doped PVA/H_3PO_4 electrolyte* Joana S. Teixeira, University of Porto Portugal	16:45-17:00	OC66 - *Prediction of molecular properties of metal-containing drugs using machine learning models* Vincenzo Vigna, University of Calabria, Italy
Room	**Grande Auditório**				
CHAIRS:	*Artur M. S. Silva, Univ. Aveiro and Joaquim Faria, Univ. Porto*				
17:00-17:35	*Machine learning tools to accelerate the chemical sciences*; Vicente de Seabra medal Tiago Correia de Oliveira Rodrigues, Faculty of Pharmacy, University of Lisbon				
Room	**Grande Auditório**				
17:35	**Closing Ceremony – Poster awards** ***Artur M. S. Silva*** - Vice-Rector of the University of Aveiro - Chair of the XXVIII Encontro Nacional da SPQ ***João Rocha*** - Department of Chemistry, University of Aveiro – Vice-Chair of the XXVIII Encontro Nacional da SPQ ***Joaquim Faria*** - Faculty of Engineering, University of Porto, President of the Sociedade Portuguesa de Química				



List of Communications

Plenary Lectures

PL1	José João Galhardas de Moura, *Embracing metals with proteins - a personal history*; Ferreira da Silva award
PL2	Carlos Frederico de Gusmão Campos Geraldes, *Lanthanide nuclear paramagnetic shift and relaxation in structural NMR and MRI - a personal experience*; Fraústo da Silva award
PL3	Jose Luis Mascareñas, *Transition metal catalysis in biological habitats*
PL4	Karine de Oliveira Vigier, *Catalytic amination of bio-based compounds*
PL5	Robert Pascal, *Tormented polycyclic aromatic compounds*
PL6	Alberto Credi, *Machine learning tools to accelerate the chemical sciences*
PL7	Luis Manuel Liz-Marzan, *From anisotropic to asymmetric nanoparticle growth, Portuguese-Spanish award "Madinaveitia-Lourenço"*
PL8	Sixto Malato, *Development of solar photoreactors for water treatment*
	Tiago Correia de Oliveira Rodrigues, *New directions for artificial molecular machines and motors*; Vicente de Seabra medal

Keynote Lectures

KN1	Francisco M. Fernandes, *The physics and chemistry of directional freezing: implications in biofabrication and cryobiology*
KN2	Alexander Kirillov, *Coordination polymers: From self-assembly to functional (bio)materials*
KN3	Ana Novo Barros, *Wine industry's untapped goldmine: Unlocking the potential of by-products in the Circular Economy*
KN4	Cláudio Manaia Nunes, *Manipulation of organic molecules by infrared vibrational excitation*
KN5	Nuno Basílio, *Photoresponsive host-guest systems with potential biological applications*
KN6	Eduardo J. M. Filipe, *Semifluorinated soft-matter*
KN7	Rui F. P. Pereira, *Engineering of silk-based materials: a quest for eco-sustainable resources*
KN8	Raquel Soengas, *Exploring the use of metals and metallic salts in the synthesis of flavonoids*
KN9	Enrique Ortí, *Theoretical insight into hole-transporting materials for perovskite solar cells*
KN10	Manuel Melle-Franco, *Computing your way out of experimental problems, from nanocarbon to covalent organic frameworks and beyond*
KN11	Cláudio M. Gomes, *Metalloprotein chaperones: Regulating protein aggregation and metal ion dyshomeostasis in Alzheimer's disease*
KN12	Rui S. Ribeiro, *Insights on the design of highly stable noble metal-free carbon electrocatalysts for oxygen reduction reaction*
KN13	André M. N. Silva, *The whereabouts of iron in the human body: insights from blood serum chemistry*
KN14	Ilídio J. Correia, Near infrared light absorbing nanomaterials for cancer photothermal therapy
KN15	Vítor Vilar, *Advanced treatment technologies for wastewater resources recovery*
KN16	Mª Manuel B. Marques, *Rethinking C-N and S-N bond formation*
KN17	Wei-Jian Xu, *Molecular design of nitroprusside-based hybrid functional materials*
KN18	Nuno R. Candeias, *Augmenting the reactions' portfolio of quinic acid*
KN19	António Candeias, *The 12 Labours of HERCULES… or from mythology to the frontiers of Chemistry and Art…or chronicle of a ready-made*
KN20	Maria de Lurdes dos Santos Cristiano, *Endoperoxide–based hybrids as tools to fight infectious diseases; synthesis, structure and properties.*
KN21	Andreia F Sousa, *Synthesis and end-of-life tailoring of furan-based polymers: in the pathway to sustainable polymers*
KN22	Susana Cardoso, *Brown algae metabolites: the catalysts for biomass valuing*
KN23	Rita Guedes, *Discovery of dual inhibitors of PD-L1 and TGF-BRI leveraged by in silico methods*
KN24	Joana Amaral, *Analytical challenges in the detection of plant food supplements adulteration*
KN25	Marcela Segundo, *Automation of molecular recognition strategies for enhanced analytical methods*
KN26	Luis Cruz, *Building chemical strategies to expand flavylium-based dyes applications*

Oral Communications

OC1	André M. da Costa Lopes, *Enhanced biomass processing using a ternary deep eutectic solvent*
OC2	Luís P. Viegas, *Understanding the chemistry behind the Kigali Amendment to the Montreal Protocol: an accurate computational protocol*
OC3	Artur Jorge Carneiro Moro, *DPA fluorescent sensors: "walking" towards the NIR*
OC4	Pedro C. Rosado, *Addressing drug resistance in methicillin-resistant Staphylococcus aureus through mass spectrometry multiple omics*
OC5	Cláudia Bento, *Improved functional excipients for high value pharmaceuticals*
OC6	Joana L. C. Sousa, *Nitro group-containing compounds as histone deacetylase inhibitors*
OC7	Tatiane C. G. Oliveira, *The extraction residues as a promising source of fiber and proteins*
OC8	Sandra C. C. Nunes, *Electrostatics on biomolecules-based drug delivery systems*
OC9	Daniela Malafaia, *Unlocking the potential of chromeno[3,4-b]xanthones as multifunctional compounds for Alzheimer's disease*
OC10	Ana P. Paiva, *Recovery of palladium by solvent extraction – A contribution for the recycling of PGMs from end-of-life devices*
OC11	Raquel Nunes da Silva, *Innovation in cork: A cork-Chemistry relationship*
OC12	Carlos Pinto, *Featuring hyperbaric storage for Clostridium perfringens endospores' inactivation – a novel breakthrough on food safety?*
OC15	Marcos A. Bento, *Photoreduction of carbon dioxide using a novel Re(I) complex*
OC16	Duarte Borralho, *Hydrogen production via electrocatalytic ammonia conversion using metal-organic frameworks films*
OC17	Rodrigo M. A. Silva, *Effect of alkylsilane and alkylsiloxane chains on the thermophysical properties of ionic liquids*
OC18	Mélanie Fonte, *New 4-(N-cinnamoylbutyl)aminoacridines as potential multi-stage antiplasmodial leads*
OC24	Luís Pinto da Silva, *Development of new analogs with anticancer activity from metabolic products of marine bioluminescent reactions*
OC25	João Vaz, *Development and evaluation of o-nitrophenethyl photocaged prodrugs for glioblastoma*
OC26	Beatriz Raimundo, *Indicator displacement assays using water-soluble deep cavity cavitands for the detection of benzodiazepines*
OC27	Mª João Nunes, *Pharmaceuticals detection by LC-MS/MS to test materials for (bio)sensors*
OC28	Luis C. Branco, *Ionic systems as additives for energy applications*
OC29	Francisco Faísca, *Pharmaceutical organic salts and ionic liquids based on Streptomycin and Cefuroxime antibiotics*
OC30	Ana Sofia dos Santos Pires, *Host-guest complexes based on p-sulfonatocalix[n]arenes and a pyranoflavylium-type dye for dynamic capture of biogenic amines*
OC31	Olinda C. Monteiro, *Exploring photocatalytic properties of titanate hybrid nanotubular materials for sustainable applications*
OC32	Pedro S. F. Mendes, *Realizing the machine learning power for catalysis: the role of small open data*
OC33	Cláudia M. B. Neves, *Extraction, identification, and antioxidant potential of phenolic compounds from stone pine cone*
OC34	João Borges, *Dynamic G-quadruplex based perfusable supramolecular hydrogels embedded in photo-cross-linkable matrices for bioapplications*
OC35	Fábio M. F. Santos, *BASHY platform: Bioimaging and therapeutics*
OC36	Rafael F. A. Gomes, *New chitin derived furanic platforms as bio-based synthons*
OC37	Joana F. Martinho, *C_2 Hydrocarbons production via oxidative coupling of methane over ABO_3 perovskites (A = La, Pr, Sm, Dy, Yb and B = Mo, Mn, Ga and In)*
OC38	Daniel P. Costa, *Extracting zeolite preparation data from scientific papers in PDF automatically*
OC43	Andreia S. F. Farinha, *Natural deep eutectic solvents from fundamentals to applications*
OC44	João Pinto, *Biorecovery of critical elements from fluorescent lamp wastes using the marine macroalga Ulva sp.*
OC45	César P. Reis, *Titanium-catalysed synthesis of imineureas*
OC46	Mário M. Q. Simões, *The meso-tetrakis(pentafluorophenyl)porphyrin: a platform for heterogeneous catalysts*
OC52	Alexandre P. Felgueiras, *meso-Aryl-1,3,5,7-tetramethyl BODIPY dyes revisited: A systematic approach for synthetic optimization*
OC53	Samuel Guieu, *Influence of proton transfer on the luminescence of organic dyes*

OC54	Sofia Pauleta, *Metalloproteins from pathogenic bacteria - targets for new antibiotics*
OC55	Anupong Nuekaew, *Detection of mutations in epidermal growth factor receptor using gold nanoparticle aggregation*
OC56	Luisa Maia, *How to reduce the problematic CO_2? Lessons from Biology*
OC57	Filipe Coreta-Gomes, *Contribution of non-ionic interactions on bile salt binding by chitooligosaccharides: potential hypocholesterolemic activity*
OC58	Joana Oliveira, *Red color stabilization of anthocyanins with lignosulfonates from the pulp industry*
OC59	Gabriela A. Corrêa, *Self-assembled binary structures of Mn(III), Fe(III) and metal-free porphyrins in catalytic hydrogenation assisted by sunlight*
OC60	Mª Margarida Antunes, *Hafnium-containing modified zeolites or silicates for catalytic transfer hydrogenation of furfural to useful bioproducts*
OC61	Iwona Kuzniarska-Biernacka, *(Photo)Oxidative transformation of biomass derived molecules into valuable products*
OC62	Nuno M. M. Moura, *Synthesis of β-functionalized porphyrin-Ir(III) complexes as photosensitizer agents towards cancer cells*
OC63	Mª Eduarda Pereira, *Validation of a methodology to quantify several elements in fruits according to ISO 17025*
OC64	Manuel Souto, *Exploiting the versatility of electroactive organic building blocks for the construction of functional framework materials*
OC65	Joana S. Teixeira, *All-solid-state thermally-chargeable textile supercapacitors based on CNTs and PEDOT:PSS-doped PVA/H_3PO_4 electrolyte*
OC66	Vincenzo Vigna, *Prediction of molecular properties of metal-containing drugs using machine learning models*

Memories Ferreira da Silva

OC13	Marisa Monteiro, *O Laboratório Ferreira da Silva: crónica de uma reconstrução desejada*
OC14	Manuel João Monte, *Os zoilos e os templos das ciências*
OC19	Fernando Remião, *Os alcalóides de Ferreira da Silva: Evolução do conhecimento da sua toxicologia*
OC20	Vânia Calisto, *Carbon materials for advanced water treatment*
OC21	Isabel M.P.L.V.O. Ferreira, *Qualidade, autenticidade e segurança alimentar: o valioso contributo do Professor Ferreira da Silva*
OC22	Manuel Lima Ferreira, *A avaliação da autenticidade do Vinho do Porto ao longo dos tempos*
OC23	Vicente Ferreira da Silva, *O passado como conhecimento para o futuro*

Memories Fraústo da Silva

OC39	Armando Pombeiro, *Fraústo da Silva and the Two Cultures: Biographic Note*
OC40	José J. G. Moura, *Remembering Fraústo da Silva*
OC41	João Costa Pessoa, *Metal complexes in biological media. Relevance of assessing their speciation*
OC42	Victor M. M. Lobo, *O Sudário de Turim, fonte de extraordinária informação científica*
OC47	Maria José Calhorda, *The undiscovered world of Werner complexes*
OC48	Isabel Moura, *A Praise for Denitrification*
OC49	Fernando Pina, *O Triunfo do Azul na Natureza e no Antropoceno. Sobre a Evolução (Química) dos Sistemas de Cor nas Plantas. O Caso das Hortênsias*
OC50	M. Fátima Guedes da Silva, *Ligações de hidrogénio e outras interações não-covalentes em química de coordenação*
OC51	Clementina Teixeira, *Living with Chemistry in a virtual world-"A Química na era da desmaterialização do conhecimento"*

Flash Communications

FC1	Valentina Silva, *Sustainable solar-driven photo-reactor for the removal of antibiotics from effluents using TiO_2/carbon quantum dots*
FC2	Maria G. Leichtweis, *Pumpkin peel phenolic extracts: optimized extraction and potential use as food preservatives*
FC3	Leandro M. O. Lourenço, *Effective light-activated photosensitizers for photoinactivation of microorganisms*
FC4	Manuel Luna, *Multifunctional g-C_3N_4-TiO_2-based treatment with photocatalytic and superhydrophillic/hydrophobic properties for building materials*
FC5	Leonor S. Castro, Silica-based supported ionic liquids as multimodal chromatographic supports for the isolation of recombinant proteins
FC6	Sara M. A. Pinto, *Fluorinated Mn(III)/(II)-porphyrin with redox-responsive ^1H and ^{19}F relaxation properties*
FC7	Ana C. Fernandes, *Depolymerization of polyester and polycarbonate plastic waste catalyzed by molybdenum, zinc and manganese compounds*
FC8	Teresa Pereira, *Self-assembled peptide-based photothermal hydrogels: cancer theranostic combining MRI and thermo-chemotherapy*
FC9	José M. Silva, *Biobased and wood inspired nanocomposite films for active packaging*
FC10	Cláudia Passos, *Pectic polysaccharides as an acrylamide mitigation strategy – Competition between reducing sugars and sugar acids*
FC11	André Seco, *An improbable rotaxane: cucurbit[7]urils and blue box binding to a flavylium axle with high stability and stimuli responsiveness*
FC12	Carla Vitorino, *Advancing brain tumor therapy with solid lipid nanoparticles*
FC13	Mónica Honrado, *Development of a loop-mediated isothermal amplification (LAMP) assay for detecting Styphnolobium japonicum as Ginkgo biloba adulterant*
FC14	Joana N. Martins, *Novel photo-responsive calixarenes for the control of transport of hydrophilic peptides across synthetic and cellular membranes*
FC15	Vitaliy Masliy, *Sustainable multi-step catalytic processes in continuous-flow*
FC16	Gonçalo Valente, *Modeling of perylene-based MOFs*
FC17	Rafaela T. Marques, *Visible light conversion of CO_2 using cryptates with Earth abundant metals*
FC18	Maria A. Barros, *Carbon nitride coated cotton for photocatalytic elimination of pharmaceutical pollutants from simulated hospital wastewater*
FC19	Rui Pereira, *Synthesis of novel polyhydroxylated bis-chalcones and their cyclodehydrogenation into bis-flavones*
FC20	Paula Ferreira, *Chitosan electromechanical response: piezoelectric or electrostritive?*
FC21	Zoé A. Arnaut, *Synthesis and evaluation of tetrapyrrolic macrocycles as potential antivirals*

Poster Communications

P1	Matilde Silva, *Green functional biomaterials for wound healing*
P2	Ana Francisca Santos, *Ecotoxicological impacts associated with fluorescent lamp waste leachates on the marine macroalgae Ulva lactuca*
P3	Navendu Paul, *Kinetic characterisation of the CO_2 reduction by the periplasmic Desulfovibrio desulfuricans formate dehydrogenase*
P4	Luis Pereira, *Exploiting bacterial formate dehydrogenases to reduce CO_2: Preparation of periplasmic fractions to purify the enzymes*
P5	Daniel José Viegas Antunes dos Santos, *A novel approach to discover ABC transporter modulators*
P6	German Perez-Sanchez, *A coarse-grain molecular dynamic simulation framework to tackle oil extraction from silica-based surfaces*
P7	Laura Pereira, *Core–shell polycationic polyurea pharmadendrimers are a potential alternative to fight planktonic and biofilm infections caused by Foodborne Pathogens*
P8	Alexis Pereira, *Proximate composition and free sugar and fatty acid profiles of Asian hornet larvae: An alternative food source?*
P9	Mariana Cunha, *Chitosan-flavylium conjugates towards construction of pH-responsive multilayer membranes for food spoilage detection*
P10	Rodrigo P. Monteiro, *Effect of the macrocyclic host on carbon monoxide release from inclusion compounds with $CpMo(CO)_3Me$*

P11	Gonçalo F. Oliveira, *Synthesis of new diketopyrrolopyrrole derivatives*
P12	Inês M. Bastos, *Synthesis of (E)-3-[3-(2-hydroxyphenyl)-4-styryl-1H-pyrazol-1-yl]pyrrolidine-2,5-diones as potential PARP1 inhibitors*
P13	Catarina Ribeiro, *Synthesis of arylated DT-TTF derivatives with tuneable molecular orbital energy levels and formation of 2D networks on surface*
P14	Pedro Ferreira, *Redox-active tetrathiafulvalene-based covalent organic frameworks as cathodes for lithium batteries*
P15	Iago C. Vogel, *Synthesis of quinic acid derivatives for α-glucosidase inhibition*
P16	Cristina M. Cordas, *Lytic polysaccharide monooxygenase direct electrochemical behavior - role of the active center ligands*
P17	Natacha C. P. Rodrigues, *The impact of increased soil salinity on the production of secondary metabolites by Olea europaea L.*
P18	Lara Almeida, *Reactivity studies of 1,5-diarylpentadienones with hydroxylamine: Synthesis of diarylpyridines and styrylisoxazoles*
P19	Lúcia Melo, *Synthesis of steroid-quinoline hybrids with donor-acceptor architectures*
P20	Alberto Trevisan, *Tuning the sign and magnitude of pKa shift in cucurbit[7]uril host-guest complexes by molecular engineering*
P21	Alfredo Bartolomeu, *Advances in platinum(II)-based chlorins: Scale-up, chemical modulation and photodynamic activity*
P22	Hajer Bouznif, *Stable Al(III) complexes of a water-soluble Schiff base: overcoming hydrolysis for improved water stability*
P23	Beatriz Sousa, *Development of hybrid-based layered molybdenum disulfide for SERS applications*
P24	Inês C. C. Costa, *Endoperoxide–pyrazole hybrids: synthesis, structure and antiparasitic properties*
P25	Margarida Teixeira, *Edible flowers rich in anthocyanins: biochemistry and biotechnology towards an emerging, healthier, and sustainable diet*
P26	João P. F. Carvalho, *Development of alginate-based bioinks with curcumin loaded cellulose particles for 3D-bioprinting of drug-releasing living structures*
P27	André Lopes, *Synthesis of 4-hydrazone-pyrimido[5,4-d]pyrimidine derivatives via a cascade reaction*
P28	Kais Iben Nassar, *A data-driven approach to unveil the reactivity of MXene-based catalysts for the water gas shift reaction*
P29	Sofia Teixeira, *Drawbacks in the synthesis of substituted aryl hydrazides*
P30	Martinique S. Nunes, *Hydrolysis of a Mo(VI) complex of 5-(2-pyridyl-1-oxide)tetrazole into a MoO_3-based hybrid catalyst for the epoxidation of bio-olefins*
P31	Mª Graça P. M. S. Neves, *Porphyrin-silica gel hybrids as effective and selective metal ions adsorbents from industrial wastewater*
P32	Carla D. Nunes, *Oxidative desulfurization with Fe_3O_4–MoO_3 catalyst*
P33	Flavia F. Magalhães, *Extractive bioconversion of polydopamine by laccase in aqueous biphasic systems*
P34	Ricardo N. S. Oliveira, *Heterologous production and characterization of nitrous oxide reductase from Pseudomonas stutzeri*
P35	Ana M. G. Silva, *Conversion of plastics into optical sensors: approach and applications*
P36	Diana M. Gomes, *Catalytic epoxidation of biobased olefins over modified mesostructured and hierarchical silicates*
P37	Bernardo L. Tavares, *Boron-doped diamond surface as a platform for the development of an enzymatic biosensor*
P38	Nalin Seixas, *Sustainable production of lignin nanoparticles assisted by green solvents*
P39	Luís F. B. Fontes, *Photo-NMR: a tool for in situ irradiation of NMR samples*
P40	Catarina N. Dias, *Preparation of catalysts for a sustainable conversion of glycerol into fuel additives*
P41	Catarina E. S. Ferreira, *Functional Zr-MOF-based materials as high potential catalysts under sustainable conditions*
P42	Joana F. C. Silva, *Stability enhancement of a ranolazine co-amorphous system*
P43	Paloma Lopes, *Uncovering raspberry seeds' biomolecules*
P44	Bruna Duarte, *Mechanochemical transformations of furans: Sustainable methodologies for the synthesis of heterocycles*
P45	José P. L. Roque, *Simultaneous tunneling control in conformer specific reactions*
P46	Eduarda Andrade, *Metal-organic frameworks: Development of a sensor for phosphate quantification*
P47	João C. S. Simões, *Oxime functionalization towards the enhancement of photophysical properties of BODIPYs*

P48	Alexandra Borges, *Unraveling the supramolecular self-assembly mechanism of a wine-inspired pyranoflavylium*
P49	Giovanna Grous, *Magnetic zeolite-based adsorbents for water remediation*
P50	Filipe Teixeira, *Walking the garden of bifurcating paths: Theoretical studies on the nucleophilic addition of methoxide to 6-cyanopurines*
P51	Ana C. Q. Silva, *Trilayered bacterial nanocellulose patches loaded with acyclovir and hyaluronic acid for dual mode treatment of herpetic lesions*
P52	Simone C. Fernandes, *Preparation of a tri-hybrid composite material through wetness impregnation method for the desulfurization of heavy fuel oil*
P53	Vitor H. Mordido, *Characterization of a small cytochrome c from Wolinella succinogenes a putative electron donor of "Clade II" cytochrome c N_2O reductase*
P54	Ana Carolina Pinto, *Decoding the exercise mimetic: An exploratory proteomic approach of plasma-derived extracellular vesicles*
P55	Filipe Estanislau, *A model-based approach for the development and scale-up of enzymatic processes in fine chemical industry*
P56	Sílvia Petronilho, *Rethinking potato chips industry byproducts for the development of active cheese packaging*
P57	Juliana Machado, *Pyrrolidine-fused chlorin conjugated gold nanoparticles: synthesis and characterization*
P58	Irene Gómez-Cruz, *Delignification of olive tree pruning through eutectic solvents*
P59	Marcelo Dias Catarino, *Pteridium aquilinum compounds: The good and the bad*
P60	João P. Castro, *Intermolecular activation of pinacol-derived chlorosilane for stereoselective hydride transfer*
P61	João Nogueira, *Carbon-silica composite nanoparticles with enhanced fluorescence emission for iron detection in water*
P62	Carlos F. P. Miranda, *Electrical conductivity of four 1-alkyl-3-methylimidazolium series: Evidence of nanostructuration in ionic liquids*
P63	Inês S. Marques, *(Electro)catalytic performance of biochar-based materials for catalytic processes and oxygen reactions*
P64	Renata Matos, *Biomass-derived catalysts towards oxygen electroreduction*
P65	Pedro Miranda, *Sulfonic acid-functionalized biochar derived from shrimp shell waste as sustainable catalysts for ethyl levulinate production*
P66	Fábio Martins, *A new rosamine loaded metal-organic framework as a potent fluorescent sensor for Cu(II)*
P67	Maria C. Teixeira, *Preparation of all-cellulose composites by partial dissolution of different cellulosic substrates*
P68	Ana M. S. Costa, *Multielements profile to trace authenticity markers of fruit cake fillings*
P69	Inês Marques, *Valorisation of rice husk: novel adsorbent materials for water treatment applications*
P70	Alexandre C. P. M. Alves, *Sputter deposition of metal nanoparticles in ionic liquid films obtained via thermal evaporation*
P71	David Elorriaga, *The surprisingly behavior of Au(III) with azoli(ni)um-2-dithiocarboxylate ligands. Synthesis, characterization, DFT studies and catalytic activity*
P72	Gabriel N. Valério, *Development of artificial enzymes based on the copper enzyme tyrosinase*
P73	Marina Ilkaeva, *Solid-state NMR-assisted adsorption techniques for CO_2 capture assessment in porous sorbents*
P74	Samuel Patinha, *Green extraction of fatty acids from Codium tomentosum: Unlocking the potential of eutectic solvents*
P75	Judite Resende, *Sustainable approach to phytosterol extraction from macroalgae using alternative solvents*
P76	Marina Justi, *Levodopa-functionalized gold nanourchins: Efficient nanosensors for food contaminant detection*
P77	Miguel F. Galrinho, *Galactomannan-based carriers for pulmonary administration of insulin – evaluating the preparation conditions*
P78	Jorge Manuel, *Gold nanoparticle SERS immunoassays for the detection of Toxoplasma gondii*
P79	Vânia Costa, *Cholesterol and phytol phenolipids – antioxidant efficiency in liposomes*
P80	José da Cunha, *Synthesis of sulfonamides via electrophilic amination mediated by hypervalent Iodine(III) reagents*
P81	Eduardo Ramos, *Study of glycation and oxidation as naturally occurring chemical modifications in serotransferrin*

P82	Telmo N. Francisco, *Synthesis of 3,5-disubstituted nitrobenzenes and their applications*
P83	Yaroslav Hryhoryev, *Synthesis and characterization of palladium porphyrins for the construction of a TTA-UC system in a solid matrix*
P84	Adrian Pastor, *Modulating the composition of layered double hydroxides to improve mild catalytic oxidation of alkanes*
P85	Nuno A. S. Dias, *Electron correlation in aromatic molecules: Analysis of conjugation in naphthalene and fluorene derivatives*
P86	Paulo N. Martinho, *Rationalising the cooperativity and salient effects on Fe(III) spin crossover compounds*
P87	Joana R. M. Ferreira, *Design and synthesis of 1,2-diarylazaindoles for thermally-activated delayed fluorescence*
P88	Andreia C. S. Gonzalez, *Development of sustainable catalytic processes towards polymeric materials versus fine chemicals via CO_2 addition to epoxides*
P89	Nicole S. Lameirinhas, *Gelatin hydrogel-based bioinks reinforced with nanofibrillated cellulose for 3D bioprinting of hepatocellular carcinoma models*
P90	Victória Paz, *Ruthenium-catalyzed CO_2 hydrogenation to methane in deep eutectic solvents*
P91	Ricardo A. L. S. Santos, *Active polymeric filtration membranes with siderophore for iron(III) removal from aqueous systems*
P92	Pedro M. P. Fernandes, *Novel therapeutic avenues: Dual inhibition of 20S proteasome and CRM1 in multiple myeloma explored through computational methods*
P93	Mª Margarida P. Borges, *Development of a xanthone-BINOL conjugate as a chemosensor for the detection of chiral amino acid*
P94	Paula Brandão, *Bioactive vitamins-metal complexes: Design, synthesis, structure, and their biological application*
P95	Joana F. M. Sousa, *Removal of copper ions from aqueous solution by using reduced chitosan*
P96	Ana Alves, *Polymersomes targeting glioblastoma cells for a chalcone delivery*
P97	Marta S. Nunes, *New hybrid carbon/metal sulfide nanomaterials for the development of smart textiles with energy storage and harvesting properties*
P98	Hugo Santos, *Evaluation of the absorption properties of rainwater in Estarreja*
P99	Tiago Gomes, *Analyzing the impact of structural changes on the spin crossover phenomenon in iron(III) complexes*
P100	Cristiana V. Ramos, *Biophysical characterization of methyl-β-cyclodextrin-membrane interaction for application in drug and gene delivery*
P101	Hélio M. T. Albuquerque, *Targeting amyloid aggregation with steroidal compounds*
P102	Daniel L. Lourenço, *Manganese compounds as efficient catalysts for the reductive depolymerization of plastic waste*
P103	Federico Basso, *Effect of hyperbaric storage at room temperature on the development of the Maillard reaction in sugar-aminoacid model systems*
P104	Diana M. Fernandes, *Tailoring the guest-host PW11Co@ZIF-67 nanocomposite ORR/OER electrochemical bifunctionality through carbonization*
P105	André Oliveira, *Recycling spent frying oil in acidogenic fermentation by microbial mixed cultures*
P106	Luís Veríssimo, *Molecular design of a metal–nitrosyl ferroelectric with reversible photoisomerization*
P107	João T. S. Martins, *Tailored solutions for plastic recycling: Evaluating eutectic solvents for selective polymer dissolution by COSMO-RS*
P108	Ana Gomes, *Peptide conjugates for the topical treatment of infected wounds*
P109	Ana C. Gomes, *Tricarbonyl-pyrazine-molybdenum(0) metal−organic frameworks for the storage and delivery of biologically active carbon monoxide*
P110	Rui G. Faria, *From bulk catalysts to membranes: Designing a new route to scale-up sustainable fuel desulfurization*
P111	Liliana J. Gomes, *Fluorescent sensors for metal cations based on coumarin-3-carboxamide derivatives*
P112	Ana Teresa Silva, *Combining natural bile acids with old basic drugs affords new triple stage antimalarial surface-active ionic liquids*
P113	Sofia N. Sarabando, *Light-activated sulfonamides for antimicrobial photodynamic therapy*
P114	Silvestre Isidoro, *Physicochemical and pharmacokinetic profiles of African natural products: A computational approach*
P115	Adriana C. S. Pais, *Exploring the bioavailability of phenolic compounds through in vitro simulated gastrointestinal digestion - INFOGEST*

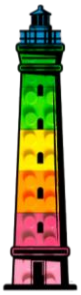
P116	Mariana N. José, *Development of a beneficial metformin drug delivery system using sustainable technologies*
P117	Artur F. M. Farinha, *Exploring dual-source thermal evaporation to create perovskite thin films for photovoltaic applications*
P118	Margarida M. Alves*, Repurposing of drugbank compounds for multitargeting of PD-L1 and TGF-β*
P119	Filipe G. A. Estrada, *Using binding pocket similarity to target unexplored proteins for the treatment of lung cancer*
P120	Ismael Rufino, *Drugging the undruggable: Exploring news ways in analyses of protein binding pocket to discover new drug targets*
P121	Paulo Almeida, *(Thio)barbiturates and fatty acids hybrids against prostate cancer: Synthesis, antiproliferative activity and inhibition of fatty acids intake*
P122	Sara Realista, *Electrosynthesis of iron-based metal-organic materials*
P123	Fernanda Machado, *Study of coffee soluble fibers cholesterol-lowering properties*
P124	Rita M. Carvalho, *Impact of deposition rate on the morphology of pure and mixed ionic liquid films via thermal evaporation*
P125	Catarina V. Esteves, *Ionic liquids and salts based on rhamnolipid and surfactin as biosurfactants*
P126	Ivo Cruz, *Revisiting the nitrobenzene scaffold for cancer therapy*
P127	Élia Fogeiro, *Potential of bioactive natural compounds from Pinus pinea L. value chain for plant protection*
P128	Gabriela P. Queirós, *Fabrication of bifunctional flexible electrochromic supercapacitors based on electrically-conductive polymer and MWCNTs*
P129	Inês Lopes, *Antimicrobial and anti-inflammatory activity of an extract of Arrabidaea brachypoda containing dimeric flavonoids*
P130	Humberto Rodríguez-Solla, *Reaction of (C^N)-cyclometallated gold(III) with Lawesson reagents: synthesis of dithiophosphonate gold(III) and gold(I) complexes*
P131	Joana P. Costa, *Fostering the combined anticancer/antibacterial activity of silver camphorimine composites*
P132	Sandra Cerqueira, *Green electrolytes for technological applications*
P133	Carolina Gonçalves, *Natural exposure to lithium and suicide rate – data from human biomonitoring of urinary lithium levels*
P134	Filipe M. P. Morais, *Unraveling the photodynamic activity of cationic dibenzoporphyrin-based photosensitizers against Escherichia coli*
P135	Inês F. M. Costa, *Heterometallic coordination polymers and tetranuclear copper(II) complexes: Self-assembly, magnetic properties, and catalytic activity*
P136	Tiago A. Fernandes, *Antibacterial starch-based biopolymer films doped with coordination compounds*
P137	Rita Assis dos Santos, *Teaching data science for chemical applications: from experiments to large representative data*
P138	Patrícia I. C. Godinho, *Oxa-Michael Henry domino reaction for the synthesis of 3-nitro-2H-chromenes*
P139	Vera L. M. Silva, *Ohmic heating assisted Hantzsch reaction for the synthesis of novel 1,4-dihydropiridines*
P140	Beatriz Teixeira, *Polymeric bovine serum albumin nanoparticles as drug delivery systems for prostate cancer treatment: An in vitro study*
P141	João Basso, *Achieving accurate measurements without breaking the bank: A highly sensitive technique for pitavastatin quantification in human plasma*
P142	Sara Hummeid, *Photoactivatable VEGFR2 inhibitors: Advancing precise cancer therapy*
P143	João L. Serrano, *(Thio)barbiturate derivatives as potential xanthine oxidase inhibitors and/or anticancer agents*
P144	Mariana I. C. Raposo, *Bioelectronic tongue for rapid detection of paralytic shellfish toxins*
P145	Filipa Pereira, *Cellulose-based materials functionalized with specific Immunoglobulin Y (IgY) antibodies aiming enhanced respiratory protection*
P146	Ana M. Pereira, *Flavones: synthesis and conjugation with chiral building blocks*
P147	Alexandra Varges, *Cyanine dyes functionalized with (thio)barbiturates as potential anticancer agents*
P148	Mariana Monteiro, *Chemical composition analysis of Lycium barbarum L. berries and Lycium chinense Mill. leaves cultivated in Southern Portugal*
P149	Samuel M. Silvestre, *Steroids coupled with (thio)barbiturates as potential anticancer agents: Synthesis and biological evaluation*
P150	João P. S. Silva, *Transparent and conductive silk films for application in thermotropic and electrochemical devices*

P151	Catarina Almeida, *Specific avian immunoglobulin Y (IgY) antibodies to tackle multiressistant bacteria*
P152	Sofia M. Bruno, *Application of organomolybdenum complexes for mild synthesis of campholenic aldehyde*
P153	Rita A. M. Barros, *Glucose oxidase immobilization onto graphitic carbon nitride for improved starvation therapy of cancer*
P154	Francisco M. Moreira, *Immunoglobin G purification using carbon nanomaterials obtained from food waste*
P155	Catarina M. Correia, *(E)-2-Styrylchromones: Synthesis and evaluation of the inhibitory effects on the oxidative burst of human monocytes*
P156	Paula C. R. Soares-Santos, *NMR Centre @ University of Aveiro*
P157	Joana C. Lopes, *Graphitic carbon nitride polymeric films for selective aldehydes synthesis using mesostructured photoreactor*
P158	Diana L. D. Lima, *Pharmaceuticals determination in water samples by solid phase extraction using low-cost waste-based sorbents*
P159	Nuno Viduedo, *Bimetallic catalyzed approaches for the synthesis of indole derivatives*
P160	Mara G. Freire, *Production and purification of non-viral vectors for gene therapy applications*
P161	Pedro M. O. Gomes, *Study of the effects of ohmic heating parameters in the synthesis of potential anticancer C-glycosylquinolones*
P162	Melani J. A. Reis, *Evaluation of the antimicrobial activity of porphyrins bearing N-donor moieties at 10,20-positions*
P163	Ana Cláudia R. Negrão, *Hypervalent iodine(III) reagents with transferable primary amines for electrophilic α-amination of stabilized enolates*
P164	Aurora Figueiredo, *Development of a cosmetic product added with Fucus vesiculosus extract rich in phlorotannins and fucoxanthin*
P165	Chris H. J. Franco, *Coordination polymers for exploring gas-phase processes: Syntheses, properties, and catalytic applications*
P166	Clementina M. M. Santos, *Exploring the inhibitory potential of 2-styrylchromones on pancreatic α-amylase*
P167	Rafaela G. Cabral, *Synthesis, characterization and antimicrobial activity of hybrid biopolymer films doped with bioactive coordination compounds*
P168	Flávia Leitão, *Synthesis and electrochemical studies of quinonemethides as potential new organic redox mediators*
P169	Catarina Henriques, *Synthesis of curcuminoids with potential antioxidant properties*
P170	Dinis F. Silva, *Simultaneous sulfur and nitrogen removal from fuel combining activated porous MIL-100(Fe) catalyst and sustainable solvents*
P171	Sara Godinho, *Sustainable synthesis of an antifouling agent from grape wastes*
P172	Cláudia P. S. Ribeiro, *Synthesis of BODIPY for theranostic application*
P173	Guilherme F. Pinto, *Use of silver nanoparticles for bacterial inactivation in water*
P174	Stéphanie Leal, *Hybrid dye – redox mediator based-coumarin for DSSCs cells: Synthesis, spectroscopic and photophysical properties*
P175	Hugo Rocha, *Photodegradation of the antibiotic amoxicillin in environmental aqueous matrices*
P176	Patricia Rijo, *Semi-synthetic abietane diterpenoids for breast cancer therapy: from molecular docking to protein kinase α activation*
P177	Raquel Dantas, *Influence of electrolyte and binder on the performance of redox-active covalent organic framework cathode materials for lithium-ion batteries*
P178	Isabel B. Calhau, *Effect of β-cyclodextrin on the CO-release kinetics and antimicrobial activity of* $[Mo(CO)_5Br][NEt_4]$
P179	João C. F. Nunes, *Novel flow-through like mode platform for the purification of L-asparaginase*
P180	Inês Pereira-Gomes, *Developing new acridine derivative doping polymers for optical sensing and antimicrobial studies*
P181	Diogo Torres, *Studying a novel fluorescent molecular probe containing a naphthalimide unit as a temperature and toxic metal ions sensor*
P182	Helena Laronha, *Wild endogenous mushroom: chemical characterization to hypocholesterolemic properties*

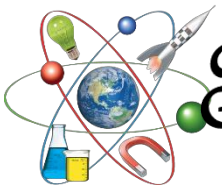
P183	**Ana I. Valente, *Integrated extraction, purification and preservation of DNA with ionic liquid-based aqueous biphasic systems***
P184	Daniel Galrito, *Development and electrochemical studies of diphenoquinones and hydrodiphenoquinones as new organic redox mediators*
P185	Augusto Q. Pedro, *Ionic liquids immobilized in macroporous supports as synthetic chromatographic ligands for the separation of nucleic acids*
P186	André L. Silva, *Di-anchoring thieno[3,4-b]thiophene-based sensitizers for DSSC applications*
P187	Cláudia Nunes, *Polysaccharides-based bionanocomposites as sustainable materials for active food packaging*
P188	Joana R. C. Santos, *Interaction of acetylcholine-binding protein from Aplysia californica with imidacloprid: a computational investigation*
P189	Rui André Dias da Costa, *Could the "eternal fountain of youth" be found in oenological waste? A case study of Região Demarcada do Douro*
P190	Renata A. Amaral, *The combination of high-pressure and pullulanase to improve starch-based films*
P191	Vasco Lima, *Food preservation by hyperbaric storage: a study with Saccharomyces cerevisiae*
P192	Carla I. M. Santos, *New fluorescent probes based on gallium(III) corrole complexes for the recognition of hydrogen sulfide*
P193	Joana Figueiredo, *Development of phenanthroline-based derivatives as telomeric G-quadruplex binders: synthesis and in vitro evaluation*
P194	Alexandre M. A. Fonseca, *Exploring the volatile profile of purple passion fruit: from consumer perception of fruit to thermal and high-pressure pasteurized juice*
P195	Patrícia Neves, *Reaction induced self-separating catalysts - Wonder catalytic systems*
P196	Ana S. C. Marques, *Potential of deep eutectic solvents to improve the conformational and colloidal stability of biopharmaceuticals*
P197	Vasco M. S. Castanheira, *Synthesis of cationic diketopyrrolopyrroles for the photodynamic inactivation of pathogenic microorganisms*
P198	Ana P. Martins, *Quality improvement of blood under pressure – Hyperbaric storage as a preservation methodology*
P199	Cátia I. Barbosa Sampaio, *Isolation of anthocyanins from natural sources using sustainable, simple and affordable methodologies*
P200	Ana C. S. Veríssimo, *The influence of Salicornia ramosissima ingestion by shrimp on their GC-MS biochemical profile: analysis optimization*
P201	Hanieh Mahmoodi, *Interaction between flavylium derivatives and ds-DNA*
P202	Isabel C. M. S. Santos-Vieira, *Towards the sustainable synthesis of microporous titanosilicates: mechanochemical pre-treatment reduces the water amount*
P203	Adriana C. C. Gomes, *Metallodrugs as therapeutic agents: Interaction with biomolecules, antibacterial activity, and incorporation into biopolymeric systems*
P204	Diogo Marinheiro, *Solvothermal synthesis of Zn(II), Cu(II) and Co(II)-flavonoid complexes with anti-diabetic potential*
P205	Bruno D. A. Pinheiro, *Volatility and solubility properties of the herbicide dichlobenil*
P206	Guilherme D. Serrão, *Bromine/iodine halogen bond synthons for co-crystalization*
P207	Ricardo J. F. Ferreira, *Targeting mutant p53 using indole-based small molecules*
P208	Maria M. M. Santos, *Development of novel dual p53-MDM2/4 protein-protein interactions inhibitors*
P209	José S. Câmara, *ChemiOMICS – identifying fingerprints on food safety, authenticity and traceability*
P210	Rita P. Lopes, *Neurotoxic effects of synthetic cathinones and its metabolites: the role of metabolism*
P211	Soraia Santos, *Unleashing the potential of incense honey from Azores: Invasive tree, profitable product!*
P212	Bruna Leite, *Synthesis of novel 5-aminopyrrolo[2,3-d]imidazoles from 5-aminoimidazole precursors*
P213	Artem Petrosian, *Chelerythrine – promising agent towards cancer treatment*
P214	Teresa Abreu, *In chemico greener technologies in grape pomace valorization. Towards a circular bio-economy model*
P215	Matheus Matos do Nascimento, *Centesimal and chemical characterization of Brazilian spinach (Alternanthera sessilis (L.) DC)*
P216	Yuliya Dulyanska, *Chemical composition of Ruscus aculeatus L. – Preliminary studies*
P217	Gabriela Matos, *Hyperbaric storage of egg white to assure microbiological safety, maintaining functional and quality parameters*
P218	Vítor J. Martins, *Development of a liposome-based cell membrane mimetic system for the characterization of glucan-receptor interaction studies*

P219	Ana P. M. Tavares, *Integrated purification strategies of RNA from recombinant lysates using biobased ionic liquids*
P220	Ana R. Circuncisão, *Bioprospecting Laminaria digitata as a potential biostimulant and drought stress mitigator in tomato plants*
P221	Ana M. Santos, *Two simple and accessible approaches for the synthesis of 2-amino-6-alcoxypurines from 5-aminoimidazole precursors*
P222	Nádia E. Santos, *A new cerium-based metal-organic framework with azobenzene-4,4'-dicarboxylic acid as ligand*
P223	Rafaela Lopes, *Moderate pressure pasteurization as an alternative to commercial HPP to pasteurize bovine meat without major colour changes*
P224	Daniel Barros, *Technological transposition and scale-up of a method for the recovery of rare earth elements using the macroalgae Ulva sp.*
P225	Carolina F. Jesus, *Exploring the synergistic relationship between sugar-based cationic surfactants and commercially accessible eco-friendly surfactants.*
P226	Anastasiya Voloshchuk, *Synthesis and activation studies of light-controllable PROteolysis-TArgeting Chimeras (PROTACs)*
P227	Inês L. Roque, *Design and synthesis of a novel class of thiazole-based necroptosis inhibitors*
P228	Newton Valério Verbisck, *MALDI-TOF mass spectrometry of molecules, cells and tissues: applications for agricultural and food chemistry*
P229	Ariana C. F. Santos, *Synthesis, physicochemical characterization, and biological evaluation of novel flavonoid chemotherapeutic metallodrugs*
P230	Fernanda F. Roman, *Wet peroxide oxidation of paracetamol from real wastewaters using multi-core shell magnetic nanoparticles as catalyst*


Abstracts



Plenary Lectures



Ferreira da Silva Award

The Ferreira da Silva Prize was established by the Portuguese Society of Chemistry in 1981 and was awarded biennially during the National Meeting of SPQ. This Prize is awarded to a Portuguese chemist who, by the scientific work produced in Portugal, has contributed significantly to the advancement of Chemistry in any of its areas.

Embracing metals with proteins – a personal history

José J. G. Moura

LAQV, REQUIMTE, Depart. of Chemistry, NOVA School of Science and Technology | FCT NOVA, Portugal
jose.moura@fct.unl.pt

A story with almost 40 years old is told, accompanying the creation of Bioinorganic Chemistry, an emerging scientific field that studies the role of metals in Biology. The interaction of transition metals with amino acid side chains of proteins offers a landscape of structural possibilities and diversity of functions, such as electron-transfer, substrate binding and activation, atom and group transfer chemistry, with implications for energy, health and environment. A visit is proposed on the multidisciplinary aspects of the properties of metals in Biological Chemistry: a challenging and different way of reporting past research work, hoping that it will be useful for a wide range of audiences. When preparing this talk, I felt like travelling in time (and "spaces") bringing together names that have made many collaborative contributions.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020 project) and PTDC/BTA-BTA/0935/2020, which are financed by national funds from Fundação para a Ciência e a Tecnologia/MCTES.

Fraústo da Silva Award

In order to incentive the Chemical Sciences in Portugal through the recognition of the research activity developed in sciences, the Portuguese Society of Chemistry, within the scope of its mission, established the Fraústo da Silva Prize in memory of one of the scientists who most influenced and dignified Science in Portugal.

PL2

Lanthanide nuclear paramagnetic shift and relaxation in structural NMR and MRI - a personal experience

Carlos F. G. C. Geraldes

CQC-IMS, Depart. of Chemistry and Depart. of Life Sciences, Faculty of Science and Technology
University of Coimbra, Portugal
geraldes@ci.uc.pt

Dedicated to the memory of Professor Victor Gil

The use of lanthanide induced NMR shift and relaxation probes is a 55 years story to which I contributed since 1972 with many collaborations. The interaction of lanthanide metal ions with small molecules and proteins leads to induced shifts (LIS) and relaxation (LIR) effects in their NMR-active nuclei, such as ^{1}H, ^{13}C, ^{15}N and ^{17}O. An introduction to the theoretical aspects of these effects will be presented, followed by examples of their applications in structural studies of small Ln^{3+} complexes and Ln^{3+}-based tags of proteins. The use of Gd^{3+}-based and of other non-Gd paramagnetic Ln^{3+}-based nanosystems as T_1/T_2 and paraCEST MRI contrast agents, as well as of MRI-based multimodal imaging and theranostic nanoplatforms will be illustrated with selected examples.

Acknowledgements
This work was supported along the years by FCTMCTES which funds the Associate Laboratories CQC/IMS and CNC, PTNMR, COST (EU), Robert Welsh Foundation, IBM and FULBRIGHT (USA), CAPES (Brasil), CNRS (France), Fondation Hebette (Switzerland) and Durham University (UK).

PL3

Transition metal catalysis in biological environments

José Luis Mascareñas

CIQUS and Departamento de Química Orgánica. Universidade de Santiago de Compostela. 15782, Santiago de Compostela, Spain

joseluis.mascarenas@usc.es; www.metbiocat.eu

Transition metal complexes have found widespread utility in a variety of scientific fields, ranging from catalysis to photophysics and supramolecular chemistry. The different coordination and redox characteristics of metals, together with the possibility of tuning their properties by changing the nature of the ligands, provides innumerable possibilities for generating new reactivities, and for implementing physicochemical responses.

Building upon these characteristics, most of our work deals with the application of transition metal complexes in the field of catalysis, biosupramolecular chemistry and chemical biology.

Our work in catalysis has been mostly focused on the discovery of new annulation reactions,[1] while in supramolecular chemistry our work has been mainly centered in the field of DNA recognition.[2]

More recently, aiming to merge metal catalysis with chemical and cell biology, we have investigated the viability of translating organometallic catalysis to biological media, and even to living cells.[3] While this represents a considerable challenge, owing to the presumed water and air incompatibility of many metal catalyzed reactions and the requirement of orthogonality and biocompatibility, we have developed several intracellular palladium, ruthenium and gold-promoted reactions.[4]

References

1. (a) J.L. Mascareñas, I. Varela, F. López, *Acc. Chem. Res.*, 2019, **52**, 465; (b) M.Gulías, J.L. Mascareñas, *Angew. Chem. Int. Ed.*, 2016, **55**, 11000; (c) X. Vidal, J.L. Mascareñas, M. Gulías, *J. Am. Chem. Soc.*, 2019, **141**, 1862; (d) D. Fernández, J.L. Mascareñas, F. López, *Chem. Soc. Rev.*, 2020, **49**, 7378.
2. (a) J. Rodríguez, S. Learte, J. Mosquera, D. Rodríguez-Larrea, M.E. Vázquez, J.L. Mascareñas, *Chem. Sci.*, 2018, **9**, 4118; (b) S. Learte, N. Curado, J. Rodríguez, M.E. Vázquez, J.L. Mascareñas, *J. Am. Chem. Soc.*, 2017, **139**, 16188; (c) J. Rodriguez, J. Mosquera, S. Learte-Aymamí, M.E. Vázquez, J.L. Mascareñas, *Acc. Chem. Res.*, 2020, **53**, 2286.
3. (a) C. Vidal, M. Tomás-Gamasa, P. Destito, F. López, J.L. Mascareñas, *Nature Commun.*, 2018, **9**, 1913; (b) S. Gutierrez, M. Tomas-Gamasa, J.L. Mascareñas, *Angew. Chem. Int. Ed.*, 2021, **60**, 22017.
4. For reviews, see: (a) M. Martínez-Calvo, J.L. Mascareñas, *Coord. Chem. Rev.*, 2018, **359**, 57; (b) P. Destito, C. Vidal, F. López, J.L. Mascareñas, *Chem. Eur. J.*, 2021, **27**, 4789; (c) J. Miguel-Avila, M. Tomás-Gamasa, J.L. Mascareñas, *Trends in Chem.*, 2023, 10.1016/j.trechm.2023.04.001.

PL4

Catalytic amination of bio-based compounds

Karine De Oliveira Vigier

IC2MP UMR CNRS 7285, Université de Poitiers, France
karine.vigier@univ-poitiers.fr

Carbohydrates and furanic derivatives are attractive commercial platform molecules for the production of a panel of compounds. For instance, bio-based amines has attracted increasing attention. Hence, amines represent a privileged class of compounds with broad interest in chemical industry. Furan-derived primary amines and tetrahydrofuran-derived amines were prepared from the aldol condensation reaction of furfural with methyl isobutyl ketone (MIBK), using NH_3 as nitrogen source, H_2 as reducing agent in the presence of metal supported catalysts. One pot reactions were studied as well as the mechanisms involved. Amination of non protected sugars was also performed in the presence of a commercial catalyst.

PL5

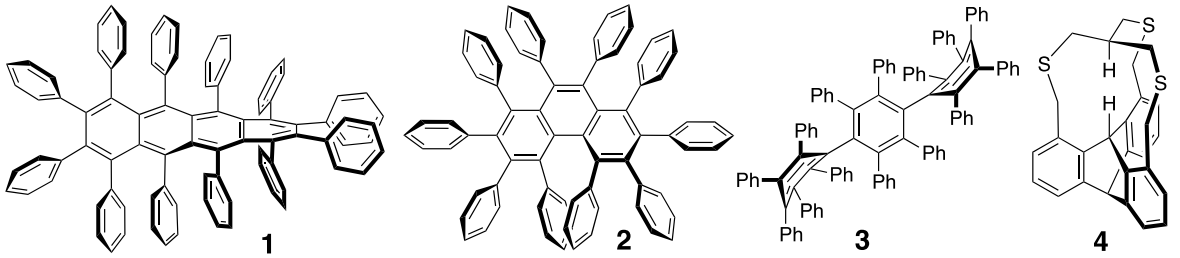
Tormented polycyclic aromatic compounds

Robert A. Pascal, Jr.*, Joel T. Mague, Yonglong Xiao, Yuchen Du

Department of Chemistry, Tulane University, New Orleans, LA 70118, USA
**rpascal@tulane.edu*

For many years we have pursued the synthesis, and structural and spectroscopic characterization, of highly strained aromatic compounds in which relatively unreactive functional groups are forced close together. In this lecture, we describe recent work on two classes of such "tormented aromatics": the perphenyl aromatic hydrocarbons and the *in,in*-cyclophanes.

The menagerie of *perphenyl* aromatic hydrocarbons (that is, simple aromatic hydrocarbons in which *every* hydrogen atom has been replaced by a phenyl group) has grown significantly in recent years. Prior to 1996, only hexaphenylbenzene[1] and decaphenylbiphenyl[2] had been prepared, but by 2002, these classic molecules had been joined by octaphenylnaphthalene,[3] decaphenylanthracene,[3] and octaphenyl-biphenylene.[4] The steric conflict of the many phenyl rings often twists such molecules from planarity, but at the same time, the "picket fence" of phenyl groups dramatically lowers the reactivity of the central rings, even if they are strongly distorted. We now discuss the syntheses of several new and larger polyphenyl aromatics, including (among others) dodecaphenyltetracene (**1**),[5] decaphenylphenanthrene (**2**),[6] and tetradecaphenyl-*p*-terphenyl (**3**).[7] The structures and conformational dynamics of these molecules provide stringent tests of the accuracy and utility of modern computational methods.



1 **2** **3** **4**

A different sort of crowding is observed in the *in,in*-cyclophanes, such as compound **4**.[8] In these macrobicyclic structures, the two functional groups on the central axis (in the case of **4**, two aliphatic hydrogen atoms) are forced into extreme proximity in order to relieve angle strain in the rest of the molecule. A variety of functional groups have been placed in such molecules, and the resulting very close (and sometimes "world record") non-bonded contacts give rise to highly unusual spectroscopic properties and chemical reactivity.

Acknowledgements
The authors thank the U.S. National Science Foundation (grants CHE-1762452 and MRI-1228232) for financial support.

References
1. W. Dilthey and G. Hurtig, *Ber. Dtsch. Chem. Ges.* 1934, **67**, 2004-2007.
2. M. A. Ogliaruso and E. I. Becker, *J. Org. Chem.* 1965, **30**, 3354-3360.
3. X. Qiao, M. A. Padula, D. M. Ho, N. J. Vogelaar, C. E. Schutt and R. A. Pascal, Jr., *J. Am. Chem. Soc*. 1996, **118**, 741-745.
4. J. Lu, J. Zhang, X. Shen, D. M. Ho and R. A. Pascal, Jr., *J. Am. Chem. Soc.* 2002, **124**, 8035-8041.
5. Y. Xiao, J. T. Mague, R. H. Schmehl, F. M. Haque and R. A. Pascal, Jr., *Angew. Chem. Int. Ed.* 2019, **58**, 2831-2833.
6. Y. Xiao, J. T. Mague, J. P. Donahue, L. J. Wilson, C. M. Kraml and R. A. Pascal, Jr., *Chem. Eur. J.* 2020, **26**, 8458-8464.
7. Y. Du, A. McSkimming, J. T. Mague and R. A. Pascal, Jr., *Chem. Eur. J.* 2022, **28**, e202200931.

Y. Xiao, J. T. Mague and R. A. Pascal, Jr., Angew. Chem. Int. Ed. 2018, **57**, 2244-2247.

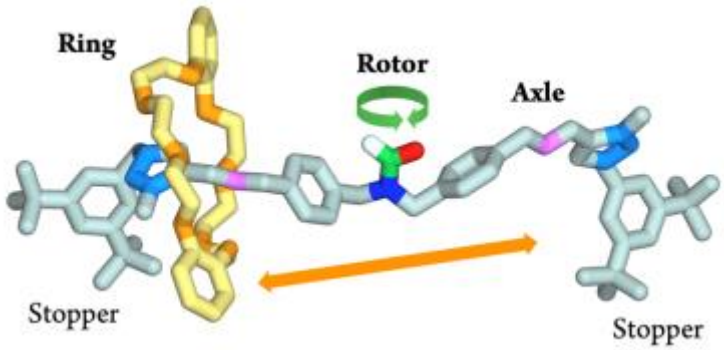
New directions for artificial molecular machines and motors

Alberto Credi, Massimo Baroncini, Stefano Corra, Massimiliano Curcio, Jessica Groppi, Serena Silvi

Center for Light Activated Nanostructures (CLAN), Dipartimento di Chimica Industriale "Toso Montanari", Alma Mater Studiorum - Università di Bologna, and Consiglio Nazionale delle Ricerche, Bologna, Italy.
alberto.credi@unibo.it

The construction of molecular scale devices and machines have formidably stimulated the creativity of chemists in the past three decades.[1,2] The interest on this kind of systems arises from their ability to perform a (useful) function in response to chemical and/or physical signals (*e.g.*, light). Mechanically interlocked molecules exhibit appealing structural and functional properties for the construction of nanoscale devices and machines; molecular shuttles based on rotaxanes constitute common examples.[2]

Here I will describe investigations undertaken in our laboratories, aimed at inducing and controlling nanoscale movements in rotaxanes and related species to perform functions such as transmitting motion between sites[3] (see Figure) and activating mechanically chiral structures for enantioselective guest recognition.[4] From a fundamental viewpoint these systems behave as molecular switches under thermodynamic control. Appropriately designed architectures, however, can exploit an energy harvesting process to operate away from thermodynamic equilibrium.[5] Moreover, by exploiting energy and/or information ratcheting effects, directional and autonomous movement of the molecular components can occur.[1,2] We have combined this strategy with a minimalist chemical design to realize artificial nanoscale pumps powered by light[6] and electricity.[7] Besides their interest for fundamental science, these systems have the potential to bring about radical innovation in catalysis, materials science, energy conversion, robotics and medicine.[8]



Acknowledgements
Support from the European Union (H2020 ERC AdG 'Leaps' 692981, FET-OPEN 'Magnify' 801378, ITN 'ArtMoMa' 860434) and the Ministero dell'Università e Ricerca (Grants 20173L7W8K and R16S9XXKX3) is gratefully acknowledged.

References

1. V. Balzani, A. Credi, M. Venturi, Molecular Devices and Machines – Concepts and Perspectives for the Nano World, Wiley-VCH, Weinheim, 2008. C. Bruns, J. F. Stoddart, The Nature of the Mechanical Bond: From Molecules to Machines, Wiley, Hoboken, 2016.
2. (a) M. Baroncini et al., *Chem. Rev.*, 2020, **120**, 200; (b) S. Corra et al., *JACS Au*, 2023, **3**, 1301.
3. S. Corra et al., *Chem.*, 2021, **7**, 2137.
4. S. Corra et al., *J. Am. Chem. Soc.*, 2019, **141**, 9129.
5. F. Nicoli et al., *J. Am. Chem. Soc.*, 2022, **144**, 10180.
6. (a) G. Ragazzon et al., *Nat. Nanotechnol.*, 2015, **10**, 70; (b). A. Sabatino et al., *Angew. Chem. Int. Ed.*, 2019, **58**, 14341; (c) J. Groppi et al., *Angew. Chem. Int. Ed.*, 2020, **59**, 14825; (d) S. Corra et al., *Chem. Eur. J.*, 2021, **27**, 11076; (e) M. Canton et al., *J. Am. Chem. Soc.*, 2021, **143**, 10890; (f) S. Corra et al., *Nat. Nanotechnol.*, 2022, **17**, 746.
7. G. Ragazzon et al., *Angew. Chem. Int. Ed.*, 2023, **62**, e202214265.
8. S. Corra et al., *Adv. Mater.*, 2020, **32**, 1906064.

PL7

From anisotropic to asymmetric nanoparticle growth

Luis M. Liz-Marzán

CIC biomaGUNE, Basque Research and Technology Alliance (BRTA), Spain; Ikerbasque, Basque Foundation for Science, Spain; Centro de Investigación Biomédica en Red, Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN), Spain; CINBIO, Universidade de Vigo, Spain
llizmarzan@cicbiomagune.es

The field of chirality has seen a strong rejuvenation due to the observation of nanoscale chirality in plasmonic nanoparticles.[1,2] This lecture will highlight recent advances in the field of plasmonic chirality, including novel methods for the synthesis of optically active plasmonic nanomaterials. Although much research in this field has been related to chiral nanostructures formed by the directed self-assembly of gold nanorods on various chiral templates, recent work has demonstrated the possibility of employing the well-known seeded-growth method, in the presence of amino acids, to endow colloidal nanoparticles with chiral features.[3,4]

An alternative approach comprises the self-organization of surfactant micelles into chiral structures on nanoparticle seeds. This simple concept opens a wide range of possibilities, by playing around with the huge variety of chiral co-surfactants, seed morphologies and metal compositions, which have been studied in the context of the seeded-growth of metal nanoparticles. We demonstrate that the addition of chiral co-surfactants leads to supramolecular interactions with CTAC, resulting in chiral helices that can wrap gold nanocrystals and template the seeded growth into chiral features. The resulting chiral nanoparticle colloids display high morphological and optical handedness, which can be tuned through the visible and the near IR. This approach provides a reproducible, simple and scalable method toward the fabrication of nanoparticles with high chiral optical activity.[5]

Acknowledgements
Funding is acknowledged from MCIN/AEI/10.13039/501100011033 (Grant PID2020-117779RB-I00).

References

1. D. Vila-Liarte, N.A. Kotov, L.M. Liz-Marzán, Template-Assisted Self-Assembly of Achiral Plasmonic Nanoparticles into Chiral Structure. *Chem. Sci.* 2022, **13**, 595-610.
2. G. Zheng, J. He, V. Kumar, S. Wang, I. Pastoriza-Santos, J. Pérez-Juste, L.M. Liz-Marzán, K.-Y. Wong, Discrete Metal Nanoparticles with Plasmonic Chirality. *Chem. Soc. Rev.* 2021, **50**, 3738-3754.
3. H.-E. Lee, H.-Y. Ahn, J. Mun, Y. Y. Lee, M. Kim, N. H. Cho, K. Chang, W. S. Kim, J. Rho, K. T. Nam, Amino-Acid- and Peptide-Directed Synthesis of Chiral Plasmonic Gold Nanoparticles. *Nature* 2018, **556**, 360-365.
4. B. Ni et al., Chiral Seeded Growth of Au Nanorods into 4-Fold Twisted Nanoparticles with Plasmonic Optical Activity. *Adv. Mater*. 2023, **35**, 2208299.
5. G. González-Rubio, J. Mosquera, V. Kumar, A. Pedrazo-Tardajos, P. Llombart, D. M. Solís, I. Lobato, E. G. Noya, A. Guerrero-Martínez, J. M. Taboada, F. Obelleiro, L. G. MacDowell, S. Bals, L. M. Liz-Marzán, Micelle-Directed Chiral Seeded Growth on Anisotropic Gold Nanocrystals. *Science* 2020, **368**, 1472-1477.

Development of solar photoreactors for water treatment

Sixto Malato

CIEMAT – Plataforma Solar de Almería, Ctra. De Senés s/n, 04200 Tabernas, Almería, Spain
sixto.malato@psa.es

This presentation will explore the state of the art and latest progress in photoreactors for solar photocatalysis for water treatment including decontamination and disinfection. Results have shown that solar photocatalysis with TiO_2 or other semiconductors is very inefficient in terms of treatment time and accumulative energy compared to solar photo-Fenton for wastewater treatment. We have not found any successful treatment results in any real effluent from industry or other sources like municipal wastewater effluents (MWWE)[1]. On the other hand, due to the photochemistry of many Fe^{3+} species, irradiation with UV or UV/Vis light can lead to a series of photochemical reactions which invariably reduced to its Fe^{2+} state, continue the Fenton process indefinitely, as long as the system remains illuminated (reacting again with H_2O_2). Fe^{3+} can also form complexes with many organic ligands, especially those acting as polydentate ligands. However, the main shortcomings of this process (e.g., frequent pH adjustment of the water matrix, disposal of the final sludge, high cost due to H_2O_2 and catalyst consumption) still limit its broader full-scale application. The majority of studies have demonstrated that the optimum pH for photo-Fenton is 2.8. However, Fe^{3+} can form complexes with higher molar absorption coefficients in the near-UV and visible regions than the aqua aquo complexes, while also using a larger fraction of the solar radiation up to 580 nm. This new approach has removed the economic burden associated with the chemical cost for pH rectification, especially for full-scale application. This use of natural sunlight dramatically lowers the operating cost of the process, and is thus a major step towards full-scale application[2].

Pilot-scale test results for the complete removal of a plethora of contaminants and microcontaminants have been quite satisfactory. Results reinforce the idea that treatment of extremely low concentrations of contaminants (as contaminants of emerging concern), requires different operating concepts from the application of photocatalysis to high-organic-load industrial wastewaters. The key matter is the design of photoreactors accordingly to the wastewater to be treated. Despite the limitations of the process, the efficiency of the technology for the treatment of wastewater has prompted its investigation at pilot-scale in combination with other technologies as biotreatment and membrane processes. Also, different solar photoreactors have been proposed for applying photocatalysis, trying to take into account the specific needs of the process (Figure 1). In this sense, Raceway Pond Reactors (RPRs), have arisen as an interesting and feasible scaling-up option for treating MWWE, being well-known solar photoreactors based on compound parabolic collectors, CPCs), more suitable for the treatment of bio-recalcitrant industrial wastewaters with high organic load.

Figure 1: Solar photoreactors based on compound parabolic collectors (left) and raceway ponds (right).

References

1. F. Sordello, P. Calza, C. Minero, S. Malato, M. Minella, M. Catalysts, 2022, **12**,1572.
2. G. Maniakova, M.I. Polo López, I. Oller, S. Malato, L. Rizzo, J. Clean. Prod., 2023, **413**,137507.

Vicente de Seabra Medal

The Vicente de Seabra Medal is an award given biannually by the Portuguese Society of Chemistry in honour of the chemist Vicente Coelho de Seabra Silva Teles that aims to reward Portuguese chemists who are distinguished by their scientific work and who are not older than forty years. This award was established in 2002.

Machine learning tools to accelerate the chemical sciences

Tiago Rodrigues

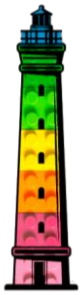
Faculty of Pharmacy, University of Lisbon, Av Prof Gama Pinto 1649-003 Lisbon, Portugal
tiago.rodrigues@ff.ulisboa.pt

Machine learning (ML) is now an established concept in the chemical sciences. In fact, ML tools are routinely used to predict retrosynthetic pathways towards molecules of potential biological interest,[1] de novo design of small molecules,[2] the prediction of drug-target relationships or physicochemical properties,[3] among others. Its informed use allows streamlining early discovery by generating viable research hypotheses and accelerating tasks that are typically time consuming and expensive. In this talk, I will present recent success studies from our group where ML was employed to accelerate chemistry and beyond. In particular, I will focus on tools to optimize chemical reactions,[4,5] identify hidden trends in the nanotechnology literature,[6,7] and discover targets / modes of action for multiple natural products with previously known phenotypic effects.[8] The implications of our discoveries will be discussed.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for funding (CEECIND/00887/2017 and CEECIND/00684/2018).

References

1. M Segler, et al. *Nature* 2018, **555**, 604
2. A Zhavoronkov, et al. *Nat Biotechnol* 2019, **37**, 1038
3. T Rodrigues, et al. *Curr Chem Biol* 2020, **56**, 16
4. D Reker, et al. *Cell Rep Phys Sci* 2020, **1**, 100247
5. F de Almeida, et al. *J Org Chem* 2021, **86**, 14192
6. S Talebian, et al. *ACS Nano* 2021, **15**, 15940
7. A Lorenc et al. *Matter* 2021, **4**, 3078
8. J Conde, et al *ACS Cent Sci* 2021, **7**, 868



Keynote Lectures

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The physics and chemistry of directional freezing: implications in biofabrication and cryobiology

Francisco M. Fernandes

Laboratoire de Chimie de la Matière Condensée de Paris, Sorbonne Université, Paris, France
francisco.fernandes@sorbonne-universite.fr

Freezing is ubiquitous in nature. In oceans, rivers, soils, and in the atmosphere, ice is formed under radically different environmental conditions that depend on hydration, temperature and pressure. In most of these conditions freezing threatens the integrity and the viability of biological entities. Paradoxically, cryopreservation (*i.e.* freezing biological entities under strictly controlled conditions) is the only solution to extend the lifespan of living cells, and to preserve biomolecules. In this lecture we will focus on the interaction between biological matter (from biopolymers up to living mammalian cells) with a controlled freezing front.[1,2]

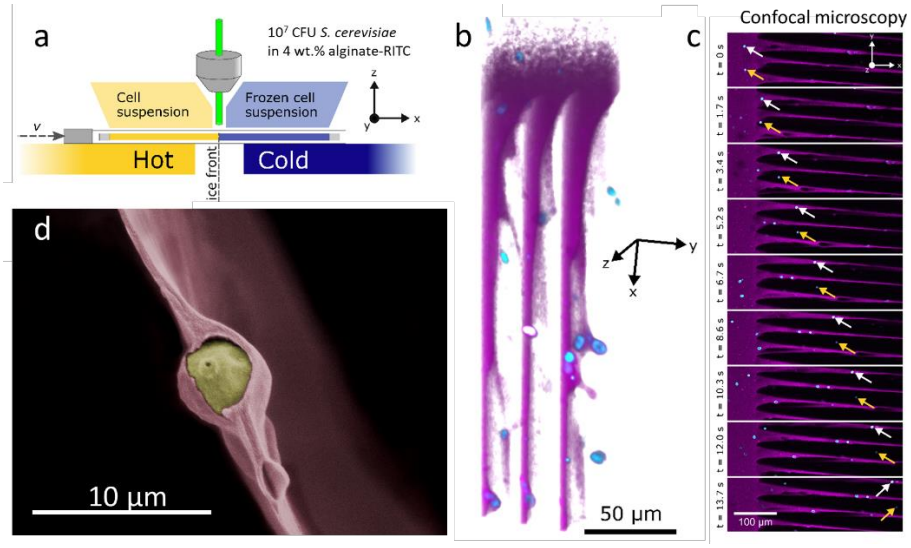


Figure 1: Studying the physicochemical conditions formed during directional freezing of model *S. cerevisiae cells*. a) Cryoconfocal microscopy system setup. b) 3D reconstruction of the freezing front interacting with suspended cells. c) Time-series of the interaction of the freezing front with suspended cells. White arrows point to cells encapsulated in the biopolymer fraction and yellow arrows point to cells directly embedded in ice. d) S. cerevisiae cell encapsulated in polysaccharide matrix.

During freezing, ice growth induces a phase separation between pure ice crystals, and the remaining solutes and suspended particles. These freezing events impose compositional, thermal and osmotic gradients that can be potentially deleterious to the integrity of the constitutive biological entities. Despite their apparent simplicity, these gradients have remained elusive for decades. In this communication, we will discuss some of our recent results in decrypting the evolving physicochemical environment of cells during freezing. Using an original coupling of techniques—spanning from calorimetry, *in situ* cryoconfocal microscopy and SAXS diffraction—we will explore the relevance of directional freezing in the elaboration of living materials from model organisms like yeast[3] and bacteria, as well as in the cryopreservation of mammalian red blood cells[4] in the absence of toxic cryoprotectants.

References

1. Qin, K., Parisi, C. & Fernandes, F. M. Recent advances in ice templating: From biomimetic composites to cell culture scaffolds and tissue engineering. J. Mater. Chem. B **9**, 889–907 (2021).
2. Parisi, C.; Thiébot, B.; Mosser, G.; Trichet, L.; Manivet, P.; Fernandes, F. M. Porous yet Dense Matrices: Using Ice to Shape Collagen 3D Cell Culture Systems with Increased Physiological Relevance. Biomater. Sci. **2022**, 10 (24), 6939–6950.
3. Qin, K. et al. Unveiling Cells' Local Environment during Cryopreservation by Correlative In Situ Spatial and Thermal Analyses. J. Phys. Chem. Lett. **11**, 7730–7738 (2020).
4. Qin et al., in preparation (2023).

Coordination Polymers: From Self-assembly to Functional (Bio)Materials

Alexander Kirillov

Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, Lisboa, Portugal
kirillov@tecnico.ulisboa.pt

To address an increasing antimicrobial resistance, the search for new bioactive molecules and sustainable materials is currently in high demand. This presentation will highlight our recent research on the self-assembly synthesis, crystallization methods, structural features and applications of a wide diversity of functional metal-organic architectures, including bioactive metal-organic frameworks (bioMOFs), coordination polymers (bioCPs) and derived materials with potent antimicrobial, antiviral, and cytotoxic properties.[1–4] The following topics will be discussed.

(A) Self-assembly generation and structural diversity of silver(I) and copper(II) coordination polymers derived from carboxylic acids, aminoalcohols and/or aminophosphines.

(B) Application of these compounds as efficient antimicrobials against different types of Gram-positive and Gram-negative bacteria, bacterial biofilms, and fungi.

(C) Design of bioCP-doped biopolymer films based on soybean oil, potato starch, or cellulose.

(D) Antibacterial and biofilm inhibition activity of the obtained biopolymer films as a function of dopant type and loading, biopolymer matrix, and metal ion release rates.

(E) Antiviral and cytotoxic activity of silver(I) coordination polymers bearing bioactive ligands.

This multidisciplinary study expands antimicrobial and antiviral use of bioactive coordination polymers and hybrid biopolymer materials obtained from renewable and low-cost biofeedstock sources.

Acknowledgements
All the coauthors of the cited references are gratefully acknowledged. Financial support is provided by the FCT (PTDC/QUI-QIN/29697/2017, LA/P/0056/2020, and UIDB/00100/2020; Portugal).

References
1. K. I. Trusau, P. Jorge, A. C. Sousa, T. A. Fernandes, V. André, M. V. Kirillova, A. I. Usevich, N. Cerca and A. M. Kirillov, RSC Sustainability, 2023, **1**, https://doi.org/10.1039/D2SU00150K
2. T. A. Fernandes, I. F. M. Costa, P. Jorge, A. C. Sousa, R. G. Cabral, V. André, N. Cerca and A. M. Kirillov, ACS Appl. Mater. Interfaces, 2022, **14**, 25104.
3. S. W. Jaros, U. K. Komarnicka, A. Kyzioł, B. Pucelik, D. S. Nesterov, A. M. Kirillov and P. Smoleński, J. Med. Chem., 2022, **65**, 11100.
4. T. A. Fernandes, I. F. M. Costa, P. Jorge, A. C. Sousa, V. André, N. Cerca and A. M. Kirillov, ACS Appl. Mater. Interfaces, 2021, **13**, 12836.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Wine industry's untapped goldmine: Unlocking the potential of by-products in the Circular Economy

Ana Novo Barros

Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB)/Institute for Innovation, Capacity Building and Sustainability of Agri-Food Production (Inov4Agro), University of Trás-os-Montes e Alto Douro, Quinta de Prados, 5000-801 Vila Real, Portugal.
** abarros@utad.pt*

The emergence of antibiotic resistance poses a significant global health challenge, requiring the exploration of alternative solutions. The wine industry, known for its production of fine wines, also generates substantial quantities of by-products during the winemaking process. These by-products, such as grape pomace, grape seeds, grape stems and grape skins, have the potential to serve as a valuable resource in combating antibiotic resistance within the framework of the circular economy. This communication checks the concept of the circular economy and highlights the unexplored potential of these wine industry by-products in addressing antibiotic resistance. These by-products contain bioactive compounds with antimicrobial properties, including phenolic compounds and other phytochemicals. Harnessing the antimicrobial potential of these by-products can contribute to the development of natural antimicrobial agents or as adjuncts to conventional antibiotics, offering a novel approach to combat antibiotic resistance. Moreover, offer extracts rich in bioactive compounds, which have demonstrated antimicrobial activity against several pathogens, including some of the most resistant bacteria for example against foot wound healing related to diabetes. Integrating these by-products into the circular economy can foster the development of sustainable and eco-friendly antimicrobial solutions. By adopting circular economy principles, the wine industry can transform these by-products into valuable resources, thereby reducing waste and promoting resource efficiency. This communication underscores the importance of recognizing the wine industry's by-products as a goldmine for fighting antibiotic resistance, highlighting the potential for innovation and sustainable practices in the field of antimicrobial research.

Acknowledgements
The author thanks the Fundação para a Ciência e a Tecnologia and Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB) research unit, grant number UIDB/04033/2020.

Manipulation of Organic Molecules by Infrared Vibrational Excitation

Cláudio M. Nunes

University of Coimbra, CQC-IMS, Department of Chemistry, 3004-535 Coimbra, Portugal
cmnunes@qui.uc.pt

Infrared vibrational excitation is a promising approach to achieve controlled manipulation of organic molecules, in ways that cannot be attained via thermal or electronic excitation. Using narrowband near-IR light, one can selectively deposit energy in a vibrational state of a molecular target. In this way, the possibility of selectively manipulate a chosen type of molecules in a complex mixture, including the manipulation of specific conformations existing in particular environments, has been demonstrated in conjugation with the matrix-isolation technique (sample trapped in a solidified noble-gas at ~10 K). This approach has been used to induce conformational isomerizations of different molecular fragments, such as −OH, −SH, −OMe, −CHO and $-CH_2OH$.[1,2]

In recent breakthrough investigations, we have shown that besides conformation isomerizations, molecular reactions involving bond-breaking and bond-forming can also be activated by infrared vibrational excitation under matrix-isolation conditions. Here, we will highlight such pioneer results, which comprise: the activation of a H-shift tunneling reaction;[3] the bidirectional activation of a thione-enol ↔ thiol-keto tautomerization (Figure 1);[4,5] and the activation of an electrocyclic ring-expansion by excitation of a remote vibrational antenna.[6,7]

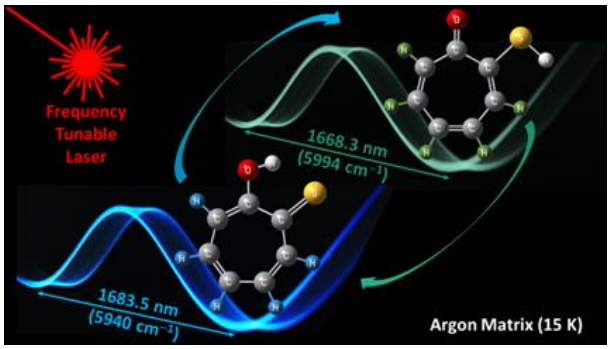


Figure 1: Bidirectional thione-enol ↔ thiol-keto tautomerization of thiotropolone induced by selective near-IR irradiation at the frequency of the 2□(CH) modes.

Acknowledgements
This work was supported by Projects POCI-01-0145-FEDER-028973 and PTDC/QUI-QFI/1880/2020, funded by National Funds via the Portuguese Foundation for Science and Technology (FCT), the first being also funded by FEDER, via Portugal 2020-POCI. The Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS) is supported by FCT through projects UIDB/00313/2020 and UIDP/00313/2020 (National Funds) and the IMS special complementary funds provided by FCT. C.M.N. acknowledges FCT for an Auxiliary Researcher grant.

References

1. R. Fausto, G. O. Ildiz, C. M. Nunes, *Chem. Soc. Rev.*, **2022**, *51*, 2853–2872.
2. C. M. Nunes, I. Reva, R. Fausto, *Phys. Chem. Chem. Phys.*, **2019**, *21*, 24993–25001.
3. J. P. L. Roque, C. M. Nunes, L. P. Viegas, N. A. M. Pereira, T. M. V. D. Pinho e Melo, P. R. Schreiner, R. Fausto, *J. Am. Chem. Soc.*, **2021**, *143*, 8266–8271.
4. C. M. Nunes, N. A. M. Pereira, I. Reva, P. S. M. Amado, M. L. S. Cristiano, R. Fausto, *J. Phys. Chem. Lett.*, **2020**, *11*, 8034–8039.
5. N. A. M. Pereira, C. M. Nunes, I. Reva, R. Fausto, *J. Phys. Chem. A*, **2021**, *125*, 6394−6403.
6. C. M. Nunes, N. A. M. Pereira, Luís P. Viegas, T. M. V. D. Pinho e Melo, R. Fausto, *Chem. Commun.*, **2021**, *57*, 9570–9573.
7. C. M. Nunes, S. Doddipatla, G. F. Loureiro, J. P. L. Roque, N. A. M. Pereira, T. M. V. D. Pinho e Melo, R. Fausto, *Chem. Eur. J.*, **2022**, e202202306.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Photoresponsive Host-Guest Systems with Potential Biological Applications

Nuno Basílio

Laboratório Associado para a Química Verde (LAQV), Rede de Química e Tecnologia (REQUIMTE), Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
nuno.basilio@fct.unl.pt

Host-guest pairs offer appealing noncovalent binding motifs for the construction of sophisticated supramolecular systems, molecular machines, and self-assembled materials. During the last years, our group has been interested in the design and development of water-soluble photoresponsive host-guest binding pairs foreseeing possible biological applications.[1–6] We focus on photochromic/photocaged guest molecules and macrocyclic receptors to assemble high-affinity hosts-guest systems that respond to light stimulus. In this communication, I will highlight some of our recent work to illustrate how properly designed guest molecules can be explored to achieve control over the host-guest structures, binding affinities, and stoichiometries and how these systems can be explored to control the encapsulation, release, and transport of functional molecules such as drugs, fragrances, peptides, etc.

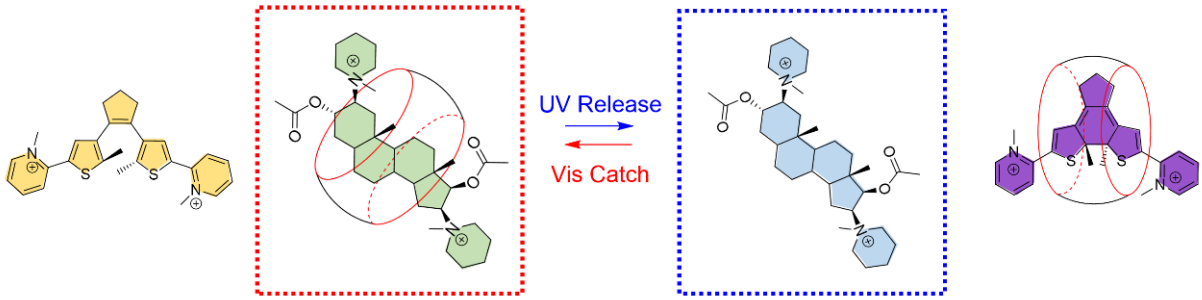


Figure 1: Light-controlled binding and release of a steroidal drug from a cucurbituril receptor using a DTE as a competitor with photocontrolled affinity.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry - LAQV (projects UIDB/50006/2020 and UIDP/50006/2020), which is financed by national funds from FCT/MCTES. FCT/MCTES is also acknowledged for the projects PTDC/QUI-COL/32351/2017, 2022.02538.PTDC and CEECIND/00466/2017.

References

1. J. N. Martins, B. Raimundo, A. Rioboo, Y. Folgar-cameán, J. Montenegro and N. Basílio, *J. Am. Chem. Soc.* 2023, DOI:10.1021/jacs.3c01829
2. P. Máximo, M. Colaço, S. R. Pauleta, P. J. Costa, U. Pischel, A. J. Parola and N. Basílio, *Org. Chem. Front.*, 2022, **9**, 4238–4249.
3. M. Paulino, I. Pérez-Juste, M. M. Cid, J. P. Da Silva, M. M. A. Pereira and N. Basílio, *J. Org. Chem.*, 2022, **87**, 14422–14432.
4. R. J. Fernandes, P. Remón, A. J. Moro, A. Seco, A. S. D. Ferreira, U. Pischel and N. Basílio, *J. Org. Chem.*, 2021, **86**, 8472–8478.
5. M. Colaço, P. Máximo, A. Jorge Parola and N. Basílio, *Chem. – A Eur. J.*, 2021, **27**, 9550–9555.
6. A. Seco, S. Yu, A. Tron, N. D. McClenaghan, F. Pina, A. Jorge Parola and N. Basílio, *Chem. – A Eur. J.*, 2021, **27**, 16512–16522.

Semifluorinated Soft-Matter

Eduardo J. M. Filipe

Centro de Química Estrutural, Institute of Molecular Sciences, Instituto Superior Técnico, Universidade Lisboa, 1049-001 Lisboa, Portugal
efilipe@tecnico.ulisboa.pt

Since the synthesis of polytetrafluoroethylene (PTFE) in 1938, perfluorinated compounds have become key fluids in a number of applications. Due to their chemical inertness, biocompatibility and particular physical properties these substances are present in many everyday products. Some of their most significant applications involve perfluorinated surfactants and processes at interfaces in which they are used mixed with hydrogenated substances and water. New exciting potential applications include liquid ventilation formulations and oxygen carriers in blood substitutes.

Surprisingly, perfluorinated chains are not only highly hydrophobic but also lyophobic, i.e. they segregate hydrogenated chains. This leads to large deviations to ideal behaviour, liquid–liquid immiscibility, large positive excess properties, as well as large anomalies in surface, transport and conformational properties. Ultimately, the mutual phobicity between hydrogenated and fluorinated chains, is responsible for the formation of nano-domains and opens the door to new levels of supramolecular organization.

In recent years we have investigated the bulk and interfacial behavior of mixtures of perfluorinated and hydrogenated substances. Examples include liquid crystalline phases, mixed hydrogenated and fluorinated micellar systems, hemi-micelles of semifluorinated alkanes at the surface of water and nano-segregated domains in ionic liquids. Different experimental techniques were used combined with molecular dynamics simulations and theoretical approaches. The investigated systems display a number of unusual phenomena such as aneotropes (minima in the surface tension vs composition curves) and the formation of nano-patterned films. The ultimate aim is to understand, and thus control, how the simultaneous presence of mutually phobic hydrogenated and perfluorinated chains induces organization.

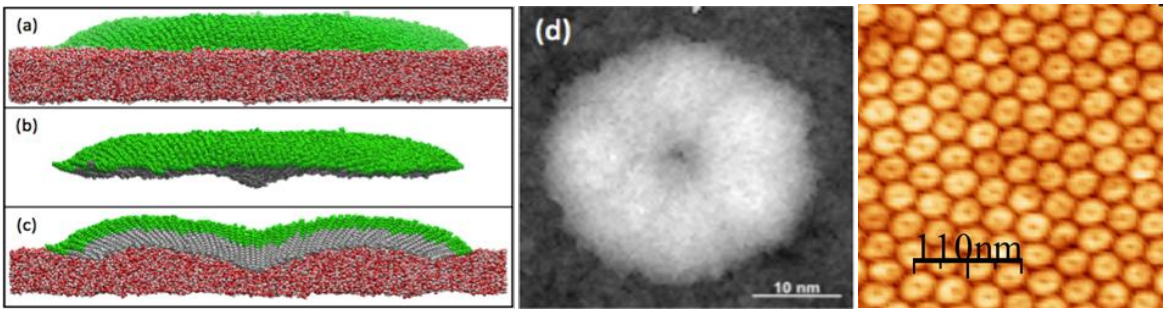


Figure 1. Simulated hemimicelle of F8H16 at the surface of water: (a) side view; (b) side view with water molecules erased; (c) cross-section displaying the internal structure; (d) top-view topography (AFM-like) image.[1]; (e) experimental AFM image of an array of F8H16 hemimicelles spin-coated on a silicon wafer.[2]

References

1. G.M.C. Silva, P. Morgado, P. Lourenço, M. Goldmann, E.J.M. Filipe, *PNAS*, 116, **2019**, 14868.
2. L. Bardin, M.-C. Fauré, E. J. M. Filipe, P. Fontaine, M. Goldmann, *Thin Solid Films* 2010, **519**, 414-416.

Engineering of silk-based materials: a quest for eco-sustainable resources

Rui F. P. Pereira

Chemistry Center and Chemistry Department, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal
rpereira@quimica.uminho.pt

Nature is the prime source to get inspiration to design renewable multifunctional sophisticated materials and one solution to tackle World's concerns with environmental and energy issues. Among the myriad of ubiquitous natural, renewable, and biodegradable polymers, proteins play a central role. Silk fiber is a natural protein, consisting of fibroin and sericin, that can be spun by several arthropods.[1] Silk fibroin (SF), the core protein of silk fiber, plays a significant role in our society, where hundred billions of euros are spent annually on silk products (2021 global market: 14.1 billion dollars; projected growth of 8.2% for the coming decade).[2] Silk is typically applied in the biomedical field but, in the last years, its application has expanded to several areas like optics, electronics or food.[3,4]

The incorporation of silk in the design of high-tech devices provides significant advantages with respect to traditional materials, including an enhanced eco-friendly label, reliability, and improved safety. Exciting new applications have been proposed in the field of energy,[4,5] with our contribution to the first ever incorporation of SF as solid polymer electrolyte in electrochromic devices and batteries.[6-10]

This talk will show the multifaceted potential of some eco-sustainable silk-based materials produced recently, going from green SF-based polymer electrolytes with outstanding filmogenic properties, very high transparency, and suitable adhesion to glass; to separators for lithium ion batteries with good electrochemical performance and self-extinguishing ability. The relevance of very recent sun-actuated thermotropic devices incorporating active SF-based films doped with an innovative ionanofluid composed of silk-derived carbon dots and ionic liquids will be also emphasized.[11]

The present bio-inspired approach can open exciting new avenues in materials research, highlighting the potential of natural proteins in high-tech devices.

Acknowledgements
Fundação para a Ciência e a Tecnologia, I.P. is acknowledged in the scope of the project SOLPOWINS-Solar-Powered Smart Windows for Sustainable Buildings (PTDC/CTM/4304/2020), and strategic projets UID/QUI/00686/2018, UID/QUI/00686/2020, UIDB/00616/2020 and UIDP/00616/2020. R.F.P.P. acknowledges FCT-UMinho for his contract in the scope of Decreto-Lei 57/2016 57/2017.

References

1. R. F. P. Pereira, M. M. Silva, V. de Zea Bermudez, *Macromol. Mater. Eng.*, 2015, **300**, 1171-1198.
2. B. Supriya and V. Vitika, Global Opportunity Analysis and Industry Forecast 2021-2031, Report A02161, 2022.
3. G. Guidetti, L. d'Amone, T. Kim, G. Matzeu, L. Mogas-Soldevila, B. Napier, N. Ostrovsky-Snider, J. Roshko, E. Ruggeri, F. G. Omenetto, Appl. Phys. Rev., 2022, **9**, 011302.
4. D.-L. Wen, D.-H. Sun, P. Huang, W. Huang, M. Su, Y. Wang, M.-D. Han, B. Kim, J. Brugger, H.-X. Zhang, X.-S. Zhang, Microsyst. Nanoeng., 2021, **7**, 35.
5. S. Strassburg, S. Zainuddin, T. Scheibel, Adv. Energy Mater., 2021, **11**, 2100519.
6. R. F. P. Pereira, R. Brito-Pereira, R. Gonçalves, M. P. Silva, C. M. Costa, M. M. Silva, V. de Zea Bermudez, S. Lanceros-Méndez, *ACS Appl. Mater. Interfaces*, 2018, **10**, 5385-5394
7. R. F. P. Pereira, R. Gonçalves, M. Fernandes, C. M. Costa, M. M. Silva, V. de Zea Bermudez, S. Lanceros-Mendez, *Adv. Sustainable Syst.*, 2018, **2**, 1800098.
8. T. C. D. Fernandes, H. M. R. Rodrigues, F. A. A. Paz, J. F. M. Sousa, A. J. M. Valente, M. M. Silva, V. de Zea Bermudez, R. F. P. Pereira, *J. Electrochem. Soc.*, 2020, **167**, 070551.
9. R. F. P. Pereira, R. Gonçalves, H. M. R. Gonçalves, D. M. Correia, C. M. Costa, M. M. Silva, S. Lanceros-Méndez, V. de Zea Bermudez, *Mater. Today Sustain.*, 2020, **9**, 100041.
10. R. F. P. Pereira, F. Sentanin, A. Pawlicka, M. C. Gonçalves, M. M. Silva, V. de Zea Bermudez, *ChemElectroChem*, 2016, **3**, 1084-1097.
11. T. A. G. Duarte, R. F. P. Pereira, B. Medronho, E. S. Maltseva, E. F. Krivoshapkina, A. Varela-Dopico, P. Taboada, L. Fu, R. A. S. Ferreira, V. de Zea Bermudez, submitted.

Exploring the use of metals and metallic salts in the synthesis of flavonoids

Raquel Soengas

Department of Organic and Inorganic Chemistry, University of Oviedo, Julián Clavería 7, 33006 Oviedo, Spain
rsoengas@uniovi.es

Flavonoids are natural products of the benzopyran class constituting an important group of oxygenated heterocycles, ubiquitously present in fruits and vegetables. Flavones exhibit a great diversity of biological activities due to their unique ability to modulate various enzyme systems standing out their antioxidant, anti-inflammatory, antitumoral and antibiotic properties. Moreover, flavonoids were recently investigated as anti-coronaviral agents, emerging as promising inhibitors of SARS-CoV-2. Due to their interest for the development of chemotherapeutical agents, flavonoids are relevant targets in Organic Synthesis.

Metals have a central role in Organic Chemistry and are used as reagents and catalysts in a wide range of processes. Nowadays, metals are used in almost every synthetic route towards natural products and compounds of pharmaceutical relevance and the synthesis of flavonoids is not an exception.

Our research group has long been devoted to the development of new synthetic procedures based on the use of metals and metallic salts and their application to the synthesis of flavonoid derivatives. Here I will present some contributions of our group in the metal-based synthesis of flavonoids, from our first steps in this field to our most recent adventures.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Theoretical insight into hole-transporting materials for perovskite solar cells

Enrique Orti*, J. Cerdá, J. Calbo, J. Aragó

Instituto de Ciencia Molecular (ICMol), Universidad de Valencia, c/ Catedrático José Beltrán, 2, 46980 Paterna (Valencia), Spain
**Enrique.orti@uv.es*

Hole-transporting materials (HTMs) are a crucial component in obtaining high power conversion efficiencies (PCEs) in perovskite-based solar cells (PSCs). They play the important roles of extracting the photogenerated holes, formed within the perovskite film, and transporting them to the electrodes. Among the wide number of chemical structures proposed as HTMs for PSCs, small organic molecules have received special attention with spiro-OMeTAD (2,2´,7,7´-tetrakis(*N*,*N*-di-*p*-methoxyphenylamine)-9,9´-spirobifluorene) as a reference.[1] In this communication, we first focus on how the donor ability and hole reorganization energy change with the chemical structure of the HTM. π-Extended, sulfur-rich compounds, such as the anthracene-tetrathiophene ATT-OMe system displayed in Figure 1a, that have been used as HTMs in PSCs achieving remarkable PCEs, are theoretically described.[2] Second, we investigate a series of HTMs based on fused polyheteroaromatic molecules incorporating 7-azaindole terminal moieties bearing hydrogen-bond donor and hydrogen-bond acceptor sites (Figure 1b). The 7-azaindole units induce the hydrogen-bond self-assembly of the conjugated molecules thus increasing the supramolecular ordering in the HTM layer. The effects of this ordering on the charrier transport in the HTM semiconducting layer are theoretically discussed.[3] Third, we briefly present how the optical properties (energy bandgap) of $Cs_2AgBiBr_6$ lead-free double perovskites can be tuned by substituting the monovalent Ag^{1+} and trivalent Bi^{3+} cations by divalent Sn^{2+}, Ge^{2+} and Zn^{2+} cations.[4]

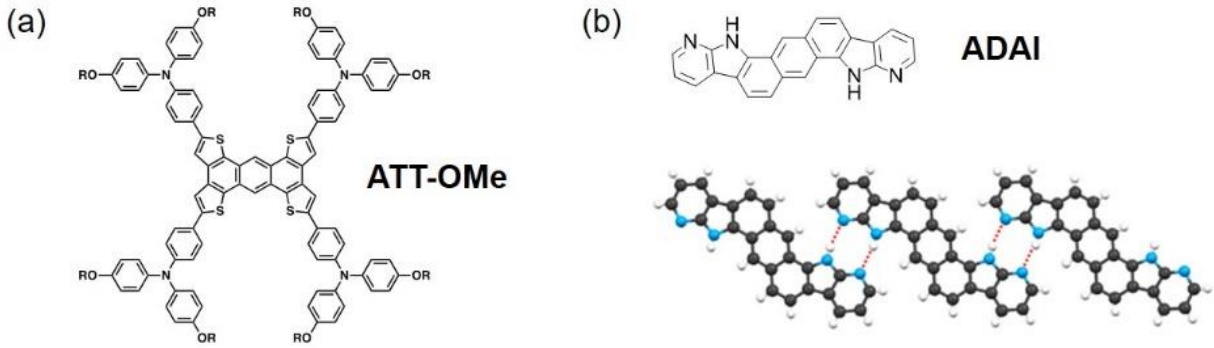


Figure 1. Chemical structure of the sulfur-rich ATT-OMe (a) and the H-bond-promoting ADAI (b) HTM molecules. Both HTMs are based on an anthracene central core.

Acknowledgements
Authors acknowledge support from the Ministry of Science and Innovation (MCIN) and the Spanish State Research Agency (AEI) (projects PID2021-128569NB-I00 and TED2021-131255B-C44 funded both by MCIN/AEI/10.13039/501100011033 and by "ERDF A way of making Europe" and European Union NextGenerationEU/PRTR, respectively).

References

1. J. Urieta, I. García-Benito, A. Molina-Ontoria and N. Martín, *Chem. Soc. Rev.*, 2016, **47**, 8541.
2. I. Zimmermann, J. Urieta-Mora, P. Gratia, J. Aragó, G. Grancini, A. Molina-Ontoria, E. Ortí, N. Martín and M. K. Nazeeruddin, *ACS Appl. Mater. Interfac.*, 2017, **7**, 1601674.
3. P. Gómez, S. Georgakopoulos, M. Más-Montoya, J. Cerdá, J. Pérez, E. Ortí, J. Aragó and D. Curiel, *J. Mater. Chem. C*, 2021, **13**, 8620.
4. P. Sebastiá-Luna, J. Calbo, N. Albiach-Sebastián, M. Sessolo, F. Palazón, E. Ortí and H. J. Bolink, *Chem. Mater.*, 2021, **33**, 8028.

Computing your way out of experimental problems, from nanocarbon to covalent organic frameworks and beyond

Manuel Melle-Franco

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
manuelmelle@ua.pt

Computer modelling has become a key feature in understanding experimental problems in current molecular and materials science. From our experience, applying and developing computational models, we will discuss available computer models and how these may be used to yield key information on real-world problems. This will be illustrated in a non-technical way with selected examples from our research, from the mechanism of formation and the structure elucidation of complex Covalent Organic Frameworks (COFs), [1-3] to record length and chiral monodisperse nanographenes, [4-5] novel doped carbon nanomaterials[6] and bio/inorganic composites. [7-8]

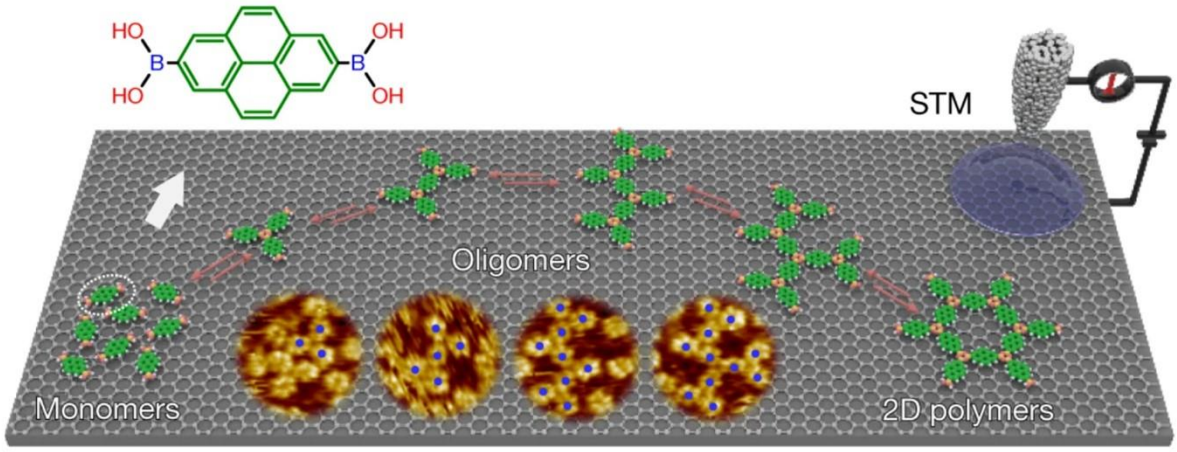


Figure 1: Real-time observation of 2D dynamic covalent polymerization. [1]

Acknowledgements
Support through the project IF/00894/2015 and within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC) together with the FantastiCOF (ref.101046231), EPROT (ref: 964593) and 2D-INK (ref. 664878) projects funded within the FET-Open and Pathfinder European programs is gratefully acknowledged.

References

1. G. Zhan, Z.-F. Cai, K. Strutyński, L. Yu, N. Herrmann, M. Martínez-Abadía, M. Melle-Franco, A. Mateo-Alonso and S. D. Feyter, *Nature*, 2022, **603**, 835–840.
2. E. De Bolòs, M. Martínez-Abadía, F. Hernández-Culebras, A. Haymaker, K. Swain, K. Strutyński, B. L. Weare, J. Castells-Gil, N. M. Padial, C. Martí-Gastaldo, A. N. Khlobystov, A. Saeki, M. Melle-Franco, B. L. Nannenga and A. Mateo-Alonso, *J. Am. Chem. Soc.*, 2022, 144, 15443–15450.
3. M. Martínez-Abadía, K. Strutyński, B. Lerma-Berlanga, C. T. Stoppiello, A. N. Khlobystov, C. Martí-Gastaldo, A. Saeki, M. Melle-Franco and A. Mateo-Alonso, Angewandte Chemie International Edition, 2021, 60, 9941–9946.
4. R. K. Dubey, M. Melle-Franco and A. Mateo-Alonso, *J. Am. Chem. Soc.*, 2022, 144, 2765–2774.
5. F. Hernández-Culebras, M. Melle-Franco and A. Mateo-Alonso, *Angewandte Chemie International Edition*, 2022, 61, e202205018.
6. M. E. Pérez-Ojeda, E. Castro, C. Kröckel, M. A. Lucherelli, U. Ludacka, J. Kotakoski, K. Werbach, H. Peterlik, M. Melle-Franco, J. C. Chacón-Torres, F. Hauke, L. Echegoyen, A. Hirsch and G. Abellán, *J. Am. Chem. Soc.*, 2021, 143, 18997–19007.
7. P. M. Martins, C. G. Ferreira, A. R. Silva, B. Magalhães, M. M. Alves, L. Pereira, P. A. A. P. Marques, M. Melle-Franco and S. Lanceros-Méndez, *Composites Part B: Engineering*, 2018, 145, 39–46.
8. D. Iglesias, M. Melle-Franco, M. Kurbasic, M. Melchionna, M. Abrami, M. Grassi, M. Prato and S. Marchesan, *ACS Nano*, 2018, 12, 5530–5538.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Metalloprotein chaperones: Regulating protein aggregation and metal ion dyshomeostasis in Alzheimer's disease

Cláudio M. Gomes

BioISI – Instituto de Biosistemas e Ciências Integrativas, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
www.folding.fc.ul.pf; cmgomes@fc.ul.pt

Protein aggregation and metal ion dyshomeostasis play crucial roles in Alzheimer's disease (AD) pathogenesis. The aggregation of amyloid-β (Aβ) and tau proteins occurs during prodromal stages, leading to increased proteostasis burden throughout the disease progression.[1] While Aβ aggregates primarily in the extracellular space, tau is promptly secreted and spreads pathology to nearby cells in the form of toxic oligomers. Thus, understanding the involvement of intra and extracellular proteostasis modulators is essential for unravelling molecular events in the diseased brain.

In this keynote seminar, I will present insights from my laboratory regarding the influence and regulation of protein misfolding, aggregation, and liquid-liquid phase separation phenomena in neurodegeneration and AD. I will begin by discussing recent findings that highlight the neuroprotective functions of Ca^{2+}-binding proteins from the S100 family as intra and extracellular chaperones.[2] We have observed the co-localization of S100 proteins with Aβ aggregates in animal models[3] and, combining biophysical, kinetic, and cellular methods, demonstrated a Ca^{2+}-binding dependent inhibitory effect of S100B as a chaperone on the aggregation, toxicity, and proteopathic seeding of both Aβ42 and tau.[4-7] Furthermore, we have just discovered the modulation of Tau liquid-liquid phase separation by the S100B chaperone, reversing tau demixing within droplets.[8]

Additionally, I will present findings that connect S100 proteins to the regulation of metal ion homeostasis and protein aggregation.[9] Certain S100 proteins, including S100B, possess a Zn/Cu binding site at the dimer interface, influencing protein folding and function. Our studies using primary neuron cultures have revealed that Zn^{2+} binding to S100B regulates trace metal homeostasis and protects against excitotoxicity in the brain.[10] Furthermore, we have demonstrated the dual-function chaperone role of S100B, inhibiting Aβ oligomerization through Zn^{2+} chelation and protein aggregation inhibition.[11] Moreover, the binding of Cu^{2+} to S100B leads to the formation of disulfide cross-linked S100B linear oligomers, exhibiting enhanced anti-aggregation activity.[12] These findings illustrate the chemical control of chaperone function, showcasing a regulatory process that becomes relevant under conditions of metal and proteostasis dysfunction, such as in AD neurodegeneration.

Acknowledgments
Collaborators, research team and funders are gratefully acknowledged. Funded by FCT/MCTES (BioISI) and by the European Union (TWIN2PIPSA, GA 101079147).

References

1. Knopman et al (2021) Nat Rev Dis Primers. https://doi.org/10.1038/s41572-021-00269-y
2. Cristóvão et al (2019) Front. Neurosci. https://doi.org/10.3389/fnins.2019.00463
3. Hagmeyer et al (2019) Front. Neurosci. https://doi.org/10.3389/fnins.2019.00640
4. Cristóvão et al (2018) Sci. Adv. https://doi.org/10.1126/sciadv.aaq1702
5. Moreira et al (2021) Nature Comm. https://10.1038/s41467-021-26584-2
6. Figueira et al (2022) J. Mol. Biol. https://doi.org/10.1016/j.jmb.2022.167791
7. Figueira et al (2023) Front. Neurosci. http://dx.doi.org/10.3389/fnins.2023.1162741
8. Moreira & Gomes (2023) J. Neurochem. https://doi.org/10.1111/jnc.15756
9. Leal et al (2012) Coord. Chem. Rev. https://doi.org/10.1016/j.ccr.2012.04.004
10. Hagmeyer et al (2018) Front. Mol. Neurosci. https://doi.org/10.3389/fnmol.2017.00456
11. Cristóvão et al (2020) ACS Chem. Neurosci. https://doi.org/10.1021/acschemneuro.0c00392
12. Cristóvão et al (2019) Chem. Comm. https://doi.org/10.1039/d0cc06842j

Insights on the design of highly stable noble metal-free carbon electrocatalysts for oxygen reduction reaction

Rui S. Ribeiro

LSRE-LCM - Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
rsribeiro@fe.up.pt

Oxygen reduction reaction (ORR) is the most challenging within those occurring during fuel cells' operation. The elementary electrochemical reaction of O_2 dissociation during ORR is very challenging due to the extremely strong O ═ O bond. Therefore, fuel cells need suitable electrocatalysts to operate efficiently. These have been traditionally based on noble metals – mostly platinum. The widespread use of fuel cell technology has thus been hindered by both the scarcity and high cost of these precious metals. Accordingly, our research focus has been directed to the development of alternatives to the use of noble metals through the development of carbon-based electrocatalysts.

Cost-effective and sustainable carbon electrocatalysts are based mostly on transition metals such as iron. Among these, single-atom electrocatalysts were shown to provide greater availability of active sites with higher reactivity compared to traditional supported catalysts. Nevertheless, designing a synthesis approach to overcome the typical lack of stability of single-atom catalysts (*e.g.*, due to aggregation and/or sintering) remains a main challenge in the field. This communication reports the main findings obtained in this quest, focusing on our contribution to advancing the design of highly stable carbon-based electrocatalysts for ORR through precise surface tuning with Fe-N active sites by employing only earth-abundant metal precursors.

Acknowledgements
This work was financially supported by project BiCat4Energy (PTDC/EQU-EQU/1707/2020), funded by national funds (PIDDAC) through FCT/MCTES; LA/P/0045/2020 (ALiCE), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM) funded by national funds through FCT/MCTES (PIDDAC). RSR acknowledges the Fulbright Grant for Professors and Researchers with PhD awarded by Fulbright Commission Portugal and FCT funding under Stimulus of Scientific Employment, Individual Support Call (CEEC IND) 5th Edition (2022.04079.CEECIND).

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The whereabouts of iron in the human body: insights from blood serum chemistry

André M. N. Silva

LAQV-REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, s/n, Porto, Portugal; LAQV-REQUIMTE, Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Rua Jorge Viterbo, n228, Porto, Portugal
andre.silva@fc.up.pt

Iron is essential for life, and therefore an indispensable micronutrient for human health, participating in crucial physiological processes such as oxygen transport, mitochondrial respiration, and DNA synthesis. Iron has been selected by evolution due to its high abundance in the Earth crust and the variability of redox potentials of iron proteins, which can be fine-tuned with the right choice of ligands. However, with the advent of oxygen in the Earth atmosphere, the same physicochemical properties which render iron essential for the most fundamental life processes underline its toxicity.

A healthy human being has *ca*. 4 g of iron, the largest part of it bound to hemoglobin and myoglobin or stored in the liver. However, the fate of iron between its place of absorption in the duodenum and the place of utilization or storage is determined by a tiny fraction (~3 mg) circulating in the blood serum. In healthy individuals, virtually all the serum iron is bound to transferrin (Tf), the systemic iron transport protein[1]. Binding to Tf warrants solubility, prevents redox toxicity, and ensures controlled cellular uptake. But, in several human conditions such as hemochromatosis, diabetes mellitus, hemolytic anemias, renal disease, and anemia when treated with iron supplementation, non-transferrin-bound iron (NTBI) occurs[2]. NTBI has been regarded as the main driver of iron toxicity, promoting oxidative stress, tissue iron accumulation, dysmetabolism[3], vasculo-toxicity[4] and atherosclerosis[5].

Research, over the last few decades, led to a great increase in our understanding of the biochemical pathways that regulate iron absorption and cellular utilization. But, ironically, the reasons for the occurrence of NTBI and the chemical nature of these iron species remains elusive and prevents its application as a useful biomarker in clinical practice. The answer may lay in the chemical modifications occurring to serum proteins resulting from reactions with oxygen, glucose or reactive aldehydes [6-8]. The current understanding of iron species in the human blood serum and how chemical modifications of serum proteins contribute to iron toxicity will be discussed.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for providing financial support through the project 2022.06328.PTDC and unit UIDB/50006/2020|UIDP/50006/2020.

References

1. A. M. N. Silva, T. Moniz, B. de Castro and M. Rangel, *Coordination Chemistry Reviews*, 2021, **449**, 214186.
2. A. M. N. Silva and M. Rangel, *Molecules*, 2022, **27**.
3. N. Wlazlo, M. M. van Greevenbroek, I. Ferreira, E. H. Jansen, E. J. Feskens, C. J. van der Kallen, C. G. Schalkwijk, B. Bravenboer and C. D. Stehouwer, *Acta diabetologica*, 2015, **52**, 337-348.
4. F. Vinchi, R. Sparla, S. T. Passos, R. Sharma, S. Z. Vance, H. S. Zreid, H. Juaidi, D. Manwani, K. Yazdanbakhsh, V. Nandi, A. M. N. Silva, A. R. Agarvas, E. Fibach, J. D. Belcher, G. M. Vercellotti, H. Ghoti and M. U. Muckenthaler, *British journal of haematology*, 2021, **193**, 637-658.
5. F. Vinchi, G. Porto, A. Simmelbauer, S. Altamura, S. T. Passos, M. Garbowski, A. M. N. Silva, S. Spaich, S. E. Seide, R. Sparla, M. W. Hentze and M. U. Muckenthaler, *Eur Heart J*, 2020, **41**, 2681-2695.
6. A. M. Silva and R. C. Hider, *Biochimica et biophysica acta*, 2009, **1794**, 1449-1458.
7. A. M. Silva, P. R. Sousa, J. T. Coimbra, N. F. Bras, R. Vitorino, P. A. Fernandes, M. J. Ramos, M. Rangel and P. Domingues, *The Biochemical journal*, 2014, **461**, 33-42.
8. A. M. N. Silva, J. T. S. Coimbra, M. M. Castro, Â. Oliveira, N. F. Brás, P. A. Fernandes, M. J. Ramos and M. Rangel, *J Inorg Biochem*, 2018, **186**, 95-102.

Near infrared light absorbing nanomaterials for cancer photothermal therapy

Ilídio J. Correia

CICS-UBI – Centro de Investigação em Ciências da Saúde, Universidade da Beira Interior, 6200-506 Covilhã, Portugal; CIEPQPF – Departamento de Engenharia Química, Universidade de Coimbra, 3030-790 Coimbra, Portugal
icorreia@ubi.pt

Cancer remains as one of the most prevalent diseases affecting the worldwide population. Surgery remains the cornerstone of cancer treatment, with the goal of complete resection. Chemotherapy, radiotherapy, endocrine therapy, targeted therapy, immunotherapy and recently developed neoadjuvant therapy also play a crucial role in the comprehensive management of cancer. These therapies still face significant challenges including limited efficacy, drug resistance, and detrimental side effects. Recent advancements in the area of materials science and nanotechnology have positioned photothermal therapy (PTT) as a promising non-invasive treatment strategy for cancer. PTT relies on the conversion of light energy into heat, which can induce the direct eradication of tumor cells as well as alterations to the tumor microenvironment that impact on tumor progression. Due to the fact that Near infrared (NIR) radiation is within the so-called biological transparency window, i.e. its interaction with endogenous components (e.g. hemoglobin, melanin or water) is minimal, NIR absorbing nanomaterials have been widely explored for cancer PTT.

This process is facilitated by photothermal agents, such as gold-based nanostructures (e.g., gold nanorods, nanoshells, and nanocages), carbon-based nanomaterials (e.g., carbon nanotubes and graphene oxide), magnetic nanoparticles and semiconducting polymer based nanoparticles.[1]

Gold nanoparticles exhibit unique optical properties due to the phenomenon known as surface plasmon resonance (SPR). [2] This property facilitates the immediate destruction of tumor cells while minimizing damage to surrounding tissues. However, gold nanoparticles have also some limitations, namely melting, colloidal stability and a limited half-life in the blood. These drawbacks of gold nanoparticles can be overcome by performing their coating with a mesoporous silica shell or through its combination with polymer functionalization.[3]

Graphene oxide nanomaterials, due to their intrinsic capacity to absorb NIR light, have also been explored for cancer PTT.[4] The photothermal capacity of these nanomaterials has been enhanced through chemical reduction.[5] Nevertheless, as synthesized graphene-based nanomaterials display a suboptimal biological compatibility and colloidal stability.[4] These limitations have been surpassed mostly by performing their functionalization with amphiphilic molecules.[4, 6]

Recently, NIR absorbing materials have been loaded into macroscale delivery systems, such as injectable hydrogels, with the aim to perform their tumor confined delivery, and thus surpass the constraints associated with the systemic administration of nanomaterials.[7, 8]

Acknowledgements
The funding from the projects/grants UIDB/00709/2020, UIDP/00709/2020, PTDC/BTABTA/0696/2020 and 2022.06320.PTDC is acknowledged.

References

1. W. Wei, X. Zhang, S. Zhang, G. Wei and Z. Su, *Materials Science and Engineering: C*, 2019, **104**, 109891.
2. C. F Rodrigues, N. Fernandes, D. de Melo-Diogo, P. Ferreira, I. J Correia and A. F Moreira, *Nanomedicine*, 2021, **16**, 2569-2586.
3. N. Fernandes, C. F. Rodrigues, D. de Melo-Diogo, I. J. Correia and A. F. Moreira, *Nanomaterials*, 2021, **11**, 1946.
4. D. de Melo-Diogo, R. Lima-Sousa, C. G. Alves, E. C. Costa, R. O. Louro and I. J. Correia, *Colloids and Surfaces B: Biointerfaces*, 2018, **171**, 260-275.
5. R. Lima-Sousa, D. de Melo-Diogo, C. G. Alves, E. C. Costa, P. Ferreira, R. O. Louro and I. J. Correia, *Carbohydrate polymers*, 2018, **200**, 93-99.
6. B. L. Melo, R. Lima-Sousa, C. G. Alves, P. Ferreira, A. F. Moreira, I. J. Correia and D. de Melo-Diogo, *Nanomedicine*, 2021, **16**, 453-464.
7. B. L. Melo, R. Lima-Sousa, C. G. Alves, A. F. Moreira, I. J. Correia and D. de Melo-Diogo, *Biochemical Engineering Journal*, 2022, **185**, 108529.
8. F. J. Costa, M. Nave, R. Lima-Sousa, C. G. Alves, B. L. Melo, I. J. Correia and D. de Melo-Diogo, *International Journal of Pharmaceutics*, 2023, **635**, 122713.

Advanced Treatment Technologies for Wastewater Resources Recovery

Vítor Vilar

Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials (LSRE-LCM), Chemical Engineering Department, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200465 Porto, Portugal; Associate Laboratory in Chemical Engineering (ALiCE), Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
vilar@fe.up.pt

The initial goal of wastewater treatment was to protect water quality, but today's scarcity of resources and sustainability initiatives are driving major global changes. The N-E-W paradigm aims to recover resources, i.e., Nutrients, Energy, and Water, for a circular and self-sufficient bio-based economy (Scheme 1). In line with the European Green Deal and Circular Economy Action Plan, the European Commission recently published a proposal for the new Urban Wastewater Treatment Directive (UWWTD)[1] targeting new standards and limit values, as well as: i) implementation of quaternary treatment to eliminate the broadest possible spectrum of micro-pollutants; ii) obligation to achieve energy neutrality and iii) promoting systematically the reuse of treated wastewater.

Scheme 1: Wastewater resource recovery.

The environmental group of LSRE-LCM has been developing a set of innovative solutions for safe and cost-effective wastewater resource recovery.
Under OZONE4WATER project, a disruptive ozone-based technology is being developed integrating functionalized membranes for O_3/O_2 separation to obtain an O_3-enriched gas stream and pressurized static micro/meso-structured mixer (NETmix), to enhance the O_3 mass transfer from the gas phase to the liquid phase to 100% or very close to it, leading to an O_3 enriched water stream, resulting in a downstream highly compact reaction chamber. SERPIC project is developing an integral technology, based on a multi-barrier approach, integrating nanofiltration and advanced oxidation, to maximize the reduction of CECs from secondary-treated urban wastewaters. A membrane nanofiltration (NF) technology is applied to reduce CECs in its permeate stream by at least 90 % while retaining the nutrients. A residual disinfection using chlorine dioxide/ozone produced electrochemically is added to the stream used for crop irrigation. The CECs in the polluted concentrate (retentate) stream will be reduced by at least 80 % by light driven electro-chemical oxidation. When discharged into the aquatic system, it will contribute to the quality improvement of the surface water body. Oxidants, such as persulfate, ozone, and chlorine dioxide are being generated using an electrolyzer based on the NETmix technology.
Additionally, nutrient recovery from the liquid sidestream generated by the dewatering of digested solids is under evaluation through precipitation/crystallization as struvite, using a low-footprint crystallizer, based on NETmix static mixer.

Acknowledgments
This work was financially supported by (i) OZONE4WATER project (PTDC/EAM-AMB/4702/2020) through the FCT/MCTES (PIDDAC); (ii) SERPIC project under ERA-NET AquaticPollutants Joint Transnational Call (GA Nº 869178); and (iii) LA/P/0045/2020 (ALiCE), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM) through FCT/MCTES (PIDDAC).

References
European Commission, Proposal for a revised Urban Wastewater Treatment Directive, 2022. https://environment.ec.europa.eu/publications/proposal-revised-urban-wastewater-treatment-directive_en

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

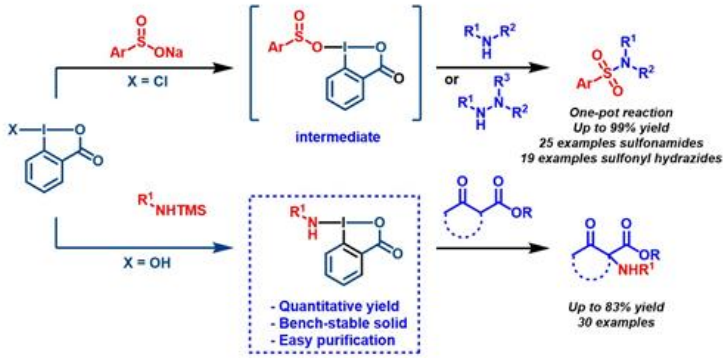
KN16

Rethinking C–N and S–N Bond Formation

Mª Manuel B. Marques

LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
mmbmarques@fct.unl.pt

Nitrogen is ubiquitously found in important pharmaceutical agents, and a crucial element to induce unique biological activity as well as physical/chemical properties. The amine group is inherently nucleophilic, and most commonly utilized methods for construction of the C–N and S–N bonds involve nucleophilic nitrogen sources. This can present problems in the synthesis of complex molecules, often avoided by use of protecting groups. These problems have been addressed by developing *umpoled* strategies that utilize electrophilic nitrogen sources, offering the ability to functionalize typically unreactive bonds.[1] In this context, cyclic hypervalent iodine reagents have shown great promise due to their stability and high reactivity, enabling new disconnections, leading to a greater diversity and synthetic efficiency.
Remarkable progress has been made in this field, and these reagents have emerged as powerful tools in electrophilic amination reactions.[2]
Our group has been investigating new benziodoxolone-derived reagents (Scheme 1). We have disclosed new transfer reactions for the sulfonylation of amines and hydrazines and oxidative amination of β-keto esters. We have combined hypervalent iodine chemistry with sulfinate salts to deliver a clean and mild transfer of sulfonyl groups to amines, anilines.[3] and hydrazines.[4] Furthermore, hypervalent iodine reagents have been prepared and applied as transfer reagents of primary amines to deliver an oxidative amination reaction.[5] These methodologies were applied in the preparation of key functional groups in medicinal chemistry, such as sulfonamides and α-amino carboxylic acids, and will be presented herein.



Scheme 1: Benziodoxolone-mediated C–N and N–S bond formation.

Acknowledgements
We thank FC&T for project funding (2022.04623.PTDC). This work was supported by the Associate Laboratory for Green Chemistry- LAQV which is financed by national funds from FCT/MCTES (UID/QUI/50006/2019) and co-financed by the ERDF under the PT2020 Partnership Agreement (POCI-01-0145-FEDER - 007265).

References
1. L. G. O'Neil, J. F. Bower, Angew. Chem. Int. Ed., 2021, **60**, 25640.
2. D. P. Hari, P. Caramenti, J. Waser, Acc. Chem. Res., 2018, **51**, 3212.
3. a) D. L. Poeira, J. Macara, H. Faustino, J. A. S. Coelho, P. M. P. Gois, M. M. B. Marques, Eur. J. Org. Chem., 2019, **15**, 2695; b) J. Macara, D. L. Poeira, J. A. S. Coelho, M. M. B. Marques, Synlett, 2021, **32**, 1730.
4. J. Macara, C. Caldeira, J. Cunha, J. A. S. Coelho, M. J. Silva, K. Krämer, C. Gratwhol, S. Bräse, M. M. B. Marques, Org. Biomol. Chem., 2022, **15**, 2695.
5. a) D. L. Poeira, A. C. Negrão, H. Faustino, C. Gomes, J. A. S. Coelho, P. M. P. Gois, M. M. B. Marques, Org. Lett., 2022, **24**, 776; b) D. L. Poeira, A. C. Negrão, J. Macara, M. M. B. Marques, Curr. Org. Chem. 2021, **25**, 2199; c) J. Macara, C. Caldeira, D. L. Poeira, M. M. B. Marques, Eur. J. Org. Chem. 2023, e202300109.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Molecular design of nitroprusside-based hybrid functional materials

Wei-Jian Xu[1*], Andrei Kholkin[2], João Rocha[1]

[1]*Department of Chemistry & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Department of Physics & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
**weijxu@ua.pt*

Transition-metal inorganic nitroprussides have garnered significant interest due to their potential applications in various fields such as gas storage, separations, photomagnetism, medical technologies, and electrochemistry.[1] Despite considerable efforts in the design and synthesis of nitroprusside-based materials with diverse physical properties, there is a scarcity of reports on the thermo/photo-responsive properties of nitroprusside-based hybrids. Herein, we present the design and synthesis of nitroprusside-based hybrids that exhibit exceptional electrical, optical, and thermal properties. Notably, we observed unusual "negative-positive" uniaxial thermal expansion switching and an "on-off" nonlinear optical switching behavior in $(Me_2NH_2)[KFe(CN)_5(NO)]$.[2,3] Furthermore, we achieved reversible photoisomerization in solid-state hybrid ferroelectrics, enabling the photo-switching between the ferroelectric ground state and the metastable state.[4,5] This groundbreaking finding offers an attractive avenue for phototunable polarization, highlighting the potential of nitroprusside-based hybrids in the field of ferroelectric materials.

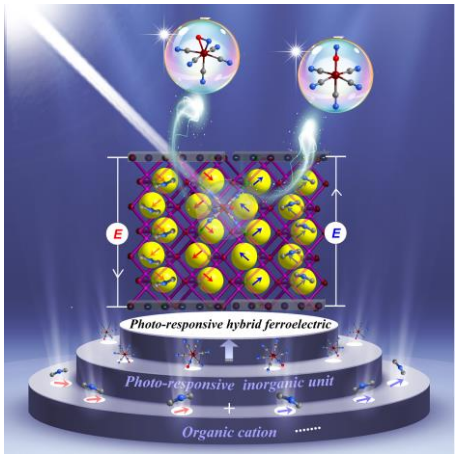


Figure 1: Design strategy of a photo-responsive nitroprusside-based hybrid ferroelectric crystal

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for UIDB/50011/2020, UIDP/50011/2020, PTDC/CTM-CTM/4044/2020, and LA/P/0006/2020

References

1. L. Reguera, Y. Avila, E. Reguera, *Coord. Chem. Rev.*, 2021, **434**, 213764.
2. R.-G. Qiu, X.-X. Chen, R.-K. Huang, D.-D. Zhou, W.-J. Xu, W.-X. Zhang, X.-M. Chen, *Chem. Commun.*, 2020, **56**, 5488-5491.
3. Q.-Y. Li, M.-F. Li, X.-X. Chen, Y.-P. Gong, D.-X. Liu, W.-J. Xu, W.-X. Zhang, *CrystEngComm.*, 2022, **24**, 4864-4868.
4. W.-J. Xu, K. Romanyuk, J. M. G. Martinho, Y. Zeng, X.-W. Zhang, A. Ushakov, V. Shur, W.-X. Zhang, X.-M. Chen, A. Kholkin, J. Rocha, *J. Am. Chem. Soc.*, 2020, **142**, 16990-16998.
5. W.-J. Xu, M.-F. Li, A.R. Garcia, K. Romanyuk, J. M. G. Martinho, P. Zelenovskii, A. Tselev, L. Verissimo, W.-X. Zhang, X.-M. Chen, A. Kholkin, J. Rocha, *J. Am. Chem. Soc.*, 2023, DOI: 10.1021/jacs.3c01530

Augmenting the Reactions' Portfolio of Quinic Acid

Nuno R. Candeias

Country LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; Faculty of Engineering and Natural Sciences, Tampere University, 33101 Tampere, Finland;
ncandeias@ua.pt

The shikimate pathway is used by many microorganisms and plants for the production of aromatic amino acids, providing quinic acid as a secondary metabolite derived from D-glucose.[1] Quinic acid is often combined with hydroxycinnamic acids to form a wide array of ubiquitous chlorogenic acids.[2] Considering quinic acid's wide distribution in Nature, and its density of stereocenters, quinic acid is an attractive molecule holding immense potential as a valuable chiral building block in organic synthesis and medicinal chemistry.[3] It is worth noting that synthetic manipulation of quinic acid often requires the use of protecting groups and harsh reaction conditions. Despite this drawback, the three-dimensional arrangement of secondary hydroxy groups and methylene units in the quinic acid skeleton offers significant potential for adapting functional groups in the chiron strategy, a popular approach in total synthesis.

Herein will be presented the modification and use of quinic acid as a building block and chirons in the synthesis of natural products (Figure 1), namely of two epimeric carbasugars isolated from *Streptomyces lincolnensis,*[4a] homocitric acid,[4b] vitamin D receptor modulator VS-105 and a metabolite from the African ant *Crematogaster nigriceps*.[4c] For such, methodologies for the deoxygenation of certain hydroxyl functionalities of quinic acid, and selective *O*,*O*-silyl group migrations were optimized to allow the isolation of key synthetic intermediates.

The utilization of light as an energy source opens the way for the activation of more benign starting materials, reducing the total number of synthetic steps necessary for the production of valuable molecules and avoiding the unnecessary production of waste. The photocatalytic decarboxylation of carboxylic acids results in the traceless extrusion of carbon dioxide to generate radical intermediates that can be trapped to generate new C-C bonds either in the presence or absence of metals.[5] Our recent efforts in increasing the complexity of quinic acid through its photocatalytic decarboxylation coupled with C-C bond formation processes will also be presented.

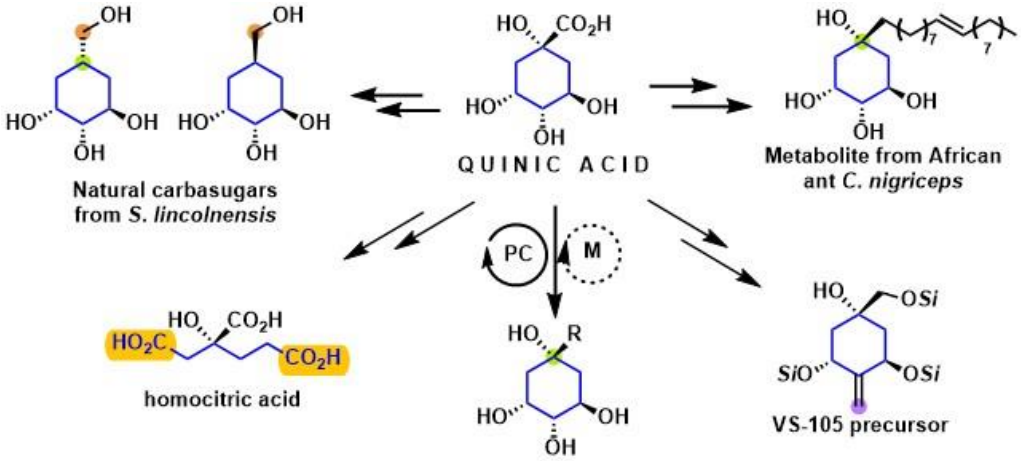


Figure 1: Synthetic manipulations of quinic acid

Acknowledgments and Funding
This work received support and funding from PT national funds (FCT/MCTES) through the projects UIDB/50006/2020, UIDP/50006/2020, CEE-CINST/2018 and PTDC/QUI-QOR/1131/2020.

References

1. Candeias, N. R.; Assoah, B.; Simeonov, S. P., *Chem. Rev.* 2018, *118*, 10458-10550.
2. Clifford, M. N.; Jaganath, I. B.; Ludwig, I. A.; Crozier, A., *Nat. Prod. Rep.* 2017, *34*, 1391-1421.
3. Barco, A.; Benetti, S.; De Risi, C.; Marchetti, P.; Pollini, G. P.; Zanirato, V., *Tetrahedron Asymmetry* 1997, *8*, 3515-3545.
4. a) Holmstedt, S.; Candeias, N. R., *Tetrahedron* 2020, *76*, 131346; b) Holmstedt, S.; George, L.; Koivuporras, A.; Valkonen, A.; Candeias, N. R., *Org. Lett.* 2020, *22*, 8370-8375; c) Holmstedt, S.; Efimov, A.; Candeias, N. R., *Org. Lett.* 2021, *23*, 3083-3087.
5. Huang, C. Y.; Li, J.; Li, C. J., *Chem. Sci.* 2022, *13*, 5465-5504.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The 12 Labours of HERCULES…or from Mythology to the frontiers of Chemistry and Art…or chronicle of a *Ready-Made*

António Candeias

Laboratório Associado IN2PAST, Laboratório HERCULES, China-Portugal Joint Laboratory for Heritage Conservation Science, City University of Macau Chair in Sustainable Heritage, Évora, Portugal
candeias@uevora.pt

Heritage research is fundamental for safeguarding cultural heritage and requires approaches that break the epistemological barriers of disciplines and professions, creating a common, integrated space, in which the rigidity of compartmentalized knowledge gives way to dialogue, the creation of new concepts, approaches and interrelationships between Art, Science and Humanities,
Created in 2009, the HERCULES Laboratory (HERança CULtural, Estudos e Salvaguarda / Cultural Heritage Studies and Safeguard) is a research infrastructure devoted to the study and valorisation of cultural heritage, focusing on the integration of chemical, physical and biological sciences methodologies and tools in interdisciplinary approaches. HERCULES Lab is based in Évora, Portugal, and is supported by both a strong analytical infrastructure and a multidisciplinary team comprising chemists, biochemists, geologists, geochemists, materials scientists, conservation scientists, conservators and archaeologists enabling a truly transdisciplinary approach to the study of cultural heritage.
HERCULES Lab sustains its activities in 4 major lines of research: 1) Archaeometric approaches to Past Cultures; 2) Science for the Arts; 3) Science for Heritage Conservation; and 4) Novel materials and tools for Cultural Heritage. The merging between these 4 lines of research allows scrolling through multiple paths at the level of research, teaching, protection and dissemination of cultural heritage.
This communication will present some of HERCULES Lab projects and ongoing activities and give a general overview on the Labs strategy and positioning focusing on two main areas: integration of Chemistry and analytical techniques in Heritage Research and development and application of novel materials and tools for Cultural Heritage. Some international collaborative projects on artistic, archaeological and built heritage will be presented with particular emphasis on the integration of *in-situ* non-invasive techniques and micro-analytical and high resolution laboratory techniques.

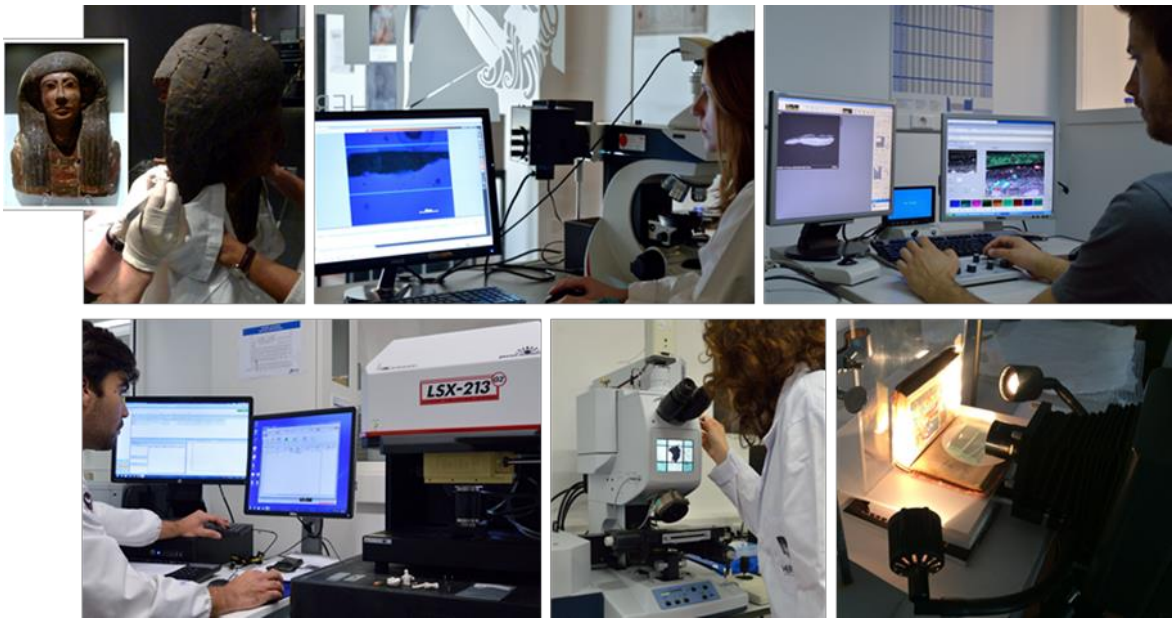


Figure 1: snapshots of HERCULES labors

Acknowledgements
The author thanks the Fundação para a Ciência e a Tecnologia for support under the contracts UIDP/04449/2020 and UIDB/04449/2020 (HERCULES Laboratory) and the National Key R&D Program of China (2021YFE0200100).

Endoperoxide–based hybrids as tools to fight infectious diseases; synthesis, structure and properties.

Maria L. S. Cristiano[1,2,*], Inês C. C. Costa[1,2], Patrícia S. M. Amado[1,2]

[1]*Center of Marine Sciences, CCMAR, Gambelas Campus, University of Algarve, UAlg, 8005-139 Faro, Portugal;* [2]*Department of Chemistry and Pharmacy, Faculty of Sciences and Technology, FCT, Gambelas Campus, University of Algarve, UAlg, 8005-139 Faro, Portugal.*
**mcristi@ualg.pt*

Organic peroxides are found in various natural products as biologically active compounds and take part in chemical reactions as intermediates. The interest in cyclic organic peroxides is mainly due to the 1,2,4-trioxane pharmacophoric moiety in artemisinin (ART), since this natural product and some of its semi-synthetic derivatives integrate the arsenal of frontline antimalarial drugs. The rise of *Plasmodium falciparum* resistance to artemisinin-based combination therapy stimulated the search for novel plasmodial "fast killers" and synthetic endoperoxides offered alternative solutions to artemisinin and its derivatives (ARTs). Selected synthetic 1,2,4-trioxanes, 1,2,4-trioxolanes and 1,2,4,5-tetraoxanes proved particularly promising in this context, some exhibiting anti-malarial activity similar or higher than ARTs, including against multi-resistant *P. falciparum* strains, as is the case for antimalarial candidates OZ439 and E209.[1] In parallel, synthetic routes for those classes have been developed and perfectioned, enabling the preparation of a chemically diverse range of analogues for selection of leads, optimization, and development into drugs or drug candidates.[2] Given their alkylating potential and multitarget nature, endoperoxides were scrutinized for their applicability in the treatment of other diseases, namely those derived from infections by microorganisms or cancer. Some of the novel compounds were designed within the “molecular hybridization” concept, whereby an endoperoxide moiety is linked to other pharmacophores, meant to afford pharmacological benefits when compared to the parent drugs, such as better efficacy, improved safety, cost-effectiveness, and less vulnerability to resistance selection. For instance, endoperoxides were linked to polypirrole moieties with minor groove binding properties, for application in cancer chemotherapy,[3] or to the pyrazole motif, for application as antileishmanial agents.[4] As for endoperoxides,[5,6] pyrazoles demonstrated anti-leishmanial activity.[7] Also, pyrazoles exhibit prototropic tautomerism due to 1,2-H shifts between vicinal nitrogen atoms, affording distinctive pyrazole-based structures with diverse reactivities, properties and biological activities.[8,9] Recently, endoperoxides have also been explored in the context of tuberculosis control. To this goal, the endoperoxide motif was coupled to highly potent antitubercular drug classes, aiming to tackle tuberculosis.[10]
The relevant issues mentioned above will be developed along the lecture, also integrating structural and mechanistic evidence.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for Grants SFRH/BD/130407/2017 (PSMA) and SFRH/BD/08242/2020 (ICCC), and projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020 (CCMAR), UIDB/00313/2020 and UIDP/00313/2020 (CQC). CRESC Algarve 2020 and COMPETE 2020 are also acknowledged, for project EMBRC.PT ALG-01-0145-FEDER-022121.

References

1. Woodley, C. M. *et al*. Artemisinin inspired synthetic endoperoxide drug candidates: Design, synthesis, and mechanism of action studies. *Med. Res. Rev.* **41** (6), 3062–3095 (2021).
2. Amado, P. S. M. *et al.* Synthesis of non-symmetrical Dispiro 1,2,4,5-tetraoxanes and Dispiro 1,2,4-trioxanes catalysed by silica sulfurica acid. *J. Org. Chem.* **86** (15), 10608–10620 (2021).
3. La Pensée, L. *et al.* Artemisinin-polypirrole conjugates: Synthesis, DNA binding and prelinimary antiproliferative evaluation. *ChemMedChem* **8** (5), 709-718 (2013)
4. Amado, P. S. M. *et al.* Synthesis, Structure and Antileishmanial Evaluation of Endoperoxide-Pyrazole Hybrids. *Mol.* **27** (17), 5401 (2022).
5. Cabral, L. I. L. *et al*. Synthesis and Antileishmanial Activity of 1,2,4,5-Tetraoxanes against *Leishmania Donovani*. *Mol.* **5**, 465 (2020).
6. Cortes, S. *et al. In Vitro* Susceptibility of *Leishmania Infantum* to Artemisinin Derivatives and Selected Trioxolanes. *Antimicrob. Agents Chemother.* **59**, 5032–5035 (2015).
7. Camargo, J. *et al.* Antiparasitic Behavior of Trifluoromethylated Pyrazole 2-Amino-1,3,4-Thiadiazole Hybrids and Their Analogues: Synthesis and Structure-Activity Relationship. *Front. Pharmacol.* **11**, (2020).
8. Secrieru, A.; Lopes, S.; Cristiano, M. L. S. UV-Induced Tautomerization in Argon Matrix. *Mol.* **26**, 4299 (2021).
9. Secrieru, A. *et al.* Revisiting the Structure and Chemistry of 3(5)-Substituted Pyrazoles. *Mol.* **25**, 42 (2020).
10. Amado, P. S. M. et al. Rrecent advances in DprE1 inhibitors against Mycobacteriam tuberculosis: Computational analysis of physicochemical and ADMET properties. *ACS Omega*, **7** (45), 40659-406812 (2022).

Synthesis and end-of-life tailoring of furan-based polymers: in the pathway to sustainable polymers

B. Agostinho[1], S. V. Pandeirada[1], V. Paula[1], A. J. D. Silvestre[1], A. F. Sousa[1,2,*]

[1]CICECO – Aveiro Institute of Materials University of Aveiro, 3810-193 Aveiro, Portugal; [2]Centre for Mechanical Engineering, Materials and Processes, Department of Chemical Engineering, University of Coimbra, Portugal
**andreiafs@ua.pt*

Polymers have a unique set of properties (such as light-weight and durability) which explains why they quickly become irreplaceable materials in our daily life. However, polymers' fossil origin and related geopolitical instability of the places where these sources are located, as well as polymers' non-circular fate after use, have encouraged a vigorous surge in interest in more sustainable alternative polymers.[1] In this context, exploitation of biomass derived key building-block chemicals such as, for example, the 2,5-furandicarboxylic acid (FDCA), in polymer synthesis is on the spotlight and attracted EU funding through the COST Action FUR4Sustain (CA18220).

Our group was pioneer in the synthesis and characterization of poly(ethylene 2,5-furandicarboxylate) (PEF), a polymer homologous to poly(ethylene terephthalate) (PET) which can be advantageously used in packaging, textiles among other applications, although its end-of-use can also be an issue since it does not (bio)degrade under relevant environmental conditions. Therefore, in this regard (bio)degradable furanic-aliphatic copolyesters have been broadly investigated at our group,[2] for instance the copolyesters based on PEF and PLA, among others.[3] Then, the concept was extended also to homopolymers with poly(1,20-eicosanediyl 2,5-furandicarboxylate) which has interest among food packaging applications (equilibrium moisture uptake very near 0% due to its hydrophobic character but biodegraded).

More recently, our group also entailed a research line on polymers' *greener* recycling. The potential of urea : zinc acetate deep eutectic solvent (DES) to assist the continuous, eco-friendly and closed-loop glycolysis followed by polytransesterification reaction for recycling PEF directly into its starting repolymerized polymer (rPEF), without the need of intermediate steps of isolation and purification of monomers and using mild conditions.[4] Further studies with (furanic) polyesters also evidenced the potential of DES to mediate recycling via hydrolysis reaction.

Acknowledgements
This work was developed within the scope of the CICECO— Aveiro Institute of Materials (UIDB/50011/2020 & UIDP/50011/2020) & LA/P/0006/2020, financed by national funds through the FCT —Fundação para a Ciência e a Tecnologia/MEC (PIDDAC). This research is also sponsored by FEDER funds through the program COMPETE—Programa Operacional Factores de Competitividade—and by national funds through the FCT under the project UID/EMS/00285/2020. The FCT is also acknowledged for the research contract under Scientific Employment Stimulus to AFS (CEECIND/02322/2020) and for a doctorate grant to BA (2020.04495.BD). This communication is supported by COST Action FUR4Sustain—European network of FURan based chemicals and materials FOR a Sustainable development, CA18220, supported by COST (European Cooperation in Science and Technology).

References

1. A. F. Sousa, R. Patrício, Z. Terzopoulou, D. N. Bikiaris, T. Stern, J. Wenger, K. Loos, N. Lotti, V. Siracusa, A. Szymczyk, S. Paszkiewicz, K. S. Triantafyllidis, A. Zamboulis, M. S. Nikolic, P. Spasojevic, S. Thiyagarajan, D. S. Van Es and N. Guigo, *Green Chem*, 2021, **23**, 8795–8820.
2. B. Agostinho, A. J. D. Silvestre, J. A. P. Coutinho and A. F. Sousa, *Green Chem*, 2023, **25**, 13–31.
3. M. Matos, A. F. Sousa, A. C. Fonseca, C. S. R. Freire, J. F. J. Coelho and A. J. D. Silvestre, *Macromol Chem Phys*, 2014, **215**, 2175–2184.
4. B. Agostinho, A. J. D. Silvestre and A. F. Sousa, *Green Chem*, 2022, **24**, 3115–3119.

Brown algae metabolites: the catalysts for biomass valuing

Susana M. Cardoso

LAQV & REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
susanacardoso@ua.pt

The expansion of algal exploitation as a component of the blue bioeconomy presents exceptional opportunities to tackle the European Green Deal agenda in industries like food, feed, agriculture, and pharmaceuticals. Even though the seaweed industry in Europe is currently a small sector, it has the potential to grow to be a multi-billion-euro sector by 2030, with a potential value of up to €9.3 billion.[1] Under appropriate conditions, European producers could capture about 30% of total European demand, generating up to 85,000 jobs. This amount of output would mitigate up to 5.4 million tonnes of CO_2 emissions/year, eliminate phosphorus and nitrogen/year from coastal waters, prevent coastal erosion and help preserve biodiversity.[1] Significant efforts are being made to achieve this goal, and one of the driving forces behind this sector's ongoing expansion is the creation of novel products. In this context, the use of efficient valorization methods and biorefinery channels are essential to fully utilize algal biomass and produce high-value intermediate or end products for new markets.[2,3]

Brown macroalgae are distinguished by their abundance in valuable metabolites, which include polysaccharides, namely alginates i.e., unbranched polysaccharides consisting of two uronic acids connected in a linear form, 1,4-β-D-mannuronic acid and α-L-guluronic acid; fucoidans (complex series of sulfated polysaccharides, with a backbone built of (1→3)-linked α-L-fucopyranosyl or of alternating (1→3)- and (1→4)-linked α-L-fucopyranosyl residues), and laminarans (mostly composed of β-(1→3)-D-glucopyranose residues with some β-(1→6)-D-glucopyranose intrachain links); phlorotannins, i.e., dehydro-oligomers or dehydro-polymers formed through C–C and/or C–O–C oxidative coupling of phloroglucinol, and the xanthophyll fucoxanthin, that is the pigment responsible for their brown or olive-green color. Notably, all these substances are known to exert a wide variety of bioactivities, giving them the potential to find use in a variety of industries, including food, agriculture, pharmaceuticals, and cosmetics.[4,5]

In this presentation, recent research advances on brown macroalgae as source of valuable compounds, trends in the application, existing challenges, production strategies and marketing opportunities will be discussed, with particularly emphasis on those that are considered as key species to be cultivated and commercialized in Europe.

Acknowledgements and Funding
Projects UIDB/50006/2020 and UIDP/50006/2020, funded by FCT/MCTES through national funds. S.M.C. thanks FCT/MCTES for the funding through the Individual Call to Scientific Employment Stimulus (Ref. 2022.06426.CEECIND).

References

1. Seaweed for Europe, *Hidden Champion of the Ocean*, available at seaweedeurope.com, accessed on May 2023.
2. E. Manirafasha, A. V. Vangh, T. Murwanashyaka, B. Rugabirwa and T. Ndikubwimana, *Algal Resources,* 2019, **7**, 1089.
3. S. U. Kadam, C. Álvarez, B. K. Tiwari and C. P. O'Donnell, *Extraction of biomolecules from seaweeds*, Elsevier Inc., 2015.
4. I. Wijesekara, S. K. Kim, Y. Li and Y. X. Li, *Process Biochemistry*, 2011, **46**, 2219–2224.
5. B. Tanna and A. Mishra, *Compr Rev Food Sci Food Saf*, 2019, **18**, 817–831

Discovery of dual inhibitors of PD-L1 and TGF-BRI leveraged by in silico methods

Carlota Leonardo de Sousa[1,2], Rita C. Acúrcio[1], Helena F. Florindo[1], Rita C. Guedes[2]

[1]Research Institute for Medicines (iMed.Ulisboa), BioNanoSicences Lab, Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisboa, Portugal; [2]Research Institute for Medicines (iMed.Ulisboa), Computational Medicinal Chemistry Lab, Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisboa, Portugal
rguedes@ff.ulisboa.pt

Immunotherapy is a crucial component of cancer treatment. Although cancer immunotherapy has advanced, there are still a few multi-target approaches that can assist the immune system in fighting cancer. Despite this, several animal models have shown that tumors can activate multiple immunosuppressive mechanisms. Suppression of the PD-1/PD-L1 immunosuppressive pathway and TGF-β signaling shows a synergistic effect of dual-blockade due to enhanced T-cell infiltration into the tumor niche, thus enhancing an antitumor immune response. However, to date, no dual small molecule inhibitor has been developed. The primary goal of our research project is the development of multi-target small molecules with the ability to simultaneously block PD-1/PD-L1 interaction and TGFsignaling, with particular emphasis on inhibitors of PD-L1 and TGF-β receptor I (TGF-βRI).

HTRF® scouting revealed 4 ChemBridge compounds with different scaffolds with the ability to disrupt the PD-1/PD-L1 interaction (IC_{50} =6-20 μM), while the ADP-Glo Kinase assay demonstrated 4 ChemBridge compounds capable to inhibit TGF-βRI (IC_{50} = 8.5-30 μM). Of these, 2 have already been confirmed as dual-target compounds. We also showed that these compounds did not affect the viability of melanoma and breast cancer cells at concentrations of at least up to 10 μM.

Acknowledgements and Funding
This work was supported by PD/BD/145161/2019, PTDC/BTM-SAL/4350/2021, UTAP-EXPL/NPN/0041/2021, EXPL/QUI-OUT/1288/2021, UIDB/04138/2020, UIDP/04138/2020, and EXPL/MED-QUI/1316/2021 from Fundação para a Ciência e a Tecnologia (FCT). It also received funding from the ”la Caixa” Foundation under grant agreements LCF/PR/HR22/52420016, LCF/PR/HR19/52160021, and LCF/TR/CD20/52700005

Analytical challenges in the detection of plant food supplements adulteration

Joana S. Amaral

Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
jamaral@ipb.pt

Since ancient times, plants have been used for medicinal purposes for their potential to treat diseases or maintain health. In the last decades, besides their implemented use in folk medicine and in traditional herbal medicinal products (THMP), medicinal plants and their extracts are also largely used as ingredients of plant food supplements (PFS). In the EU, food supplements are legally considered as foods under Directive 2002/46/EC, therefore not requiring any safety assessment prior to commercialization, with legal responsibility for its safety relying on business operators.[1,2] Moreover, they are easily available on supermarkets and e-commerce, and because they have plants in their formulation, they are frequently advertised as being “natural products”. Therefore, the consumption of PFS has been steadily increasing in the last decade as well as its global market value, making these products attractive targets for economically motivated adulteration. Those concern mainly the illegal addition of pharmaceuticals to provide for quick effects[1] and botanical adulterations by substituting high-valued botanicals by lower-cost plants.[3]

So far, different techniques have been proposed for the identification of drugs illegally added to PFS, with the most successful and widely accepted relying in liquid chromatography coupled to mass spectrometry. Regarding botanical adulterations, the swap of high-priced botanicals by other plants similar but cheaper and the unintentional mislabeling are among the frauds and safety issues reported to occur in PFS. For the identification of plant species, DNA-based methods are undoubtedly the most suited and frequently used. While these methods are generally straightforward when applied to raw botanicals, its application along the value-chain in the authentication of extracts or the final products is more challenging.

This keynote will briefly address both types of adulterations and the methods most frequently used for their detection. A particular focus will be given to botanical adulterations, namely the use of orthogonal approaches to detect and identify adulterant plants and the need for fast and on-site methods for authenticating raw botanicals.

Acknowledgements
To the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CIMO (UIDB/00690/2020 e UIDP/00690/2020) and SusTEC (LA/P/0007/2020) and for financing the project “POIROT: novel methods and approaches for detecting the illegal addition of Pharmaceutical drugs and bOtanIcal adulteRatiOn in planT food supplements” (PTDC/SAU-PUB/3803/2021).

References
1. T. Rocha, J.S. Amaral and M.B.P.P Oliveira, *Compr. Rev. Food Sci. Food Saf.*, 2016, **15**, 43-62.
2. T.Y Low, K.O Wong, A.L.L Yap, L.H.J De Haan, I.M.C.M Rietjenset, *Compr. Rev. Food Sci. Food Saf.*, 2017, **16**, 821-834.
3. L. Grazina, J.S. Amaral and I. Mafra, *Compr. Rev. Food Sci. Food Saf.* 2020, **19**, 1080-1109.

Automation of molecular recognition strategies for enhanced analytical methods

D. R. Cunha, A. N. Meireles, S. R. Fernandes, S. S. Marques, L. Barreiros, M. B. Quinaz, M. A. Segundo*

LAQV/REQUIMTE, Faculty of Pharmacy, University of Porto, R. Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal
**msegundo@ff.up.pt*

Automation of molecular recognition strategies offers several benefits. It can reduce human error, increase throughput, and enable high-throughput analysis of large sample sets. It also allows for the optimization and standardization of experimental protocols, ensuring consistent and reliable results. Furthermore, automation can enable the integration of multiple analytical techniques, facilitating multidimensional analyses and enhancing the overall sensitivity and selectivity of the methods. Molecular recognition involves the specific interaction between molecules, such as analytes and receptors, based on their complementary structural and chemical properties. Automation of this process can enhance the analytical figures of merit through strict control of reaction time and repeatable contact between analyte and reagents, particularly recognition elements that are immobilized or present in solid supports.

The present communication addresses the implementation of flow-based strategies to foster molecular recognition through molecularly imprinted polymers and through biochemical ligands immobilized in solid supports. Different flow setups will be compared, namely those based on flow networks with packed columns[1] and those based on the bead injection concept. Bead injection (BI) involves the introduction and movement of particles within a flowing system. Lab-on-valve (LOV) devices are used for sample treatment and/or analysis in this context, offering greater potential and compatibility with real-world samples compared to microfluidic devices.

The combination BI-LOV enables the implementation of immunoassays in various formats, such as sandwich and direct competitive ELISA, as well as immunoaffinity chromatography. These assays can be performed with real-time monitoring of reactions directly on the surface of the solid support. Importantly, these methods require minimal intervention from the operator and provide quick results. They offer a high surface-to-volume ratio, utilize small quantities of samples, sorbents, and reagents, and effectively prevent fouling phenomena. Several examples will be critically discussed, including the evaluation of immunoglobulin G (IgG) capture using immobilized protein A through automated BI-LOV, with the quantification performed using in situ spectrophotometry.[2] The miniaturization and automation of ELISA protocols will also be presented, demonstrating a significant reduction in the time required to obtain results (from 2 hours to 5 minutes) for the quantification of carbamazepine and IgG.[3,4] Overall, the automation of molecular recognition strategies in analytical methods is a promising area of research that has the potential to revolutionize the field by improving efficiency, accuracy, and the ability to handle complex samples.

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020. Support from PT national funds (FCT/MCTES) through projects EXPL/QUI-QAN/0360/2021 and 2022.06012.PTDC is also acknowledged. D. R. Cunha and S. R. Fernandes thank FCT/MCTES and ESF (European Social Fund) for the PhD grants ref. 2020.04917, SFRH/BD/130948/2017, and COVID/BD/152406/2022. L. Barreiros thanks FCT for funding through program DL 57/2016 – Norma transitória.

References

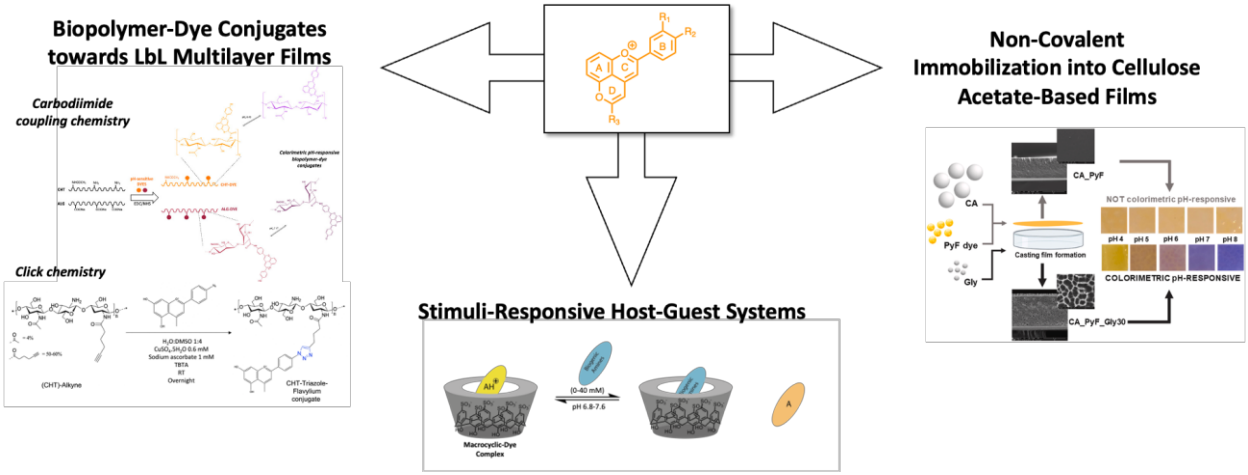
1. P. S. Peixoto, E. M. P. Silva, M. V. Osório, L. Barreiros, J. L. F. C. Lima and M. A. Segundo, Anal. Methods, 2018, 10, 2180-2186.
2. I. I. Ramos, S. S. Marques, L. M. Magalhães, L. Barreiros, S. Reis, J. L. F. C. Lima and M. A. Segundo, Talanta, 2019, 204, 542-547.
3. I. I. Ramos, P. Carl, R. J. Schneider and M. A. Segundo, Anal. Chim. Acta, 2019, 1076, 91-99.
4. I. I. Ramos, L. M. Magalhães, L. Barreiros, S. Reis, J. L. F. C. Lima and M. A. Segundo, Anal. Bioanal. Chem., 2018, 410, 981-988.

Building chemical strategies to expand flavylium-based dyes applications

Luís Cruz, Ana Sofia Pires, Vânia Gomes, Mariana Cunha, Nuno Mateus, Victor Freitas

REQUIMTE/LAQV, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Porto, Portugal.
luis.cruz@fc.up.pt

Flavylium-based dyes comprehend a large family of synthetic and natural pigments, including anthocyanins and pyranoanthocyanin derivatives. These compounds display a pH-dependent equilibria network giving rise to a wide portfolio of beautiful colors such as orange-red at low pH values (flavylium cation) and blue-violet at basic pH values (quinoidal bases). Because of their attractive chromatic features and important biological properties, flavylium dyes have been gaining increased attention by the scientific community and they could find several technological applications as dyes, colorants, pH-sensors, antioxidants, photosensitizers and photochromic systems in food, textile, cosmetics, energy, pharmaceutical and biomedical industries[1]. Over the last years, my research has been focused in: (i) extending the stabilization of colored species of anthocyanins in a wide pH range, and (ii) tuning the flavylium dyes optical properties in soft and solid materials for food sensing applications (Scheme 1). This has involved strategies of biocatalytic lipophilizations, interaction/encapsulation assays with deep eutectic solvents, dendrimers and self-assembled micellar systems, chemical conjugation at marine-origin polysaccharides towards the construction of multilayer films[2] as well as non-covalent immobilization in cellulose acetate-based films[3] and development of fluorescent and colorimetry stimuli-responsive host-guest systems.



Scheme 1: Chemical-driven strategies followed to expand pyranoflavylium-based dyes food sensing applications.

Funding
These works were supported by the Associate Laboratory for Sustainable Chemistry, Clean Processes and Technologies LAQV and financed by national funds from UIDB/50006/2020.

Acknowledgements
Ana Sofia Pires and Vânia Gomes acknowledge the PhD grants from FCT (BD2021.08670.BD and SFRH/BD/136556/2018, respectively). Luís Cruz acknowledges the FCT research contract (DL 57/2016/CP1334/CT0008).

References

1. Cruz, L.; Basílio, N.; Mateus, N.; de Freitas, V.; Pina, F., *Chem. Rev.* **2022,** *122* (1), 1416-1481.
2. Pires, A. S.; Gomes, V.; Neves, D.; Mateus, N.; de Freitas, V.; Cruz, L., *ACS Appl. Polym. Mater.* **2022**.
3. Gomes, V.; Bermudez, R.; Mateus, N.; Guedes, A.; Lorenzo, J. M.; de Freitas, V.; Cruz, L., *Food Hydrocoll.* **2023,** *143*, 108914.

.

Oral Communications

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Enhanced biomass processing using a ternary deep eutectic solvent

Helena Poy[1], André M. da Costa Lopes[2,3,*], Estela Lladosa[1], Carmen Gabaldón[1], Sonia Loras[1], Armando J. D. Silvestre[2]

[1]Department of Chemical Engineering, Universitat de València, Av. De la Universitat S/N, 46100, Burjassot, Spain; [2]CICECO, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, Aveiro, Portugal; [3]CECOLAB - Collaborative Laboratory Towards Circular Economy, R. Nossa Senhora da Conceição, 3405-155 Oliveira do Hospital, Portugal
**andremcl@ua.pt*

In order to tackle the recent energy crisis and the growing environmental concerns related with the overexploitation of fossil fuels, substantial efforts have been deployed for the production of biofuels from lignocellulosic biomass.[1] However, a paradigm shift towards the development of sustainable biomass pre-treatment methods is still imperative to achieve biorefinery profitability. In this sense, deep eutectic solvents (DES) have emerged as solvents with remarkable potential for biomass pre-treatment. Particularly, the binary mixture of cholinium chloride:lactic acid (ChCl:LA) has been showing high delignification performances at high molar ratios of LA (1:5 to 1:10).[2] Nonetheless, an excess of organic acid can negatively impact the quality of the extracted lignin, while part of hemicelluloses are hydrolyzed and degraded into furans and undesired humins.[3] Therefore, this work evaluated the effectiveness of a ternary DES composed of ChCl, LA and a diol (ethylene glycol – EG- or 1,6-hexanediol – HEX) as less acidic system in the pretreatment of rice straw towards the production of biobutanol. Among the examined DES mixtures, the most promising results were obtained for the ternary ChCl:LA:EG 1:5:5 mixture at 120 ºC for 4 h, since it allowed the preservation of the hemicellulose fraction in contrast to ChCl:LA after pre-treatment and enabled the highest conversion of polysaccharides (89.3% glucose yield; 53.6% xylose yield). Furthermore, the produced sugars were efficiently converted into biobutanol through the acetone-butanol-ethanol (ABE) fermentation process, resulting in the production of 95.7 g butanol/kg rice straw as one of the top values reported in literature.

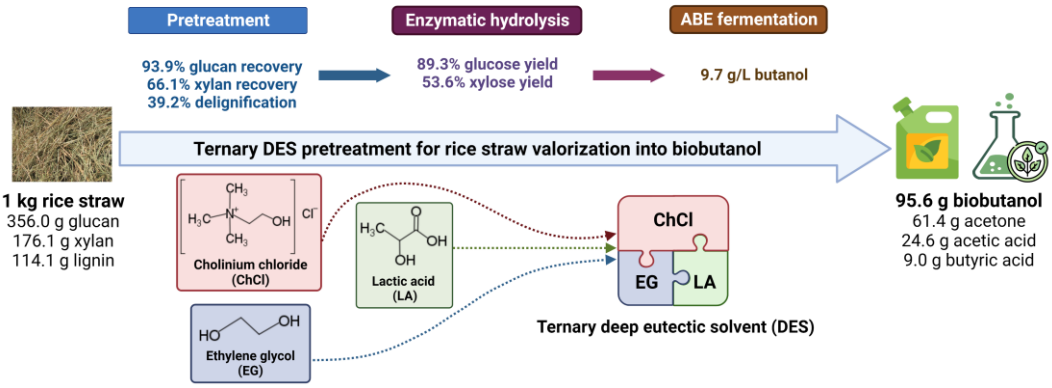


Figure 1: Graphical abstract of the present work.

Acknowledgements
Financial support was obtained from Ministerio de Ciencia e Innovación (MCIN) (Grant PID2021-122454OB-I00 funded by MCIN/AEI/10.13039/501100011033 and by "ERDF A way of making Europe") and from Conselleria d'Innovació, Universitats, Ciència i Societat Digital (Project AICO/2021/121, Generalitat Valenciana). H. Poy acknowledges to the Ministerio de Educación y Ciencia (Spain) for her PhD fellowship (FPU18/02817) and to Ministerio de Universidades (Spain) for the research stay grant (EST21/00403). The project CICECO–Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC) are also acknowledged. André M. da Costa Lopes acknowledges his research contract funded by the Fundação para a Ciência e Tecnologia (FCT) and project CENTRO-04-3559-FSE-000095—Centro Portugal Regional Operational Programme (Centro2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund.

References

1. G. De Bhowmick, A. K. Sarmah and R. Sen, *Bioresour Technol*, 2018, **247**, 1144–1154.
2. C. W. Zhang, S. Q. Xia and P. S. Ma, *Bioresour Technol*, 2016, **219**, 1–5.
3. E. S. Morais, A. M. Da Costa Lopes, M. G. Freire, C. S. R. Freire and A. J. D. Silvestre, *ChemSusChem*, 2021, **14**, 686–698.

Understanding the chemistry behind the Kigali Amendment to the Montreal Protocol: an accurate computational protocol

Luís P. Viegas

Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS), Department of Chemistry, University of Coimbra, Coimbra 3004-535, Portugal.
lpviegas@ci.uc.pt

The impact of hydrofluorocarbons (HFCs) on global warming can be hundreds to thousands of times greater than that of CO_2. With the rapid rise of HFC emissions and their projected catastrophic effects on the atmosphere and climate, the Kigali Amendment[1] of 2016 seeks to drastically reduce the global production and consumption of HFCs, thus contributing to the Paris agreement target of limiting the global temperature rise below 2 degrees Celsius. For this reason, new ideas and green technologies are necessary to achieve the Kigali goals and mitigate climate change effectively. Based on recent results[2-4], we demonstrate that our cost-effective computational protocol[5,6] based on multiconformer transition state theory (MC-TST) and a method for performing transition state sampling called constrained transition state randomization (CTSR)[2] is capable of predicting with unprecedented accuracy the rate coefficients of the OH-initiated degradation reactions of several families of saturated organic compounds that could replace HFCs. Specifically, our calculations based on the M08-HX/pcseg-2 level of theory yield rate coefficients that agree with the recommended experimental values[7], on average, to within a factor of two.

Furthermore, the fitted Arrhenius-Kooij curves based on the improved semiclassical TST tunneling correction[8] show a good agreement with the recommended experimental Arrhenius fits, implying that MC-TST/CTSR temperature-dependent data can be used to model reactions in the atmosphere in situations where experimental information is not available. Consequently, our cost-effective computational approach has the potential not only to deliver the required fundamental knowledge but also to actively take part in this critical scientific endeavor.

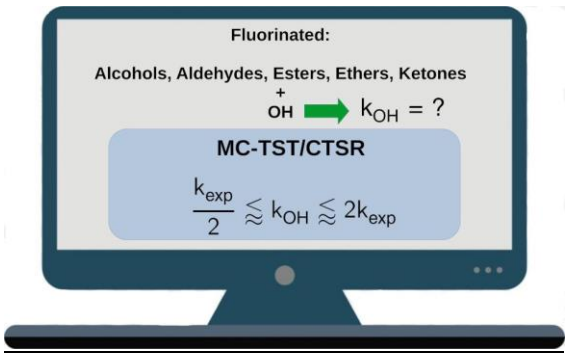


Figure 1: Accuracy of the rate coefficients calculated at 298.15 K by our cost-effective computational protocol.

Acknowledgements
The Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS) is supported by the Portuguese Foundation for Science and Technology (FCT) through projects UIDB/QUI/0313/2020, UIDP/QUI/0313/2020 and LA/P/0056/2020 (national funds). L. P. V. acknowledges FCT for an Assistant Researcher contract.

References

1. E. A. Heath, *Int. Leg. Mater.*, 2017, **56**, 193-205.
2. L. P. Viegas, *Chem. Phys. Lett.*, 2022, **803**, 139829.
3. L. P. Viegas, *J. Phys. Org. Chem.*, 2023, **36**, e4470.
4. L. P. Viegas and F. Jensen, *Environ. Sci.: Atmos.*, 2023, **3**, 855-871.
5. L. P. Viegas, *J. Phys. Chem. A*, 2018, **122**, 9721-9732.
6. L. P. Viegas, *J. Phys. Chem. A*, 2021, **125**, 4499-4512.
7. M. R. McGillen, W. P. L. Carter, A. Mellouki, J. J. Orlando, B. Picquet-Varrault and T. J. Wallington, *Earth Syst. Sci. Data*, 2020, **12**, 1203-1216.
8. A. F. Wagner, *J. Phys. Chem. A*, 2014, **116**, 13089-13100.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

DPA fluorescent sensors: "walking" towards the NIR

Artur J. Moro[1*], Liliana J. Gomes[1], Pedro Mateus[2], Laura Rodríguez[3]

[1]*LAQV-REQUIMTE, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, Caparica, Portugal.*
[2]*Instituto de Tecnologia Química e Biológica António Xavier, Universidade NOVA de Lisboa, Oeiras, Portugal.*
[3]*Institut de Nanociència i Nanotecnologia (IN²UB), Universitat de Barcelona, Barcelona, Spain.*
**artur.moro@fct.unl.pt*

The development of optical sensors for biological applications has attained tremendous interest from the world scientific community. Nowadays, current sensors for ions can already be applied in a widespread manner in Biological research[1]. Nevertheless, there is still a constant demand for creating new dye systems for sensing of relevant ions, particularly in the Near InfraRed (NIR) region, where deep-tissue penetration of light is possible[2]. Supramolecular systems have become a powerful tool for designing taylor-made chemical sensors capable of detecting both cations and anions. A successful example is the use of 2-(dipicolyl)-amine (DPA) to form stable coordination with metal ions (typically Zn^{2+} and Cu^{2+}), and which can subsequently bind to anionic species (e.g. adenosine 5'-triphosphate, ATP).[3]
Herein, we present our latest developments in creating DPA-based chemosensor systems (figure 1), capable of emitting in the NIR region[4], some of which having been applied for intracellular imaging.[5,6]

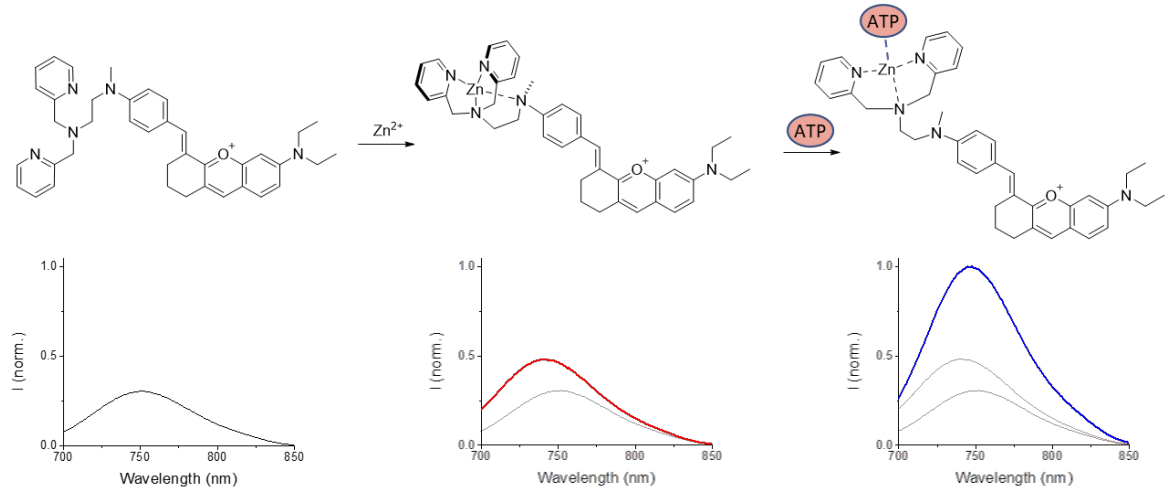


Figure 1: One of our NIR emissive chemosensor systems, capable detecting Zn^{2+} and subsequently Adenosine 5'-triphosphate (ATP).

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry - LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). The NMR spectrometers are part of Rede Nacional de RMN (PTNMR), supported by FCT/MCTES (ROTEIRO/0031/2013 - PINFRA/22161/2016) (co-financed by FEDER through COMPETE 2020, POCI, and PORL and FCT through PIDDAC). Support from FCT/MCTES program "Verão com Ciência" is also acknowledged. The Spanish Ministerio de Ciencia e Innovacion (Project PID2019-104121 GB-I00) is also aknowledged.

References
1. D. Wu, A. C. Sedgwick, T. Gunnlaugsson, E. U. Akkaya, J. Yoon, T, D. James, *Chem. Soc. Rev.*, 2017, **46**, 7105-7123.
2. E. D. Cosco, B. A. Arús, A. L. Spearman, T. L. Atallah, I. Lim, O. S. Leland, J. R. Caram, T. S. Bischof, O. T. Bruns, E. M. Slette, *J. Am. Chem. Soc.* 2021, **143**, 18, 6836-6846.
3. A. J. Moro, P. J. Cywinski, S. Körsten, G. J. Mohr, *Chem. Commun.*, 2010, **46**, 1085-1087.
4. A. Karkosik, A. J. Moro, *Chemosensors*, 2022, **10**, 343.
5. A. J. Moro, M. Santos, M. Outis, P. Mateus, P. M. Pereira, *Biosensors*, 2020, **10**, 129.
6. L. J. Gomes, J. P. Carrilho, P. M. Pereira, A. J. Moro, *Sensors*, 2023, **23**, 471.

Addressing drug resistance in methicillin-resistant *Staphylococcus aureus* through mass spectrometry multiple omics

Pedro C. Rosado[1,*], Mª Matilde Marques[1,2], Gonçalo C. Justino[1]

*[1]Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal; [2]Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal; *pedrocrosado@tecnico.ulisboa.pt*

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major cause of nosocomial infections, with a high mortality rate caused by multiple drug resistance. Due to the low drug availability to treat MRSA infections, there is a pressing need for innovative drugs.[1] A combined mass spectrometry approach was employed to explore the mechanism underlying the activity of ampicillin, chloramphenicol, ciprofloxacin, methicillin, and vancomycin at the lipidome, proteome and metabolome level of MRSA ATCC 43300 at 0.5 × IC_{50}, IC_{50} and 2 × IC_{50} concentrations.

Protein expression in MRSA is highly robust and greatly insensitive to these drugs ($p < 0.05$). Altered proteins at both the endo- and exoproteome levels are involved in DNA replication and in the PBP-dependent peptidoglycan biosynthesis pathways. ABC transporters were also found to be dysregulated. Exoproteome changes are related to quorum sensing and peptidoglycan biosynthesis, and were observed in the presence of ampicillin, ciprofloxacin, and vancomycin. At the endoproteome level, DNA repair, glycerophospholipid metabolism, and peptidoglycan biosynthesis are the main affected pathways, indicating that some of the up-regulated proteins related to transmembrane transport can be further explored as therapeutic targets. Metabolomics results evidence drug-specific and common metabolic changes across the different antibiotics, but also indicate that, except for vancomycin, all interfere with the glycan and peptidoglycan pathways, apart from a wide effect on energy production and nucleos(t)ide pathways. Interestingly, all drugs except methicillin also interfere with the molybdopterin biosynthesis, acetyl-CoA-related panthothenate and mevalonate pathways, and with folate biosynthesis. At the exometabolomic level, significant changes in arginine-dependent polyamine and pantothenate pathways are observed, together with some effect on the mevalonate pathways, which are related with cell wall biosynthesis and energy metabolism.

Results obtained from the lipidome analysis show changes in the lipid profiles depending on the tested drug. Changes in the demethylmenaquinol-8/menaquinol-8 biosynthesis pathways were observed for ampicillin, vancomycin, and chloramphenicol, suggesting an effect in the electron transfer chain. Moreover, some changes were observed in peptidoglycan biosynthesis with ampicillin, involving the production of a specific peptidoglycan precursor, emphasizing the interference of this drug with the cell wall biosynthesis pathways.

In summary, the results obtained provide a comprehensive analysis of the mechanisms underlying MRSA resistance to different antibiotics, using a combined MS-omics approach (Figure 1). The characteristic changes observed can be used not only to elucidate the pathways for antimicrobial resistance to the tested drugs but can also enable finding promising new targets to overcome MRSA resistance.

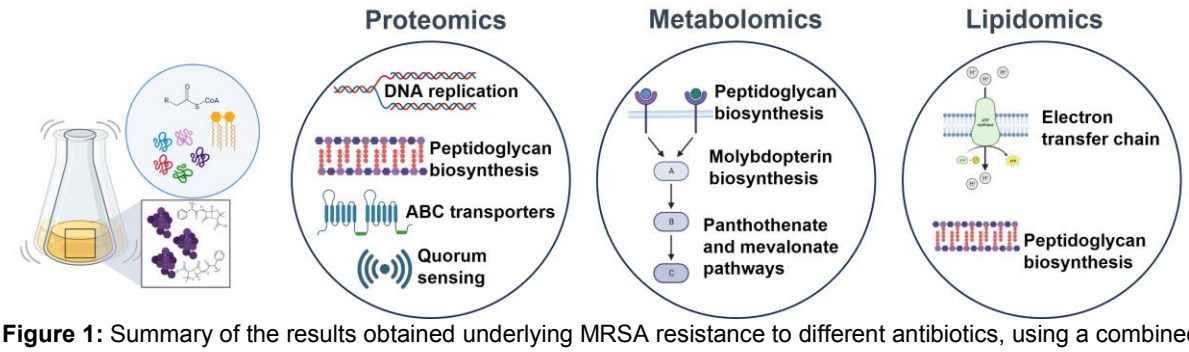


Figure 1: Summary of the results obtained underlying MRSA resistance to different antibiotics, using a combined MS-omics approach.

Acknowledgements

Centro de Química Estrutural is a Research Unit funded by FCT through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. The National Mass Spectrometry Network is funded through FCT (POCI-01-0145-FEDER-402-022125).

References

S. Lee, H. de Lencastre, J. Garau, J. Kluytmans, S. Malhotra-Kumar, A. Peschel and S. Harbarth. Nat Rev Dis Primers 4, 2018,18033. https://doi.org/10.1038/nrdp.2018.33

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Improved Functional Excipients for High Value Pharmaceuticals

Cláudia Bento[1,2*], Marianna Katz[1], Maria M. M. Santos[2], Carlos A. M. Afonso[2]

[1]Hovione Farmaciência S.A., Estrada do Paço do Lumiar, Campus do Lumiar, Edifício R, 1649-038 Lisbon, Portugal
[2]Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Avenida Professor Gama Pinto, 1649-003 Lisbon, Portugal
**cdbento@hovione.com*

Poly(ethylene glycol) (PEG) is used in drug delivery systems due to its non-toxicity, low immunogenicity, and well-established safety profiles, which are key requisites for any component used in formulation development. For over 20 years, this polymer has been widely used in drug delivery of small drugs, proteins, oligonucleotides, and liposomes, improving the stability and pharmacokinetics of many drugs[1], resulting in over 30 approved PEGylated drugs for clinical applications, with a market size of over 10 billion USD[2]. However, conventional PEG relies on the use of carcinogenic ethylene oxide which produces a mixture of polymers, presenting challenges in drug synthesis and purification, leading to potential immunogenic reactions[3]. To overcome this limitation, the synthesis of PEGs with precise molecular weight is of interest.

Here, we report the key challenges in monodisperse PEG synthesis and highlight a controlled polymerization strategy comprising two crucial steps: PEG monomer monosubstitution and subsequent chain extension. The research into the monosubstitution step revealed that the presence of similar hydroxyl end groups promotes the formation of an impurity: disubstituted PEG. Attempts to enhance reaction selectivity with O-alkylation chemistry showed promising results, with monosubstituted PEG yields above 70%. Furthermore, this step was explored both in batch and continuous mode, providing important insight on the advantages and limitations of each method.

Chain extension strategies using leaving groups were employed to increase the PEG length. Both leaving groups demonstrated high reaction rates and yields (>90%) in extending the PEG chain thus elongating the chain with a discrete molecular weight standing as an improvement when compared to the polydisperse counterparts (Figure 1).

To achieve robust process control, analytical techniques were developed using HPLC-ELSD (High-Performance Liquid Chromatography – Evaporative Light Scattering Detector) and HPLC-UV. Additionally, advanced technological tools as EasySampler and ReactIR were used to enhance the experiments efficiency. To ensure the results accuracy, nuclear magnetic resonance (^{1}H NMR) and mass spectrometry (MS) were used to characterize products and intermediates. Furthermore, computational studies carried out in Gaussian complement the experimental data by predicting chemical reactions and comparing protecting groups to enhance monosubstitution selectivity. A mixture of mono and disubstituted PEG is still obtained, the computational insights on the most suitable protecting groups study paved the way for further optimization. Computational research has also provided insightful data on the most suitable leaving groups for chain extension which corroborate with the experimental data, emphasizing the efficiency of the proposed methods. Overall, this study provides valuable insights into the challenges and advancements in monodisperse PEG synthesis. The combination of computational guidance and experimental data contributes to a controlled polymerization approach that offers potential pathways to synthesize monodisperse PEGs with improved control.

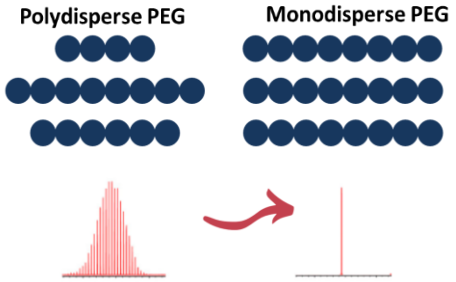


Figure 1: Polydisperse and monodisperse PEG synthetic pathways and mass profiles

References

1. D'souza and R. Shegokar, *Expert Opinion on Drug Delivery*, 2016, **13**, 1257–1275.
2. J. Hu and S. Liu, *Current Opinion in Biomedical Engineering*, 2022, **24**, 2468–4511.
3. P. Bohn and M. A. R. Meier, *Polymer Journal*, 2020, **52**, 165–178.

Nitro group-containing compounds as histone deacetylase inhibitors

Joana L. C. Sousa[1,*], Daniela Malafaia[1], Bruno M. Neves[2], Telmo N. Francisco[1], Hélio M. T. Albuquerque[1], Artur M. S. Silva[1]

[1] *LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2] *Department of Medical Sciences and Institute of Biomedicine-iBiMED, University of Aveiro, 3810-193 Aveiro, Portugal*
** E-mail: joanasousa@ua.pt*

Histone deacetylase inhibitors (HDACi) are a modern chapter in drug discovery. They include natural and synthetic compounds that differ in their target specificity and activities. As examples of HDACi there are the natural product **trichostatin A** (Figure 1), which was the first potent HDACi to be discovered, and the **vorinostat** (Figure 1), which became the first HDACi to receive FDA approval in 2006 for the treatment of cutaneous T-cell lymphoma. These two HDACi perfectly illustrate the most common HDAC pharmacophores, *i.e.*, their hydroxamic acid moiety works as a bidentate Zn^{2+} chelator (Figure 1), which is the main mechanism of action to inhibit zinc-dependent histone deacetylases (HDACs). However, these pan-HDACi (*i.e.*, non-selective HDACi) often exhibit significant adverse side effects such as fatigue, nausea, diarrhea and thrombocytopenia when administrated to humans.
The present work discloses two series of novel **nitro group-containing compounds** (Figure 1) as first-in-class HDACi for cancer treatment. These compounds present high *in chemico* inhibitory effects towards HDACs, and their structures are very distinctive from the classical hydroxamic acid-based pharmacophoric architecture of well-known HDACi. The synthesis of the two sets of nitro group-containing compounds through new simple and scalable methods is also involved in this work.[3,4] The nitro group-containing compounds now disclosed might be used to produce more effective and selective HDACi drugs for cancer therapy.

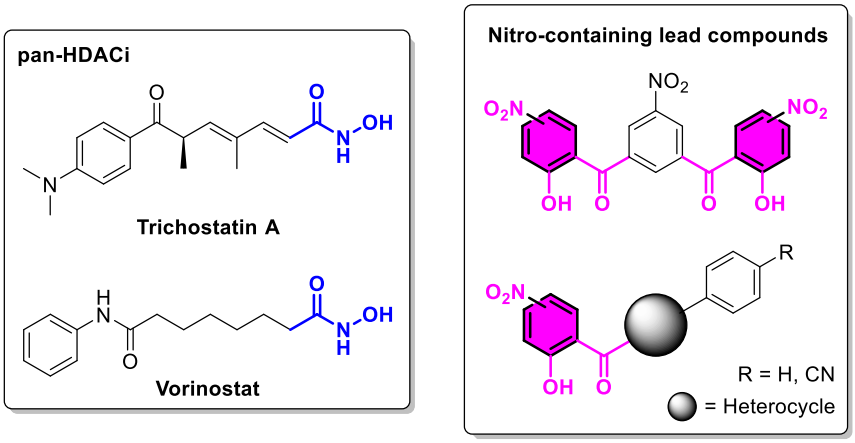


Figure 1: Chemical structures of two acknowledged HDACi, trichostatin A and vorinostat, and of the nitro group-containing lead compounds disclosed within this work.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), as well as the Portuguese NMR Network. H.M.T. Albuquerque gratefully acknowledges MuTaTher-AD project – "Multi-target theranostics for Alzheimer's disease" (2022.06064.PTDC) for his researcher contract. J.L.C. Sousa gratefully acknowledges LAQV-REQUIMTE for her researcher contract. D. Malafaia and T.N. Francisco also thanks FCT/MCTES and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for their PhD grants (2021.05641.BD and 2022.12243.BD, respectively).

References
1. T. C. S. Ho, A. H. Y. Chan and A. Ganesan, *J. Med. Chem.*, 2020, **63**, 12460–12484.
2. S. Geurs, D. Clarisse, K. De Bosscher and M. D'hooghe, *J. Med. Chem.*, 2023, DOI: 10.1021/acs.jmedchem.3c00226.
3. T. N. Francisco, J. L. C. Sousa, S. Guieu, A. M. S. Silva and H. M. T. Albuquerque, *Synlett*, 2022, **33**, 1505–1510.
4. European Patent Application nº. 22190310.7 – "Nitro-containing compounds, compositions and uses thereof".

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The extraction residues as a promising source of fiber and proteins

Tatiane C. G. Oliveira[1,2,3], Cristina Caleja[1,2], Délio Raimundo[4], M. Beatriz P. P. Oliveira[3], L. Barros[1,2*], E. Pereira[1,2]

*[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, C. Santa Apolónia, 5300-253 Bragança, Portugal; [2]Laboratório para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [3]REQUIMTE/LAQV, Departamento de Ciências Químicas, Faculdade de Farmácia da Universidade do Porto, Rua Jorge Viterbo Ferreira 228, 4050-313 Porto, Portugal. [4]Campotec IN S.A., Estrada Nacional 9, Zona Industrial de Casalinhos de Alfaiata 2560-393 Silveira Torres Vedras – Portugal. *lillian@ipb.pt*

Considering the annual waste production in the food industry throughout the entire value chain, it is important to establish strategic measures to reduce it, promoting its reuse and valorization. The use of fruit and vegetable biowastes to obtain bioactive compounds has been increasingly enhanced, since these compounds are molecules with wide application in the food and pharmaceutical industries, due to their associated bioactive characteristics[1]. However, the extraction processes of these compounds also result in a large amount of waste, that requires attention for proper reuse, thus promoting a circular economy. In addition, the disposal of this waste can result in a loss of economic value, since fruit and vegetable biowastes have a wide range of compounds of interest beyond bioactive compounds[2]. Therefore, this work aims to identify several molecules with nutritional interest present in the waste resulting from the extraction process, using a conventional technique widely used in the industry – maceration using ethanol/water as extraction solvent. The phytochemicals were extracted from kale (*Brassica oleracea* var. Acephala) and onion peel (*Allium cepa*) biowastes and the residues resulting from this extraction procedure were characterized in terms of ash, protein, fat, and fiber contents by standardized methods of the AOAC[3]. For the individual free sugar profile, HPLC-RI system was applied.

The onion peel extraction residue showed a substantial amount of dietary fiber (80.00±0.02% TDF DW), followed by an ash level of 8.48±0.02 g/100g DW, a protein content of 3.0±0.1 g/100g DW, and a fat content of 2.1±0.2 g/100g DW. The kale extraction residue presented a fiber level of 49±1% TDF DW, a protein concentration of 26.9±0.1 g/100g DW, an ash level of 11.55±0.05 g/100g DW, and a fat content of 3.4±0.2 g/100g DW. Regarding the sugar profile, both residues presented only a fructose (0.180±0.001 g/100g DW and 0.42±0.01 g/100g DW) and glucose concentration (0.38±0.03 g/100g DW and 0.21±0.01 g/100g DW). The results showed that both biowastes presented a high fiber content, which can arouse a great interest of the food industry. In addition, the kale biowaste presented an interesting protein content. Both fibers and proteins can be used as ingredients in different formulations, since foods enriched with these components have gained much popularity among the consumers, as they offer several health benefits. Therefore, this study highlights that agri-food industry biowastes can be used as a whole, closing their life cycle and ensuring a circular economy and sustainability of the sector, while adding value to something that is commonly discarded.

Acknowledgements

The Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES to CIMO (UIDB/00690/2020 and UIDP/00690/2020) and SusTEC (LA/P/0007/2020), for Tatiane C.G. Oliveira. grant (2021.06046.BD) and for Eliana Pereira and Lillian Barros contracts. To the project VIIAFoods for the contract of Cristina Caleja (PRR | Aviso n.º02/C05 -i01/2022; n.º de agenda: C644929456 -00000040). Conducted under the project "BIOMA – Bioeconomy integrated solutions for the mobilization of the Agro-food market" (POCI-01-0247-FEDER-046112).

References

1. Magama, P., Chiyanzu, I., & Mulopo, J. (2022). A systematic review of sustainable fruit and vegetable waste recycling alternatives and possibilities for anaerobic biorefinery. *Bioresource Technology Reports*, *18*, 101031. https://doi.org/https://doi.org/10.1016/j.biteb.2022.101031
2. Patra, A., Abdullah, S., & Pradhan, R. C. (2022). Review on the extraction of bioactive compounds and characterization of fruit industry by-products. *Bioresources and Bioprocessing*, *9*(1), 1-25.
3. AOAC Official Methods of Analysis of AOAC INTERNATIONAL; 20th ed.; 2016.

Electrostatics on biomolecules-based drug delivery systems

Sandra C. C. Nunes[1,*], Bruna C. Veríssimo[1], Ana C. L. Duarte[1], Maria Mendes[1,2], Tânia F. Cova[1], Carla Vitorino[1,2], Alberto A. C. C. Pais[1]

[1]Coimbra Chemistry Center, Institute of Molecular Sciences -IMS, Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal; [2]Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal
**snunes@qui.uc.pt*

The existence of electrostatic interactions can significantly affect the design and subsequent behavior of various biomolecule-based systems, particularly those related to drug delivery employing nucleic acids and polymers. These interactions play a direct role in some cases, while in others, they exert an indirect but crucial influence.

To explore these effects, our research group has been actively developing effective models to describe the adsorption behavior of charged polymers in complex systems driven by electrostatic interactions[1,2]. We use Monte Carlo simulations and simple coarse-grained models. Our aim is to simplify the inherent complexity of these systems by focusing on a limited set of parameters, such as the overall charge, chain length, and charge distribution to evaluate how these parameters impact the overall behavior of the systems.

As part of our case studies, we have specifically focused on DNA nanostructures including hyaluronic acid and nanoparticles grafted with cell-penetrating peptides. These modifications hold promise in improving the effectiveness of chemotherapeutic agents, enhancing targeting capabilities, facilitating biological barrier penetration, enabling specific cellular uptake, and ultimately reducing side effects and overcoming tumor resistance[3-6].

Acknowledgements
The authors acknowledge Fundação para a Ciência e a Tecnologia (FCT), the Portuguese Agency for Scientific Research for the financial support through projects UIDP/00313/2020. Tania Cova acknowledge the Junior Researcher Grant CEECIND/00915/2018 assigned by FCT.

References

1. Nunes, S. C.C., Pais, A.A.C.C., *Journal of Molecular Liquids*, 2022, **346**,117060.
2. Nunes, S.C.C., Cova, T.F. G. G.,Dias, R. S. and Pais, A. A. C. C., *Phys. Chem. Chem. Phys.*, 2018, **20**, 19811-19818,
3. Liu, J.; Song, L.; Liu, S.; Zhao, S.; Jiang, Q.; Ding, B., *Angewandte Chemie International Edition* 2018, **57**, 15486-15490.
4. Mendes, M., Cova,T., Basso, J., Ramos, ML, Vitorino, R, Sousa,J., Pais, A., Vitorino, C., *Journal of Molecular Liquids*, 2020, **315**, 113774.
5. Milad Ashrafizadeh et al., *Carbohydrate Polymers*, 2021, **272**, 118491.
6. Raucher D., *Curr Opin Pharmacol.* 2019, **47**, 14-19.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Unlocking the potential of chromeno[3,4-*b*]xanthones as multifunctional compounds for Alzheimer's disease

Daniela Malafaia[1,*], Natércia F. Brás[2], Pedro A. Fernandes[2], Maria J. Ramos[2], Artur M. S. Silva[1], Hélio M. T. Albuquerque[1]

[1]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal.*
[2]*LAQV-REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal*
**danielamalafaia@ua.pt*

The Alzheimer's disease (AD) is a complex multifactorial neurodegenerative disorder, mainly characterized for the progressive and unremitting memory loss and cognitive, motor, and functional capacity[1]. To date, there is no cure or prophylaxis for this neurological disorder, as the clinically available small-molecule drugs only provide limited symptomatic treatment and do not alter the course of the disease[2]. In fact, since 2003, only two drugs have been approved for AD by the Food and Drug Administration (FDA), aducanumab and lecanemab[3,4]. However, due to the high cost of these monoclonal antibodies (an estimated value of up to $26.500 per year), many experts believe that the number of people that will be able to get the drugs will be extremely limited, particularly countries with under-resourced public health systems[5]. Unlike bulky biologics, small molecules can make Alzheimer's treatment cheaper, more convenient to administer, and widely accessible. To address this, in 2021 we disclosed a novel class of multifunctional chromeno[3,4-*b*]xanthone derivatives[6]. Herein, we describe the lead optimization effort to establish a complete profile of these compounds *in vitro*, including design, synthesis, anticholinesterase and antiaggregating properties, molecular docking studies and cytotoxicity in human neuroblastoma cell line (SH-SY5Y).

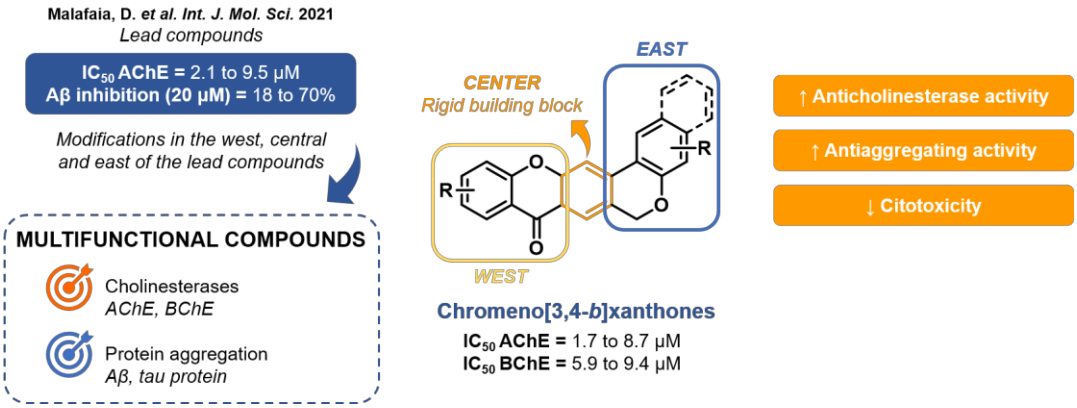


Figure 1: Chromeno[3,4-*b*]xanthones representation as a new class of multifunctional compounds for Alzheimer's disease.

Acknowledgements
This work received financial support from PT national funds (OE) through FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) within the projects: LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), and MuTaTher-AD—"Multi-target theranostics for Alzheimer's disease" (2022.06064.PTDC). Daniela Malafaia thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for her PhD grant (2021.05641.BD). Natércia F. Brás thanks FCT for her CEEC grant (CEECIND/02017/2018).

References
1. Malafaia, D. et al. *Eur. J. Med. Chem.* **2021**, *214*, 113209.
2. Association, A.S. *Alzheimer Dement.* **2019**, *15*, 321.
3. van Dyck, C. H. et al. *N. Engl. J. Med.* **2023**, *388*, 9.
4. Karlawish, J. & Grill, J. D. *Nat. Rev. Neurol.* **2021**, *17*, 523.
5. Ferri, C. P. & Jacob, K. S. *PLOS Med.* **2017**, *14*, e1002271.
6. Malafaia, D. et al. *Int. J. Mol. Sci.* **2021**, *22*, 4145.

Recovery of palladium by solvent extraction – A contribution for the recycling of PGMs from end-of-life devices

A. P. Paiva*, P. G. Rodrigues

Centro de Química Estrutural – Institute of Molecular Sciences, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Lisbon, Portugal.
**appaiva@ciencias.ulisboa.pt*

Everyone knows and accepts that circular economy is essential for the sustainable survival of living species on the Earth planet rather soon. Accordingly, recycling practices developed to recover critical materials – those that are crucial for the maintenance of our living standards – should always be considered, for the health of all living organisms and preservation of Earth resources.[1] Platinum-group metals (PGMs) have been considered by European Union as critical metals since 2011, due to their high economic value, rarity in mineral resources, and difficult replacement in most technological applications, particularly those related with their catalytic activity.[1] Palladium, together with platinum, is the most required of the PGMs, being the inclusion in automotive catalysts (an essential device for minimizing the emission of toxic exhaust gases from combustion engines) its most relevant application.[2]

After a brief introduction focusing on the state-of-art of liquid metallurgy to recover Pd(II) from leachates of spent automotive catalysts, this work describes the preliminary evaluation of the solvent extraction performance towards Pd(II) by a new organic extractant, *N,N'*-dimethyl-*N,N'*-dicyclohexylthiodipropanamide (DMDCHTDPA), similar to another previously developed, *N,N'*-dimethyl-*N,N'*-dicyclohexylthiodiglycolamide (DMDCHTDGA) (Figure 1).[3,4]

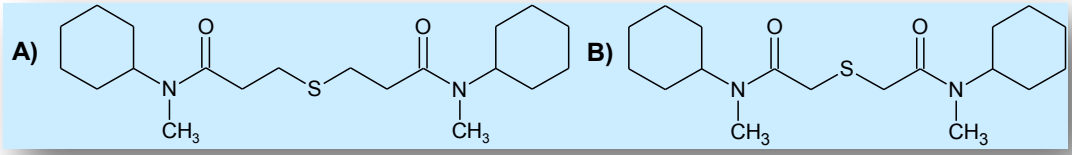


Figure 1: Structures of DMDCHTDPA **(A)** and DMDCHTDGA **(B)**.

DMDCHTDPA was synthesized, properly characterized, and its content was evaluated by HPLC-DAD, after ESI (+)/MS. DMDCHTDPA in toluene is a powerful solvent to recover Pd(II) from dilute and concentrated HCl solutions, with extraction percentages varying between 100 and 96% within 1M and 6M HCl. Furthermore, Pd(II) is quantitatively stripped from the loaded organic phases by an acidic thiourea aqueous solution. Equilibrium distribution and spectroscopic data allow proposals for the most probable Pd(II) extraction reactions involved, presumably of the compound formation type through ligand substitution. DMDCHTDPA shows a very good Pd(II) loading profile and a promising behavior for a suitable reutilization in successive extraction-stripping cycles. Introductory results obtained with the DMDCHTDPA solvent to selectively recover Pd(II) from model and real leaching solutions of spent catalysts are presented, adequately discussed, and compared with data achieved with other commercial extractants as well.[5]

Acknowledgements
We thank Fundação para a Ciência e a Tecnologia (FCT) for the financial support offered to Centro de Química Estrutural (CQE), a Research Unit funded by the projects UIDB/00100/2020 and UIDP/00100/2020, and to Institute of Molecular Sciences, an Associate Laboratory funded by FCT through project LA/P/0056/2020. The collaboration of Dr. Conceição Oliveira, from CQE, for the analysis of DMDCHTDPA samples by ESI (+)/MS and HPLC-DAD is gratefully acknowledged.

References

1. C. Hagelüken, *Platinum Metals Rev.*, *2012*, **56**, 29-35.
2. Johnson Matthey: https://matthey.com/pgm-market-report-2022 (accessed June 2023).
3. O. Ortet, A. P. Paiva, *Sep. Purif. Technol.*, *2015*, **156**, 363-368.
4. A. P. Paiva, O. Ortet, G. I. Carvalho. C. A. Nogueira, *Hydrometallurgy*, *2017*, **171**, 394-401.
5. A. P. Paiva, F. V. Piedras, P. G. Rodrigues, C. A. Nogueira, *Sep. Purif. Technol.*, *2022*, **286**, 120474.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Innovation in cork: A cork-chemistry relationship

R. Nunes da Silva

Cork Technological Centre, Rua Amélia Camossa, Santa Maria de Lamas, Portugal
rsilva@ctcor.com

Cork is a naturally renewable material with unique properties that make it versatile and with economic value.

Over the past decades, the cork industry and cork researchers have undergone a constant process of innovation, exploring new applications and developing more sustainable products.

Cork research goes from different forms of innovation covering a wide variety of scientific fields, with a strong emphasis on chemistry and chemistry related fields. Over the literature it is possible to find innovation examples that goes from product innovation, design and aesthetics, manufacturing, efficiency and optimization, advanced-materials, digitalization, business model, marketing and even value chain integration innovation.

But it is in chemistry area that the most differentiative research has been taken. It goes from better technical performing products - by exploring creation of innovative cork-based products, such as lightweight composites, bio-based materials and smart cork applications -; to innovative manufacturing techniques including high-performing disinfection procedures and advanced molding processes; and even to efficient waste reduced operations in a sustainable perspective.

This communication aims to present the state of the art of cork innovation, highlighting the main areas of research and future possibilities of investigation in this field, with focus on the most recent research on chemical innovations.

Acknowledgements
This work is funded by SIAC2021: Scientific and technological interface. Cork industry (PO-CI-01-0246-FEDER-181298) and CTCOR – Innovation and Technological Centre – CTI base founding. R. Nunes da Silva her Researcher contract by PORNorte (NORTE-06-3559-FSE-0000112).

Featuring hyperbaric storage for *Clostridium perfringens* endospores' inactivation – a novel breakthrough on food safety?

C. Pinto*, A. Ganjeh, D. Galante, J. Saraiva

LAQV-REQUIMTE, Chemistry Department, University of Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal
**carlospinto@ua.pt*

Clostridium perfringens is a pathogenic spore-forming bacteria commonly associated with foodborne illness. One of the significant concerns related to *C. perfringens* in food safety is its ability to form highly resistant spores termed endospores[1]. These endospores can survive harsh conditions, such as high temperatures and low nutrient availability, making them challenging to eliminate from food products, being prevalent in pasteurized foods[2]. To temporarily delay endospores' germination and development, refrigeration is the most used strategy, yet with considerable energetic costs associated.

Hyperbaric storage (HS) is a novel food preservation technique that controls storage pressure and temperature, aiming to inhibit microbial growth similarly to the conventional refrigeration processes. HS offers several advantages over refrigeration, particularly when applied at uncontrolled room temperatures (RT). This study focuses on evaluating the potential of HS in inhibiting the development of pathogenic microorganism *Clostridium perfringens'* endospores and comparing it with the conventional refrigeration[3].

To do so, *C. perfringens* spores were inoculated in brain-heart infusion (BHI) broth, used as a model system, and coconut water, used as a real food product for validation. Various HS conditions were tested, ranging between 75-200 MPa, for up to 30 days at uncontrolled RT. Control samples at atmospheric pressure and refrigerated at 4 ºC were also evaluated. The enumeration of endospores was conducted by spread plating in BHI-agar, which were incubated anaerobically at 37 ºC for 24 hours. To assess the thermal-resistant fraction, a portion of each sample was heat-treated at 70 ºC for 10 minutes, followed by plating and incubation under the aforementioned conditions.

The results revealed that HS/RT effectively inhibited the germination of *C. perfringens* endospores in both BHI broth and coconut water, surpassing the performance of refrigeration, being the effect pH-dependent, particularly in the case of BHI broth. In coconut water, HS led to a significant reduction of endospores by up to 3-log units after 30 days, regardless of the storage pressure. Conversely, minor reductions of approximately 1-log unit were observed in BHI-broth. Furthermore, HS did not sensitize the endospores to heat treatment, as minor variations in the thermal-resistant fraction were observed for both BHI broth and coconut water.

In conclusion, HS/RT demonstrated the ability to prevent the development of *C. perfringens* endospores in a model system (BHI-broth), and this finding was furtherly validated in highly perishable coconut water. Moreover, HS exhibited the potential for inactivating *C. perfringens* spores during storage, particularly in coconut water. The use of HS as a tool for inactivating bacterial spores holds great potential for ensuring food safety, as an innovative nonthermal and *quasi* energetically costless bacterial spores' inactivation methodology.

Acknowledgements

Thanks are due to the University of Aveiro and FCT/MCT for the financial support to the LAQV-REQUIMTE research Unit (UIDB/50006/2020 & UIDP/50006/2020) through national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement, and for financing the PhD grant of Carlos A. Pinto (SFRH/BD/137036/2018 and COVID/BD/153220/2023) and Alireza M. Ganjeh (2022.12558.BD).

References

1. J. E. Grass, L. H. Gould and B. E. Mahon, *Foodborne Pathog Dis*, 2013, **10**, 131–136.
2. A. S. Sant'Ana, A. Rosenthal and P. R. Massaguer, *Journal of Applied Microbiology*, 2009, **107**, 197–209.
3. M. D. Santos, L. G. Fidalgo, C. A. Pinto, R. V. Duarte, Á. T. Lemos, I. Delgadillo and J. A. Saraiva, *Critical Reviews in Food Science and Nutrition*, 2020, 1–12.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Photoreduction of carbon dioxide using a novel Re(I) complex

M. A. Bento[1,*], E. Devid[2], J. Rocha[3], M. Gleeson[2], P. N. Martinho[1]

[1]Centro de Química Estrutural - Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal; [2]Dutch Institute for Fundamental Energy Research (DIFFER), De Zaale 20, 5612 AJ Eindhoven, The Netherlands; [3]Department of Chemistry, CICECO-Aveiro Institute of Materials, University of Aveiro, Portugal
**mambento@fc.ul.pt*

Carbon dioxide is one of the main greenhouse gases in the Earth's atmosphere and stands out due to its versatility in terms of product formation. At present, there is a much interest in devising strategies to capture and convert this gas into economically valuable chemicals.[1] CO_2 conversion can be achieved through a variety of technologies, such as electroreduction, and photochemical reduction, to name a few. Photocatalysis and plasma technology are promising methods for CO_2 conversion, as they operate at ambient pressure and temperature, and are capable of converting CO_2 into basic chemicals that can be easily converted into synthetic fuels, high-value chemicals and other products (such as CO, CH_4 and CH_3OH).[2-4] In the process of CO_2 conversion, various types of molecular complexes or materials (i.e. metal organic frameworks) based on different metal centers can serve as catalysts.[5] Of these, rhenium bipyridine complexes have been extensively studied as photocatalysts for CO_2 reduction. These complexes only require a sacrificial donor to reduce CO_2 into CO.[6] Our work aims at synthesizing a novel Re(I) complex (Figure 1) that can be used for CO_2 photoreduction and CO_2 plasma conversion through both homogeneous and heterogeneous approaches. Here we present our results regarding the photoreduction of CO_2 to CO using a solar light simulator, and the subsequent mechanistic studies aimed at understanding this new Re(I) photocatalyst. Our photoreduction experiments have shown that the Re(I) photocatalyst remains active even in the nanomolar scale.

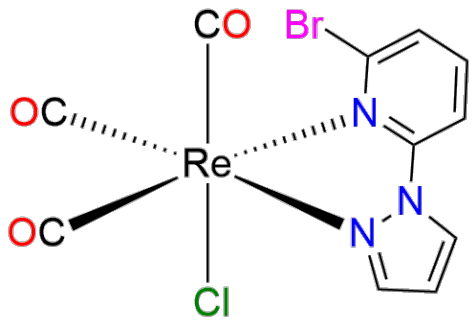


Figure 1: Rhenium complex used in this work.

Acknowledgements
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e a Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. This work was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020 & UIDP/50011/2020, financed by national funds through the FCT/MEC and when appropriate co-financed by FEDER under the PT2020 Partnership Agreement. We are grateful to Fundação da Ciência e a Tecnologia, FCT, for Project PTDC/QUI-QIN/0252/2021. P.N.M. acknowledges FTC for financial support (CEECIND/00509/2017) and PTDC/QUI-QIN/0252/2021

References
1. P. Friedlingstein et al, *Earth Syst. Sci. Data*, 2019, **11**, 1783–1838.
2. P. R. Yaashikaa, P. Senthil Kumar, S. J. Varjani, A. Saravanan, *J. CO2 Util.*, 2019, **33**, 131–147.
3. A. Bogaerts, G. Centi, *Front. Energy Res.*, 2020, **8**, 1–23.
4. A. Bogaerts et al, *J. Phys. D. Appl. Phys.*, 2020, **53**, 443001.
5. H. Chen, Y. Mu, Y. Shao, S. Chansai, H. Xiang, Y. Jiao, C. Hardacre, X. Fan, *AIChE J.*, 2020, **66**, 1–11.
6. V. A. Müller, L. A. Faustino, K. T. de Oliveira, A. O. T. Patrocínio, A. Polo, *ACS Catal.*, 2023, **13**, 633-643.

Hydrogen production via electrocatalytic ammonia conversion using metal-organic frameworks films

Duarte Borralho[1]*, Paulo N. Martinho[1], Maria E. Melo Jorge[2], Sara Realista[1]

[1]Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Ed. C8, 1749-016 Lisboa, Portugal; [2]Biosystems and Integrative Sciences Institute, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
**fc51349@alunos.fc.ul.pt*

The excessive use of fossil fuels as a response to the energy demand has led to the increase in the concentration of the greenhouse effect gases in the atmosphere contributing to climate change. Therefore, it is urgently needed to investigate and develop clean and renewable fuel alternatives.
Molecular hydrogen as a non-carbon green fuel is a great alternative due to its accessibility, non-toxicity and higher gravimetric energy density compared to traditional fuels. However, its implementation is hampered due to its properties such as extremely low volumetric energy density, flammability and volatility which leads to challenges in its storage and transportation. One solution to this problem is using a hydrogen carrier such as ammonia, a non-flammable chemical with a well-known storage technology that can be converted to produce nitrogen and hydrogen, while having the advantage of a lower conversion potential when compared with water.[1-2]
The focus of this work is the synthesis and immobilisation of metal-organic frameworks (figure 1. (a) MOFs) on electrodes to be used in the electrocatalytic conversion of ammonia to hydrogen, owing its interest to its superb properties of high permanent porosity and potential as catalyst.[3]
Two methods of deposition were performed, a direct method (cathodic deposition) which uses the MOF precursors and an indirect method (electrophoretic deposition) where the MOF is previously synthesised. The films formed (figure 1. (a)) were characterised by infrared spectroscopy, x-ray diffraction and scanning electron microscopy. Ammonia conversion studies using MOF films were performed using cyclic voltammetry (figure 1. (b)) and controlled potential electrolysis experiments. Hydrogen was quantified using gas chromatography with a thermal conductivity detector.

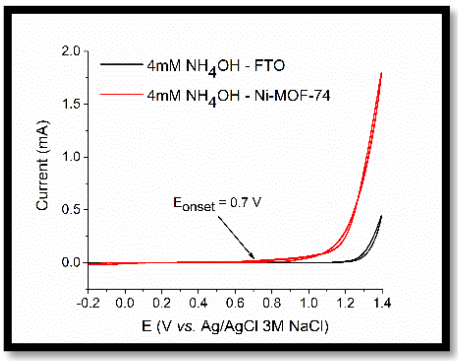


Figure 1: (a) Ni-MOF-74 deposited on FTO. (b) Cyclic voltammetry studies using (a) in presence of ammonia.

Acknowledgements
CQE is a Research Unit funded by Fundação para a Ciência e a Tecnologia (FCT) through projects UIDB/00100/2020 and UIDP/00100/2020. IMS is an Associate Laboratory funded by FCT through project LA/P/0056/2020. We are grateful to FCT for Project PTDC/QUI-QIN/0252/2021 and to Telmo Nunes and the FCUL Microscopy Facility for the SEM analysis (JEOL(JSM-35C)). S.R. acknowledges FTC for financial support (2020.02134.CEECIND).

References
1. M. Aziz, A. T. Wijayanta, A. B. D. Nandiyanto; *Energies*, 2020, **13**, 3062.
2. N. M. Adli, H. Zhang, S. Mukherjee, G. Wu; *Journal of The Electrochemical Society,* 2018, **15**, 3130-3147.
3. L Jiao, Y. Wang, H. Jiang, Q. Xu; *Advanced Materials* 2018, **30**, 1703663.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Effect of alkylsilane and alkylsiloxane chains on the thermophysical properties of ionic liquids

Rodrigo M. A. Silva[1,*], Hadrián Montes-Campos[1], Ana I. M. C. Lobo Ferreira[1], Eduards Bakis[2], Luís M. N. B. F. Santos[1]

[1]CIQUP, Institute of Molecular Sciences (IMS) – Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Rua Campo Alegre, 4169-007 Porto, Portugal; [2]Faculty of Chemistry, University of Latvia, Jelgavas 1, Riga, LV-1004, Latvia
**rodrigo.m.a.silva98@gmail.com*

It has been shown that the use of cations bearing alkylsilane or alkylsiloxane chains is an effective way to produce ionic liquids (ILs) with reduced viscosity and density.[1-3] This work presents the study of the thermophysical properties of ILs with alkylsilane and alkylsiloxane chains. Additionally, some of their analogs with carbon-based chains were also studied, with the aim of understanding the impact that alkylsilane and alkylsiloxane chains have on the thermophysical properties of ILs.

The phase behavior of these compounds was studied by differential scanning calorimetry (DSC) and their thermal stability was evaluated by thermogravimetric analysis (TGA). Their heat capacity was measured, as a function of temperature (from T = 283 K to T = 333 K) by means of high-precision differential scanning microcalorimetry (*iSenseDSC*) and, at T = 298.15 K, via high-precision drop calorimetry[4]. Their volatility was studied by means of Knudsen effusion method coupled with a quartz crystal microbalance (KNQ)[5].

No first-order transitions were detected for the ILs with carbon-based chains, however, for some of the ILs with alkylsilane and alkylsiloxane chains, DSC experiments revealed that it was possible to obtain them in the crystalline state. We verified that the IL with an alkylsiloxane chain melts at a lower temperature than its alkylsilane analog. The replacement of the quaternary carbon atoms in the cation chain causes an increase in the molar heat capacity, and a slight increase in thermal stability. The vaporization studies show that the ILs with alkylsilane chains are slightly more volatile and have similar cohesive energy to their carbon-based chain analogs. The use of an alkylsiloxane chain was shown to have a more significant impact on the IL's volatility. This observation seems to arise due to a lowering of the cohesive energy.

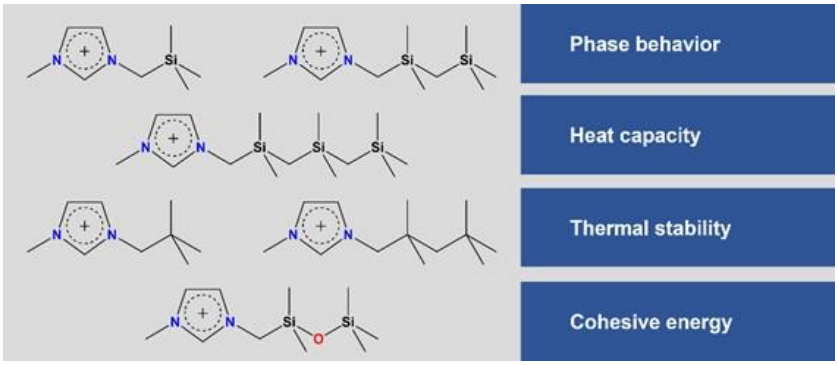


Figure 1: Cation structures and investigated properties.

Acknowledgements
This work was supported by the Fundação para a Ciência e Tecnologia (FCT) (funded by national funds through the FCT/MCTES (PIDDAC)) to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), IMS-Institute of Molecular Sciences (LA/P/0056/2020). RMAS is grateful to FCT for the award of his PhD grant (U1/BD/153093/2022). AIMCLF is also financed by national funds through the FCT-I.P., in the framework of the execution of the program contract provided in paragraphs 4, 5 and 6 of art. 23 of Law no. 57/2016 of 29 August, as amended by Law no. 57/2017 of 19 July. EB acknowledges *PostDoc Latvia* for financial support (Grant No. 1.1.1.2/VIAA/3/19/549).

References
1. H. Shirota, E. Castner, J. Phys. Chem. B, 2005, **109**, 21576-21585.
2. H. Shirota, J. Wishart, E. Castner, J. Phys. Chem. B, 2007, **111**, 4819-4829.
3. E. Bakis, K. Goloviznina, I.M.C. Vaz, D. Sloboda, D. Hazens, V. Valkovska, I. Klimenkovs, A. Pádua, M. Costa Gomes, Chem. Sci., 2022, **13**, 9062.
4. L.M.N.B.F. Santos, M.A.A. Rocha, A.S.M.C. Rodrigues, V. Stejfa, M. Fulem, M. Bastos, J. Chem. Thermodyn., 2011, **43**, 1818-1823.
5. L.M.N.B.F. Santos, A.I.M.C. Lobo Ferreira, V. Stejfa, A.S.M.C. Rodrigues, M.A.A. Rocha, M.C. Torres, F.M.S. Tavares, F.S. Carpinteiro, J. Chem. Thermodyn., 2018, **126**, 171-186.

New 4-(*N*-cinnamoylbutyl)aminoacridines as potential multi-stage antiplasmodial leads

Mélanie Fonte[1,*], Diana Fontinha[2] Mélanie, Diana Moita[2], Omar Caño-Prades[3], Yunuen Avalos-Padilla[3], Xavier Fernàndez-Busquets[3,4,5], Miguel Prudêncio[2], Paula Gomes[1], Cátia Teixeira[1,6]

[1]LAQV-REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Portugal [2]Instituto de Medicina Molecular, Faculdade de Medicina, Universidade de Lisboa, Portugal; [3]Nanomalaria Group, Institute for Bioengineering of Catalonia (IBEC), The Barcelona Institute of Science and Technology, Spain; [4]Barcelona Institute for Global Health (ISGlobal), Barcelona Center for International Health Research (CRESIB), Hospital Clínic-Universitat de Barcelona, Spain; [5]Nanoscience and Nanotechnology Institute (IN2UB), University of Barcelona, Spain; [6]Current affiliation: Gyros Protein Technologies Inc., Tucson, Arizona, USA
**up201305020@edu.fc.up.pt*

Malaria is one of the deadliest infectious diseases in the world. Malaria's ongoing burden is due in part to (i) the complex *Plasmodium* parasite's life cycle and (ii) the fast selection and spread of parasite strains resistant to all the antimalarial drugs developed so far.[1] To overcome this, antimalarial drug discovery has focused on creating multi-stage drugs that might affect several stages of the *Plasmodium* parasite's life cycle, thus increasing efficacy while lowering the likelihood of emergence of resistant parasite strains.[1] Quinacrine (QN) was the first synthetic antiplasmodial drug employed as a blood schizonticidal agent, but its place was swiftly taken by chloroquine (CQ), given its better safety, effectiveness, and bioavailability. However, the widespread appearance of CQ-resistant strains revived the interest in QN derivatives.[2] Interestingly, QN acridine's core is a fusion between CQ and primaquine (PQ), the latter being an antimalarial drug active against liver forms of the parasite and able to block malaria transmission. Previous results reported by us showed that new QN derivatives, 4-*N*-butylaminoacridines, corresponding to the fusion between PQ and the CQ core, display dual-stage antimalarial activity *in vitro*.[3, 4] Based on this and inspired by the "covalent bitherapy" concept first advanced by Meunier,[5] which supports the combination of two pharmacophores in one molecule, we have now developed a second generation of 4-*N*-butylaminoacridines (Figure 1) through conjugation of first-generation ones to bioactive *trans*-cinnamic acids (CA). In this communication, we describe the chemical synthesis of these new conjugates and the *in vitro* evaluation of their activity against (a) erythrocytic forms of *Plasmodium falciparum*, (b) liver stages of *Plasmodium berghei*, and (c) early and mature gametocytes of *Plasmodium falciparum*. Results reveal that introduction of the CA moiety clearly has a positive impact on the overall antiplasmodial activity, given that the new compounds have an improved *in vitro* activity against all the three stages of the malaria parasite life cycle in the mammalian host without increased toxicity to mammalian cells.

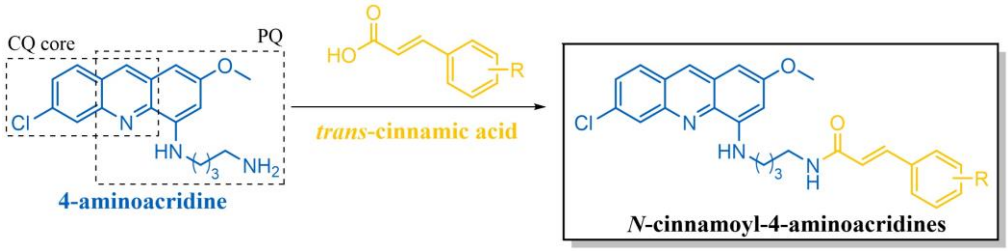


Figure 1: Chemical structure of the *N*-cinnamoyl-4-aminoacridines family.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the doctoral grant SFRH/BD/147345/2019 to MF. MP further acknowledges the "la Caixa" Foundation for Grant HR21-848.
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through project UIDB/50006/2020.

References
1. Teixeira, C. et al. Chem Rev., 2014, **114**, 11164-11220.
2. Fonte, M. et al. Molecules, 2021, **26**, 600.
3. Fonte, M. et al. Tetrahedron Lett., 2019, **60**, 1166-1169.
4. Fonte, M. et al. ChemMedChem, 2021, **16**, 788;
5. B. Meunier, Acc. Chem. Res., 2008, **41**, 69-77.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of new analogs with anticancer activity from metabolic products of marine bioluminescent reactions

L. Pinto da Silva*, C. M. Magalhães, P. González-Berdullas, J. C. G. Esteves da Silva

Centro de Investigação em Química (CIQUP), Instituto de Ciências Moleculares (IMS), Departamento de Geociências, Ambiente e Ordenamento do Território, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal.
**luis.silva@fc.up.pt*

Cancer is still one of the major health problems globally, with many patients not escaping therapy failure and serious side-effects. The development of new anticancer drugs presents also high rates of failure due to problems with efficacy or toxicity. So, it is essential that more effective and safe therapeutic agents are developed, while more detailed investigations of their mode of action are needed at preclinical stages.
Bioluminescence is the emission of light due to a biochemical reaction.[1] While widespread in nature, this phenomenon is more prevalent in the oceans, in which the most common bioluminescent substrate is marine Coelenterazine (Clz, Figure 1).[1] Following our previous development of self-activating photosensitizers for photodynamic therapy of cancer based on Clz,[2,3] we have recently turned our attention to a metabolic product of this reaction, Coelenteramine (Clm, Figure 1). More specifically, we have synthesized several Clm analogs, and evaluated their anticancer potential.[4,5] Among the studied analogs, we highlight Br-Clm (Figure 1), which showed relevant anticancer activity toward different cancer cell lines, including gastric and lung.[4,5] Also, this compound showed only residual toxicity toward noncancer cells, presenting an interesting selectivity profile.[4] Lastly, when used in combination, Br-Clm was able to enhance the activity of a chemotherapeutic agent.[5]
Further investigation showed that Br-Clm can activate effector caspases.[4] Moreover, synchrotron radiation-based FTIR (SR-FTIR) microspectroscopy was also used to investigate its mechanism of action.[6] SR-FTIR is a powerful technique that allows to probe the biochemical composition of biological systems, including cells, with single-cell resolution.[6] This approach showed that the anticancer activity of Br-Clm is closely connected with cellular lipids, by affecting their organization and composition due to oxidative stress.[6] Interestingly, this effect was not observed in noncancer cells, helping to explain its selectivity profile.[6]

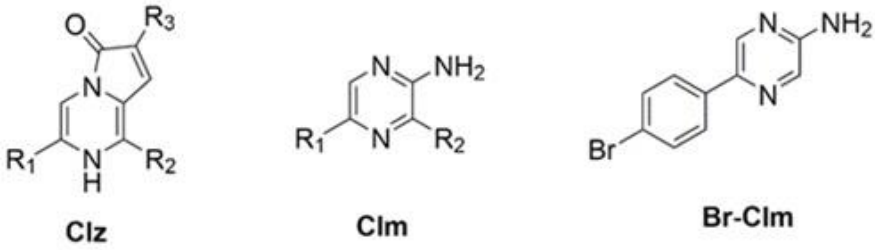


Figure 1: Structures of natives Clz and Clm, and selected analog Br-Clm.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia, FCT, for funding project PTDC/QUI-QFI/2870/2020, CIQUP (UIDB/000081/2020 and UIDP/00081/2020), IMS (LA/P/0056/2020), L. Pinto da Silva (CEECINST/00069/2021), and CM Magalhães (SFRH/BD/143211/2019).

References

1. J.P. Silva, P. González-Berdullas, M. Pereira, D. Duarte, J.E. Rodríguez-Borges, N. Vale, J.C.G. Esteves da Silva, L. Pinto da Silva, *J. Photochem. Photobiol. A*, 2023, **434**, 114228.
2. L. Pinto da Silva, A. Nunez-Montenegro, C.M. Magalhães, P.J.O. Ferreira, D. Duarte, P. González-Berdullas, J.E. Rodríguez-Borges, N. Vale, J.C.G. Esteves da Silva, *Eur. J. Med. Chem.*, 2019, **183**, 111683.
3. C.M. Magalhães, P. González-Berdullas, D. Duarte, A.S. Correia, J.E. Rodríguez-Borges, N. Vale, J.C.G. Esteves da Silva, L. Pinto da Silva, *Biomedicines*, 2021, **9**, 1199.
4. P. González-Berdullas, R.B. Pereira, C. Teixeira, J.P. Silva, C.M. Magalhães, J.E.Rodríguez-Borges, D.M. Pereira, J.C.G. Esteves da Silva, L. Pinto da Silva, *Int. J. Mol. Sci.*, 2022, **23**, 8271.
5. C.M. Magalhães, P. González-Berdullas, M. Pereira, D. Duarte, N. Vale, J.C.G. Esteves da Silva, L. Pinto da Silva, *Int. J. Mol. Sci.*, 2022, **23**, 13981.
6. C.M. Magalhães, T. Ducic, R.B. Pereira, P. González-Berdullas, J.E. Rodríguez-Borges, D.M. Pereira, J.C.G. Esteves da Silva, M. Algarra, L. Pinto da Silva, *Arch. Biochem. Biophys.*, 2023, *Just Accepted*.

Development and evaluation of *o*-nitrophenethyl photocaged prodrugs for glioblastoma

J. Vaz[1,*], R. Moreira[2], M. J. Perry[2], L. G. Arnaut[3]

[1]*Faculdade de Farmácia da Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisboa, Portugal*
[2]*Research Institute for Medicines (iMed.ULisboa), Faculdade de Farmácia da Universidade de Lisboa, Av. Prof. Gama Pinto,1649-003 Lisboa, Portugal*
[3]*Chemistry Department, University of Coimbra, 3004-535 Coimbra, Portugal*
**joaomvaz@campus.ul.pt*

Glioblastoma (GBM) stands as the most frequent and deadly form of primary brain tumor, exhibiting a notably poor survival rate. Although advances in our understanding of GBM have allowed some progress, the prognosis remains bleak, presenting a significant societal problem. GBM's resilience against standard therapy and consequential severe side effects persist as substantial obstacles in its treatment.[1]

Photopharmacology emerges as an auspicious drug delivery method, leveraging light to dictate drug release, thereby enhancing precision, and mitigating systemic side effects. Photocages, photoresponsive compounds that liberate a coupled bioactive substance under specific light exposure, represent a powerful advancement in the spatiotemporal control of drug release, especially anticancer drugs.[2,3] Traditionally, photocages were engineered to discharge coupled drugs under UV light, yet this method raises concerns of tissue damage and suffers from limited penetration depth and spatiotemporal resolution. Consequently, the past decade has seen a shift towards the design of photocages activated by visible to near-infrared (NIR) light.

This project seeks to enhance the treatment tolerance and prognosis for GBM patients by designing prodrugs capable of controlled antitumor drug release upon NIR light exposure. We postulate that modifying antitumor drugs with a two-photon-activable protective group allows for precise delivery to GBM cells when irradiated with NIR light, minimizing unintended effects, and enhancing effectiveness.

Within this work, we synthesized *o*-nitrophenethyl photocage derivatives, including a novel photocage from this family featuring a julolidine group as the electron-donor within the second aromatic ring. Furthermore, we achieved our desired photoactivable prodrugs: a photocaged combretastatin A-4 analogue and a photocaged doxorubicin. The mechanism of release of the drug from this class of photocages involves a β-elimination with the release of the drug and of a styrene byproduct (Figure 1). The prodrugs are currently under investigation for their photochemical properties, photorelease kinetics, and activity against cancer cell lines in both irradiated and non-irradiated conditions. Our project's ambition is to promote advances in light-activated cancer therapeutics, possibly triggering breakthroughs in photoactivated chemotherapy.

Figure 1: *o*-Nitrophenethyl photocage class and its mechanism of drug release upon irradiation

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the support provided through UID/04138/2020 and by the PhD Fellowship 2021.04705.BD.

References

1. C. Tan, D. M. Ashley, G. Y. López, M. Malinzak, H. S. Friedman and M. Khasraw, *CA Cancer J Clin*, 2020, **70**, 299–312.
2. L. Josa-Culleré and A. Llebaria, *ChemPhotoChem*, 2021, **5**, 296–314.
3. S. Bonnet, *Dalton Transactions*, 2018, **47**, 10330–10343.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Indicator displacement assays using water-soluble deep cavity cavitands for the detection of benzodiazepines

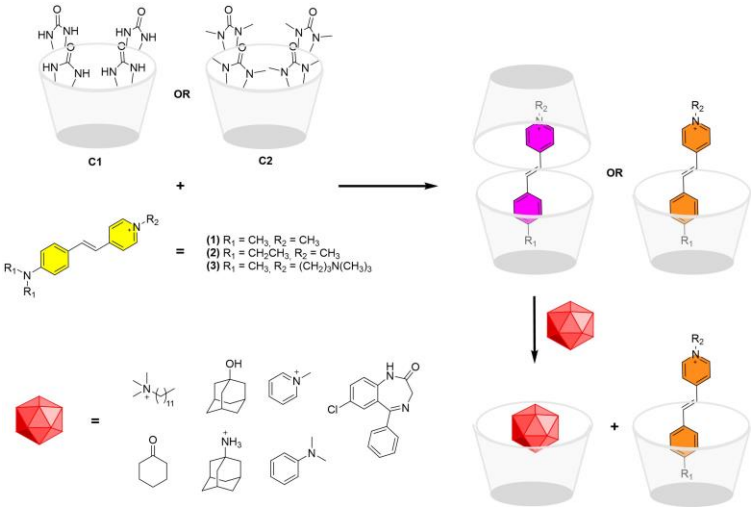
Beatriz Raimundo*, Artur J. Moro, Nuno Basílio

Laboratório Associado para a Química Verde (LAQV-REQUIMTE), Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516, Caparica, Portugal
**b.raimundo@campus.fct.unl.pt*

Cavitands are a class of supramolecular containers with an hydrophobic deep cavity, that have the possibility to encapsulate different hydrophobic molecules and also perform reactions inside of this vessel.[1]

Three styryl merocyanines dyes with different substituents were studied in the presence of two water-soluble cavitands, previously reported by Rebek's group.[2] The results shown that dyes 1 and 2 promote the formation of dimeric capsules with cavitand 1 (C1). The formation of the capsule is driven by 16 intermolecular hydrogen bonds established by the benzimidazolones in the upper rim of C1. In contrast to dyes 1 and 2, dye 3 is long enough to prevent the approximation of the benzimidazolones units, precluding the formation of the capsule. The second cavitand (C2) cannot establish hydrogen bonds and, as such, only half encapsulation is observed for all the dyes (Scheme 1). Therefore, it is possible to manipulate the formation of the capsule, modifying structurally the cavitand or the dye.

Cavitand-dye system was further studied to develop self-assembled chemosensors for the detection of different organic guests that have affinity towards hydrophobic environments, using competitive indicator displacement assays (IDA).[3] Due to the high affinity of the half capsule (K_a > 1x10^6 M^{-1}), we focused on the competitive dissociation of the dimeric capsule which has a lower stability constant. As result of the positive results in the previous IDA, we focus our efforts on the detection of benzodiazepines in aqueous solution, a class of psychotropic drugs used in facilitated sexual assault, in order to have a sensitive chemosensor for this relevant compound.[4]



Scheme 1: Representation of the interaction between cavitands and merocyanines and the respective use in IDAs

Acknowledgements
B. R. thanks Fundação para a Ciência e Tecnologia for a Grant under the program "Verão com Ciência 2022". This work was supported by LAQV (projects UIDB/50006/2020 and UIDP/50006/2020), which is financed by national funds from FCT/MCTES. FCT/MCTES is also acknowledged for the research contract CEECIND/00466/2017 (N.B.), project 2022.02538.PTDC and for NMR Network (ROTEIRO/0031/2013–PINFRA/22161/2016, cofinanced by FEDER through COMPETE 2020, POCI, PORL, and FCT through PIDDAC).

References

1. R. J. Hooley, J. Rebek, *Chem. Biol.*, 2009, **16**, 255–264.
2. S. Mosca, Y. Yu, J. Rebek, *Nat. Protoc.*, 2016, **11**, 1371–1387.
3. A. C. Sedgwick, J. T. Brewster, T. Wu, X. Feng, S. D. Bull, X. Qian, J. L. Sessler, T. D. James, E. V. Anslyn, X. Sun, *Chem. Soc. Rev.*, 2021, **50**, 9–38.
4. H. Druid, P. Holmgren, J. Ahlner, Forensic Sci. Int., 2001, **122**, 136–141.

Pharmaceuticals detection by LC-MS/MS to test materials for (bio)sensors

Mª João Nunes*, João Paulo Noronha, Luis C. Branco

LAQV REQUIMTE, Associated Laboratory for Green Chemistry Department of Chemistry, NOVA School of Science and Technology, NOVA University Lisbon, Campus Caparica, 2829-516 Caparica, Portugal
**mjm.nunes@fct.unl.pt*

Pharmaceuticals contamination in waters is an emerging environmental concern due to their considerable ecotoxicities and associated health issues. NATURIST Project aims to develop (Bio)Sensors based on paper and carbon fiber fabric for pharmaceutical pollutants as new sustainable platforms to ensure fish food safety and monitor ecosystems[1]. Materials that are intended to be tested for sensors are porous organic frameworks nanostructures exclusively performed through eco-friendly and sustainable approaches.
To test different materials that could be used for biosensors in the detection of pharmaceuticals pollutants, it was necessary to develop a simple, rapid and versatile method able of identifying and quantifying pharmaceuticals by ultra high-performance liquid chromatography coupled with multiple-reaction monitoring tandem mass spectrometry (LC-MSMS), considering previous work[2]. Three pharmaceuticals such as Diclofenac, Ciprofloxacin and Enrofloxacin have been selected.
The remaining quantity of pharmaceuticals still present in the water phase, after each extraction/adsorption will be identified and quantified by the developed methodology. LC-MS/MS ion chromatogram of a mixed standard of 50 ppb containing the three pharmaceuticals and its mass labeled of the correspondent standards such as diclofenac, diclofenac-d4, ciprofloxacin, ciprofloxacin-d8, enrofloxacin and enrofloxacin-d5 are also presented (Figure 1). The validation results are presented in this communication.

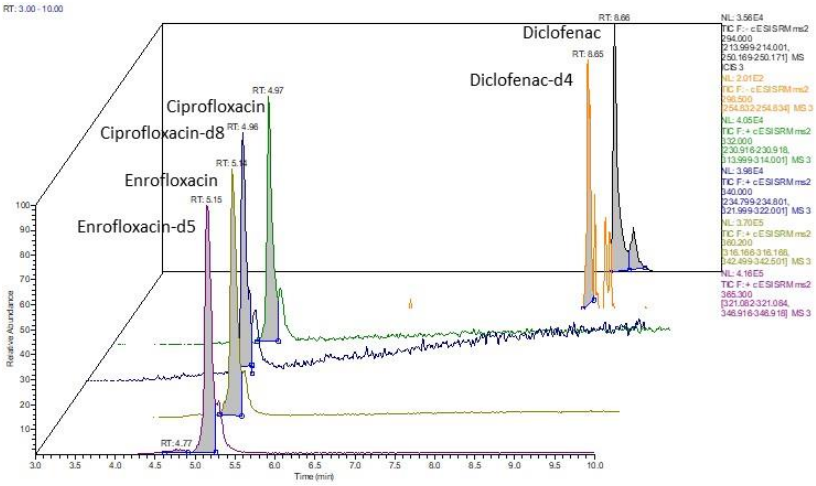


Figure 1: LC-MS/MS ion chromatograms for pharmaceutical and mass labeled standards

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for financial support through Project 2022.07089.PTDC (NATURIST), the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020) and Solchemar company for the financial support of this work. The authors thank the PhD. Student João Paulo Afonso for the help in samples preparation.

References
1. Project NATURIST – (Bio)Sensors based on paper and carbon fiber fabric for pharmaceutical pollutants as new sustainable platforms to ensure fish food safety and monitor ecosystems, 2022.07089.PTDC.
2. M. J. Nunes, V. Paz, C. M. Cordas, J. P. Noronha, L. C. Branco, Anal. Methods, 2022, **14**, 935–948.

OC28

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Ionic systems as additives for energy applications

Luis C. Branco[1,*], Mariana Donato[1,2], João Sarrato[1], Noémi Jordão[1], Paula Branco[1], Hugo Cruz[1], Rogério Colaço[3], Benilde Saramago[2]

[1]LAQV-REQUIMTE, Chemistry Department, NOVA School of Science and Technology, Caparica, Portugal; [2]Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal; [3]IDMEC-Instituto de Engenharia Mecânica, Departamento de Engenharia Mecânica, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal
**l.branco@fct.unl.pt*

Nowadays, the design of alternative and renewable energy technologies is one of the current and most important challenges due to the growth in the energy requirement by the world population demands. For other side, it is estimated that around 23% of the world's total energy consumption comes from tribological contacts, namely due to energy losses during the mechanical movements, which accentuated the need for more efficient lubrication. Ionic systems composed by Ionic Liquids and Eutectic systems exhibit interesting physical-chemical properties such as high chemical and thermal stability, low volatility, large electrochemical window and a great potential to be used for application as electrolytes for energy devices (e.g. solar cells, batteries)[1] as well as alternative lubricants for nano- and microelectromechanical devices.[2]
Herein, two sustainable approaches for application of ionic systems in energy will be described:
a) **Alternative electrolytes** based on Iodide-Based Organic Salts and Ionic Liquid Additives for Dye-Sensitized Solar Cell (DSSCs) and different alkali eutectic systems composed by ethyleneglycol as electrolytes for electrochromic devices and DSSCs.[3,4]
b) **Alternative lubricants** based on Ionic and Eutectic systems including the protic ones based on different organic cations combined with sulfonate anions as additives to the commonly used base oil PEG 200 and assess the tribological performance, namely friction and wear.[5,6] The friction coefficients were measured using steel and silicon spheres against Si surfaces. The most promissory ionic systems showed a good tribological performance, both in terms of friction and wear reduction comparing to commercial lubricant PEG 200 making them very good candidates for future applications in electronic devices.

Acknowledgements
This work was supported by Fundação para a Ciência e Tecnologia (FCT) [projects UID/QUI/50006/2019, UIDB/50006/2020, UID/QUI/00100/2019, UIDB/00100/2020, UIDB/50022/2020 (LAETA), PTDC/QUI-QOR/7450/2020 and MIT-EXPL/CS/0055/2021 and PhD grant SFRH/BD/140079/2018 from Mariana Donato, respectively] and PRR InsectERA project.

References
1. H. Cruz, N. Jordão, A.L. Pinto, M. Dionisio, L.A. Neves, L.C. Branco, *ACS Sustain. Chem. Eng.* 2020, **8**,10653–10663.
2. M.T. Donato, R. Colaço, L.C. Branco, B. Saramago, *J. Mol. Liq.* 2021, **333**, 116004.
3. J. Sarrato, A.L. Pinto, H. Cruz, N. Jordão, G. Malta, P. S. Branco, J.C. Lima, L.C. Branco, *Nanomaterials* 2022, **12**, 2988.
4. H. Cruz, A. L. Pinto, N. Jordão, L.A.Neves, L.C. Branco, *Sustain. Chem.* 2021, **2**, 222-236.
5. M. T. Donato, L. Santos, H. P. Diogo, R. Colaço, L. C. Branco, B. Saramago, *J. Mol. Liq.* 2022, **350**, 118572.
6. M. T. Donato, J. Deuermeier, R. Colaço, L. C. Branco, B. Saramago, *Molecules* 2023, **28**, 2678.

Pharmaceutical organic salts and ionic liquids based on streptomycin and cefuroxime antibiotics

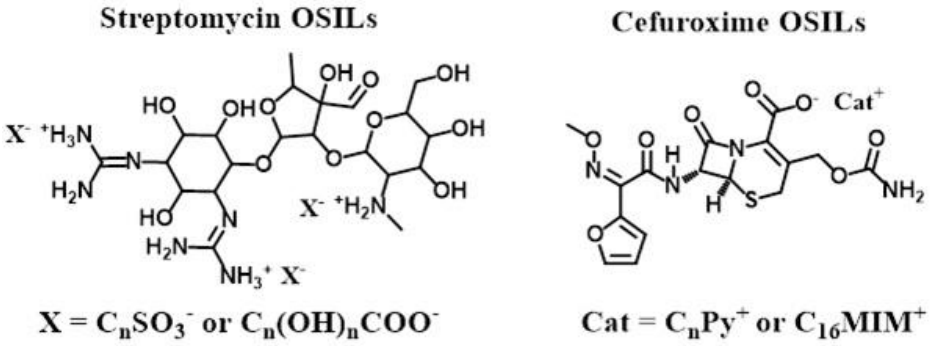
Francisco Faísca[1,2], Paula Gameiro[2], Miguel M. Santos[1], Sofia A. C. Lima[2], Luis C. Branco[1]*

[1]LAQV-REQUIMTE, NOVA School of Science and Technology, 2829-516 Caparica, Portugal
[2]LAQV-REQUIMTE, University of Porto Faculty of Pharmacy, Portugal, 4050-313 Porto, Portugal
f.faisca@campus.fct.unl.pt

Despite huge investments being made in the discovery of novel antimicrobials by big Pharma companies, very limited approvals have been achieved since the early 1960s.[1] To overcome this issue, the association of antibiotics with adjuvants.[2] that enhance established drugs' physicochemical and pharmaceutical properties and/or act at host defense mechanisms or bacteria resistance pathways are very promising. In the last decade, the combination of Active Pharmaceutical Ingredients (APIs) with such adjuvants as Organic Salts and Ionic Liquids (OSILs) has risen in the academia, and has recently reached Pharma, as an alternative to improve the properties of current drugs, in particular bioavailability, chemical and thermal stability, safety and therapeutic efficiency.[3]

In our lab, several antibiotics (β-lactam, fluoroquinolones)[4,5] among others, have been successfully combined as anions and/or cations with biocompatible organic counter-ions, with very interesting chemical and biological improvements being observed.

In this communication, we present the sustainable synthesis and characterization of cationic streptomycin OSILs (STP-OSILs) via direct protonation with a total of 9 sulfonic and carboxylic acids (figure 1), as well as anionic cefuroxime OSILs (CFX-OSILs) synthesized via buffer-assisted neutralization methodology with a total of 5 pyridinium (Py) and imidazolium (MIM) cations (figure 1). Complementary biological studies such as the determination of water solubility and octanol-water partition coefficients, in vitro cytotoxicity on human keratinocytes and 3T3 murine fibroblasts, for STP-OSILs and CFX-OSILs respectively, as well as antimicrobial activity profile against resistant and sensible strains of gram-positive and gram-negative bacteria were performed.



Acknowledgements
This work was supported by FCT/MCTES through projects UIDB/50006/2020, LA/P/0008/2020 and UIDP/50006/2020 of the Associate Laboratory for Green Chemistry – LAQV. Francisco Faísca thanks the doctoral grant (UI/BD/151273/2022.)

References

1. Lewis, K. The Science of Antibiotic Discovery. *Cell* **2020**, *181*, 29–45, doi:10.1016/j.cell.2020.02.056.
2. Wright, G. D. Antibiotic Adjuvants: Rescuing Antibiotics from Resistance. *Trends Microbiol.* **2016**, *24*, 862–871, doi:10.1016/j.tim.2016.06.009.
3. Pedro, S. N.; R Freire, C. S.; Silvestre, A. J. D.; Freire, M. G. The Role of Ionic Liquids in the Pharmaceutical Field: An Overview of Relevant Applications. *Int. J. Mol. Sci.* **2020**, *21*, doi:10.3390/ijms21218298.
4. Ferraz, R.; Silva, D.; Dias, A. R.; Dias, V.; Santos, M. M.; Pinheiro, L.; Prudêncio, C.; Noronha, J. P.; Petrovski, Ž.; Branco, L. C. Synthesis and Antibacterial Activity of Ionic Liquids and Organic Salts Based on Penicillin G and Amoxicillin Hydrolysate Derivatives against Resistant Bacteria. *Pharmaceutics* **2020**, *12*, doi:10.3390/pharmaceutics12030221.
5. Madeira, D.; Alves, C.; Silva, J.; Florindo, C.; Costa, A.; Petrovski, Ž.; Marrucho, I. M.; Pedrosa, R.; Santos, M. M.; Branco, L. C. Fluoroquinolone-Based Organic Salts and Ionic Liquids as Highly Bioavailable Broad-Spectrum Antimicrobials. *Proceedings* **2021**, *78*, doi:10.3390/IECP2020-08649.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Host-guest complexes based on *p*-sulfonatocalix[*n*]arenes and a pyranoflavylium-type dye for dynamic capture of biogenic amines

Ana Sofia Pires[1*], Nuno Basílio[2], Vânia Gomes[1], Nuno Mateus[1], Victor de Freitas[1], Luís Cruz[1]

[1]REQUIMTE/LAQV, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Porto, Portugal;
[2]REQUIMTE/LAQV, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Monte de Caparica, Portugal.
**sofia_pires97@hotmail.com*

Biogenic amines (BAs) are biologically active nitrogen-containing compounds, formed in the normal metabolism of living organisms, during food spoilage process and are key markers of food quality and safety. Since their presence in foods at high levels can cause significant health problems, researchers have been focused on developing novel strategies and methods for early detection/capture of these analytes. Host−guest chemistry is a subfield of supramolecular chemistry focused on molecular recognition (non-covalent binding) of small molecules or ions (guests) by larger receptors (hosts) to form a host−guest complex. These systems allow the modification and control of the physical-chemical properties of the guest molecules, potentially leading to applications in sensing field and drug delivery[1].

The main goal of this work was to develop new host-guest systems based on the complexation of water-soluble sulfonated calix[n]arenes host receptors with positively charged and pH-sensitive pyranoflavylium-based[2] guests. The interactions between the hosts and the pigment towards BAs detection was evaluated by means of UV-Vis, fluorescence, ^{1}H NMR, and ITC techniques.

The dye concentration, host-guest molecular ratio, and working pH was adjusted to promote the highest interaction between the free dye (pK_a 6.72) and the macrocyclic receptors (*e.g.*, p$K_{a\ SC8\text{-}dye}$ 8.45). Overall, the host-flavylium cation complexes were able to detect putrescine/tyramine in phosphate buffer solutions (pH 7.2-7.6) with the simultaneous release of the neutral quinoidal base species of dye to the bulk, resulting in a colorimetric variation from yellow to pink-red. The BAs sensing was further established by fluorescence quenching for the calix[n]arene:dye complexes and fluorescence dye recovery upon the addition of BAs. ^{1}H NMR spectroscopy was used to demonstrate the interaction mode, suggesting an encapsulation-driven process. Overall, these host-guest systems demonstrated significant potential for detecting BAs, one of the most important crucial markers of food deterioration.

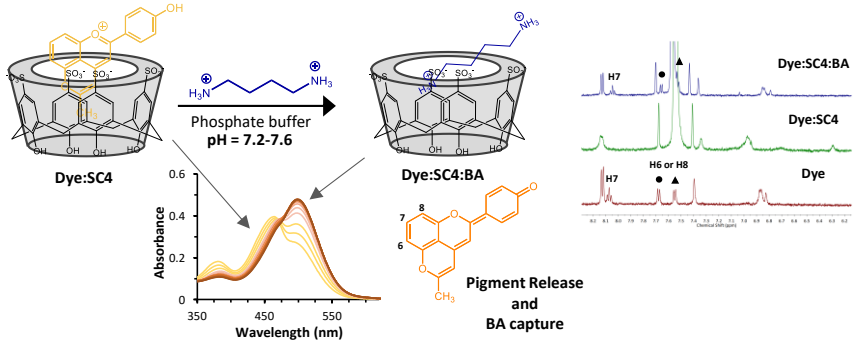


Figure 1: Strategy developed for sensing/capture BAs using molecular switch-type systems.

Funding
This work was supported by PTDC/OCE-ETA/31250/2017—"Novel Anthocyanin-Based Smart Sensors for Food Packaging", supported by national funds by FCT / MCTES and co-supported by Fundo Europeu de Desenvolvimento Regional (FEDER) throughout COMPETE 2020-Programa Operacional Competitividade (POCI-01-0145-FEDER-031250)

Acknowledgements
This work was supported by the Associate Laboratory for Sustainable Chemistry, Clean Processes and Technologies LAQV. The latter is financed by national funds from UIDB/50006/2020. Ana Sofia Pires acknowledges the research grant from the project PTDC/OCEETA/31250/2017. Luís Cruz acknowledges the FCT research contract (DL 57/2016/CP1334/CT0008). Vânia Gomes acknowledges the PhD grant from FCT (SFRH/BD/136556/2018).

References
1. D.-H. Qu, Q.-C. Wang, Q.-W. Zhang, X. Ma and H. Tian, *Chemical Reviews*, 2015, **115**, 7543-7588.
2. L. Cruz, N. Basílio, N. Mateus, V. De Freitas and F. Pina, *Chemical Reviews*, 2021, **122**, 1416-1481.

Exploring photocatalytic properties of titanate hybrid nanotubular materials for sustainable applications

Olinda C. Monteiro

Departamento de Química e Bioquímica, Centro de Química Estrutural - Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa.
ocmonteiro@ciencias.ulisboa.pt

Among the 17 Sustainable Development Goals proposed by the United Nations, great attention is devoted to the need to produce goods and chemicals by use renewable raw materials, to recycle products, and to use renewable or natural sources of energy.
In this framework, nowadays, the search for materials with exceptional performances for water pollution control is a topic of outstanding importance. Several methodologies have been proposed for pollutants removal being the use of nanocrystalline semiconductors on photocatalytic treatment of wastewaters, one of the most interesting methods. Furthermore, the raising up of the UV radiation that reaches the Earth, due to climate change and environmental degradation climate, is currently a global problem that urgently needs to be addressed to not compromise (more) future generations. Therefore, it is also urgent to search for new materials, with UV-filter properties suitable for use as shields/protectors against UV radiation.
In this context, titanate nanotubular materials combines the properties and applications of conventional TiO_2 (e.g. photocatalytic activity) with the properties of layered titanates (e.g. ion exchange ability). Additionally, the intrinsic properties of these 1D materials, namely surface area, good proton and electron conductivities, physical and chemical adsorption ability and photocatalytic properties, make them very promising for photocatalytic applications, including pollutants photodegradation. More recently, the use of hybrid TNTs (Figure 1), to slow down, or to suppress (undesirable) photo-oxidation processes, start to be explored. After use as protective shields, their known photocatalytic properties, for pollutants removal, will contribute to making their discharge in the environment more sustainable and to improve circular economy.
However, to improve TNTs photocatalytic performance under visible solar light irradiation, new sensitization processes are still needed. Therefore, the synthesis of TNTs-based materials with either a broader range of light absorption and/or a lower charge recombination rate would be an important achievement towards the development of successful photoactive materials.
In this presentation, several methodologies, including doping, semiconductor and metal sensitization, that have been used to improve TNTs optical and photocatalytic properties will be described and discussed.

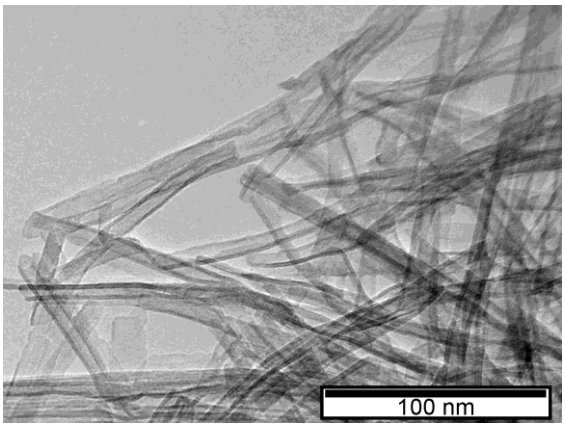


Figure 1: TEM image of titanate nanotubes

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for financial support through projects UIDB/00100/2020 and UIDP/00100/2020 (Centro de Química Estrutural), and LA/P/0056/2020 (Institute of Molecular Sciences). The authors also thank financial support from FCT through project _2022.06165.PTDC.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Realizing the machine learning power for catalysis: the role of small open data

Pedro S. F. Mendes

Departamento de Engenharia Química & Centro de Química Estrutural, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
pedro.f.mendes@tecnico.ulisboa.pt

Machine learning can provide useful black-box models for establishing quantitative relationships when complex phenomena take place, e.g. for structure-properties relationships in catalysis [1,2]. However, to obtain a statistically sound machine learning model, sufficient data is needed. Open science is about breaking barriers to knowledge and has become ubiquitous for public-funded research, such that loads of research data will become available in the years to come. This wealth of data has the potential, thus, to revolutionize catalysis informatics, providing inputs for unprecedent research. However, as a community, we still do not have (i) clear guidelines on how to usefully share data and (ii) machine learning techniques tailored to ensure to make the most out of the data to come. Therefore, the goal of this work is double: (i) provide best open science practices for data sharing and (ii) assess and develop ML techniques tailored to catalysis.
In first part of the study, the recommendations produced by key institutions on open science (e.g. Research Data Alliance and IUPAC) were reviewed leading to a set of guidelines for data sharing in catalysis grounded in the FAIR principles. The stepwise implementation of this common guidelines is believed to ensure in the near future that data sharing will be most beneficial for catalysis (informatics). In that way, the cross-fertilization of open data and the new collaborative catalyst informatics tools behind it will significantly improve the impact of catalysis in the transition to a circular economy.
In the second part, catalysis kinetics datasets were analysed making clear that the lack of (big) data is compensated by the availability of numerous small, scattered datasets as typically found in literature[2]. Therefore, machine learning needed to be adapted to extract most knowledge out of this small data. In particular, to establish the kinetics (i.e. rate equations) of a reaction from experimental data, a methodology was developed to, firstly, automatically recognize physically meaningful trends in catalytic data (Fig. 1b) and, secondly, screen kinetic models to determine the most likely rate equation. This was grounded on the Hougen Watson formalism. The results show that the expected rate equation was recognized in four out of five case studies.

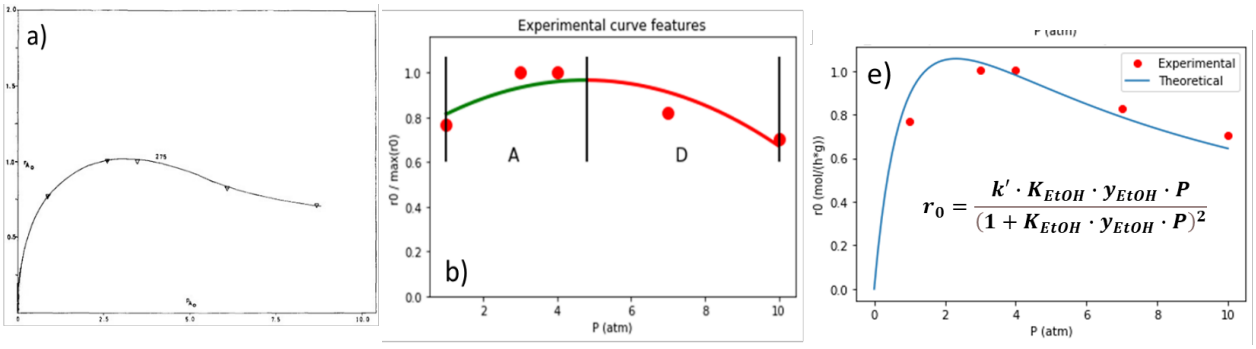


Figure 1: Images of liquid-liquid extraction column with low (left) and high (right) hold-ups

In summary, typical catalytic data does significantly require specific ML models, advising for a robust model selection and fine tuning. Further investigations will determine how the various data characteristics (e.g. correlation between variable) do impact typical machine learning modelling for catalysis and chemistry in general.

Acknowledgements
Pedro Mendes acknowledges all colleagues contributing to various parts of this work, namely Daniel Costa and Filipa Ribeiro at ULisboa and Laura Pirro, Sebastien Siradze, Florence Vermeire, Thibaut Van Haute, and Joris W. Thibaut at UGent. This work has received funding from EU Horizon 2020 under grant agreement no. 101017536.

References
1. Medford, A. J., Kunz, M. R., Ewing, S. M., Borders, T., & Fushimi, R. (2018). ACS Catalysis, 8(8), 7403-7429.
2. Mendes, P. S. F., Siradze, S., Pirro, L., & Thybaut, J. W. (2021). ChemCatChem, 13(3), 836-850.

Extraction, identification, and antioxidant potential of phenolic compounds from stone pine cone

C. M. B. Neves[1,2*], D. Tavares[2], E. Fogeiro[2], A. R. Circuncisão[2], S. M. Cardoso[2], D. F. Wessel[1,2,3]

[1]Polytechnic Institute of Viseu, Agrarian School, 3500-606 Viseu, Portugal; [2]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [3]CITAB Research Centre and Agro-environmental and Biological Technologies of Vila Real, University of Trás-os-Montes e Alto Douro, 5001-801 Vila Real, Portugal
**ferdulcineia@esav.ipv.pt*

Stone pine (*Pinus pinea*) is a coniferous tree native to the Mediterranean basin, which represents a high economic value, mainly due to its pine nuts. It occupies more than 960,000 ha in the Mediterranean region with Portugal, Turkey, Italy, and Spain accounting for over 90%.[1] In Portugal, the stone pine planted area has more than doubled in the last decade, and an annual production of around 414,300 tonnes of cones per year is estimated, of which around 41,000 tonnes are obtained in the Center region.[2] The black pine nut represents approximately 15% of the cone mass, and after its removal, a high amount of remaining pine cone is mostly discarded without using its potential. The pine cone obtained as a by-product of the pine nuts processing industry may be a source of valuable secondary metabolites, such as resin acids, terpenes, and phenolic compounds, which can have high-value applications due to their biological properties and beneficial health effects. To our knowledge, the studies on the phytochemical composition of stone pine cones is limited to the essential oil,[3] and lipophilic extractives.[4] The phenolic composition of pine cones from other pine species has been described,[5] however information for *P. pinea* species is limited to other components of stone pine such as the bark.[6]

In this work, phenolic compounds were recovered from discarded stone pine cones through the preparation of extracts obtained by conventional and ultra-sound extraction. Different conditions were tested, namely the solvent and temperature, to maximize the content of bioactive compounds. The content of total phenolic compounds in the extracts was quantified using the Folin-Ciocalteu colorimetric method and the identification of individual phenolic compounds was performed by UHPLC-DAD-ESI/MS^n. Extracts showed a total phenolic content ranging from 185.38 to 400.59 mg GAE/g dry extract and were mainly composed of procyanidins, phenolic acids, catechin, and taxifolin. The cone extracts were evaluated for their *in vitro* antioxidant and anti-inflammatory potentials. The extracts showed high radical scavenging activities against the cation radical 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic) ($ABTS^{\bullet+}$), nitric oxide radical ($NO^{\bullet}$), and superoxide anion radical ($O_2^{\bullet-}$).

Overall, this work opens perspectives in the use of a low-value by-product through the recovery of phenolic compounds with biological properties that can be used as valuable natural ingredients in food, nutraceuticals, or cosmetics, contributing to economic valuation in the stone pine value chain.

Acknowledgements
The authors thank the financial support from PT national funds (FCT/MCTES, Foundation for Science and Technology and Ministry of Science, Technology and Higher Education) to LAQV-REQUIMTE through the projects UIDB/50006/2020 and UIDP/50006/2020 and to CITAB through the project UIDB/04033/2020. This work was funded by the project Forest4Future PP21 – Pilot project for the valorization of pine cone and pine nuts (CENTRO 08-5864-FSE-000031) and by the proof of concept Pineaceutic with award-winning funding within the scope of INOVC+ project actions (CENTRO-01-0246-FEDER-000044) supported by Central Region Operational Program (CENTRO 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF).

References

1. S. Mutke, C. Guadaño, S. Iglesias, D. Leon, S. Arribas, J. Gordo, L. Gil and G. Montero. Proceedings of the Options Méditerranéennes, Series A: Mediterranean Seminars, 2017.
2. INE, Instituto Nacional de Estatística, Data Relating to Agricultural Censuses Carried out in Portugal in 1989, 1999, 2019.
3. F. Macchioni, P. L. Cioni, G. Flamini, I. Morelli, S. Maccioni, and M. Ansaldi, Flavour Fragr. J., 2003, **18**, 139–143.
4. A. Kilic, H. Hafizoglu, I. E. Dönmez, I. Tümen, H. Sivrikaya, M. Reunanen and J. Hemming, Eur. J. Wood Wood Prod., 2011, **69**, 37–40.
5. L. Wang, X. Li, and H. Wang, Int. J. Biol. Macromol.,2019, **126**, 385-391.
6. P. A. B. Ramos, C. Pereira, A. P. Gomes, R. T. Neto, A. Almeida, S. A. O. Santos, A. M. S. Silva and A. J. D. Silvestre, Appl. Sci., 2022, **12**, 784.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Dynamic G-quadruplex based perfusable supramolecular hydrogels embedded in photo-cross-linkable matrices for bioapplications

J. Borges*, V. Sousa, A. J. R. Amaral, E. J. Castanheira, I. Marques, J. M. M. Rodrigues, V. Félix, J. F. Mano

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
**joaoborges@ua.pt*

DNA is a ubiquitous macromolecule in nature that has been widely used to precisely assemble a library of complex, dynamic and adaptive supramolecular nanoarchitectures with emergent properties and (multi)functionalities. Among them, G-quadruplexes are noncanonical four-stranded self-assembled structures formed in guanine-rich DNA and RNA sequences within cells that have attracted considerable interest owing to their unique self-assembled features and multiple biological roles.[1-3] Such bioinspired supramolecular structures are developed by the self-recognition of guanines into stacked tetrads, formed by the Hoogsteen-type hydrogen bonding interactions between four guanines and stabilized by alkali metal cations.
Herein, a novel dynamic hyaluronic acid (HA)-functionalized G-quadruplex based multicomponent supramolecular hydrogel will be presented via a combined experimental-computational study by exploring the hydrogen bonding and *π-π* interactions between four guanosines coupled *via* dynamic boronate ester bonds to 3-aminophenylboronic acid-functionalized HA and stabilized by K^+.[4] The self-healing, thermos-responsive, injectable, and conductive properties of the hydrogel will be discussed, and its well-known instability explored to produce interconnected, size- and shape-tunable perfusable microchannels when embedded in virtually any kind of photo-cross-linkable supporting matrices (Figure 1). The higher number of viable cells denoted by the microchannel-embedded 3D constructs when compared to the 3D bulk construct and their migration towards the perfusable microchannels will be showcased aiming for being use as artificial vessels for enabling the diffusion of nutrients and oxygen essential for cell survival. The versatility imparted by the proposed approach is expected to open new avenues in drug/therapeutics delivery, tissue engineering and regenerative medicine.

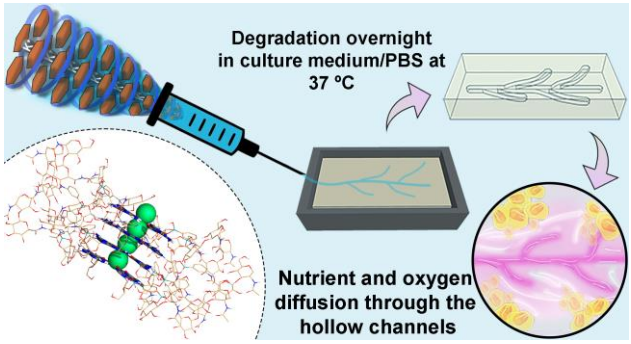


Figure 1: Schematic representation of perfusable 3D constructs obtained by the supramolecular self-assembly of HA-functionalized G-quadruplex hydrogels used as sacrificial materials.

Acknowledgements
This work was funded by the European Union's Horizon Europe research and innovation programme under the grant agreement No. 101079482 ("SUPRALIFE"), as well as by the Programa Operacional Regional do Centro-Centro 2020 (Component FEDER) and national funds (FCT/MCTES) in the scope of the project "SUPRASORT" (PTDC/QUI-OUT/30658/2017, CENTRO-01-0145-FEDER-030658). The financial support by FCT through the PhD grants (2020.06771.BD, V.S.; SFRH/BD/144880/2019, E.J.C.), and Junior (CEECIND/01363/2018, J.M.M.R.) and Assistant Researcher contracts (2020.00758.CEECIND, J.B.) is gratefully acknowledge. This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). Part of the MD simulations were performed on the BOB supercomputing cluster installed at MACC, under FCT, I.P. Advanced Computing Project CPCA/A1/470074/2021.

References
1. D. Rhodes and H. J. Lipps, *Nucleic Acid Res.*, 2015, **43**, 8627-8637.
2. D. Varshney, J. Spiegel, K. Zyner, D. Tannahill and S. Balasubramanian, *Nat. Rev. Mol. Cell Biol.*, 2020, **21**, 459-474.
3. G. M. Peters and J. T. Davis, *Chem. Soc. Rev.*, 2016, **45**, 3188-3206.
4. V. Sousa, A. J. R. Amaral, E. J. Castanheira, I. Marques, J. M. M. Rodrigues, V. Félix, J. Borges and J. F. Mano, *Biomacromolecules*, 2023, DOI: 10.1021/acs.biomac.3c00433.

BASHY platform: Bioimaging and therapeutics

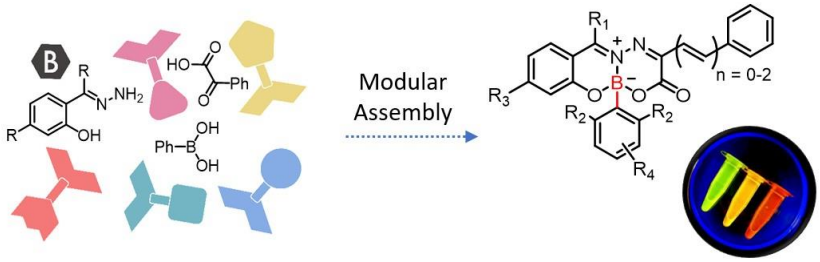
F. M. F. Santos[1,*], J. F. Felicidade[1], S. Baldo[1], U. Pischel[1,2], P. M. P. Gois[1]

[1]Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisbon, Portugal; [2]CIQSO – Centre for Research in Sustainable Chemistry and Department of Chemistry, University of Huelva, Campus de El Carmen s/n, 21071 Huelva, Spain
**fabiosantos1@campus.ul.pt*

The search for modular approaches that enable the preparation of electronically tunable and responsive fluorophore platforms has become crucial for the development of functional dyes used in bioimaging applications. In this context, numerous highly fluorescent probes, such as BODIPYs, have been extensively investigated. BODIPYs have emerged as an important class of dyes with a wide range of applications, due to their exceptional photophysical properties.[1] The success of this dye family has triggered the interest in the design of fluorescent molecules incorporating a central boron atom coordinated to π-conjugated ligands, including tetracoordinate organoboron complexes, some of which have exhibited high fluorescence.[2] In many of these molecular frameworks, the boron atom plays a crucial role by stabilizing the ligand and promoting planarity, conjugation, and charge transfer throughout the π system of the dye.[3]

Hence, it is surprising that boronic acids (BAs), which are widely available and structurally diverse, have generally been overlooked as useful building blocks for the assembly of fluorescent probes. The disregard for BAs as conformational components may indicate certain challenges in the modular construction of fluorescent probes based on this functionality. BAs are known to form fluorescent complexes through chelation with bidentate ligands. However, due to the reversible nature of the chelation process, the resulting B-complexes often lack the long-term stability required for their application as functional dyes.[4] On the other hand, chelation of boronic acids with tridentate ligands leads to more stable B-complexes, but at the expense of their fluorescent properties, as the central boron atom adopts an out-of-plane tetrahedral geometry.[5] The properties of BAs offer new opportunities in the discovery of novel fluorescent supramolecular architectures, as this functionality can be used to rigidify unexplored structures of tridentate π-conjugated ligands.

With this concept in mind, a modular and fluorescent boron-based platform (BASHY dyes) was developed (Scheme 1). These dyes possess a promising range of photophysical properties, including high photostability, absorption at wavelengths greater than 450 nm, high molar absorption coefficients (up to 70,000 $M^{-1}cm^{-1}$), two-photon absorption and a polarity-dependent emission in the green-to-red spectral range. Due to this unique combination of features and their low toxicity, BASHYs have been used in various bioimaging studies, such as the imaging of lipid droplets, astrocytic cells, myelin debris, cell apoptosis, and also as fluorescent linker in bioconjugates.[6]



Scheme 1: Modular and fluorescent BASHY platform.

Acknowledgements
We acknowledge the financial support from Fundação para a Ciencia e a Tecnologia (FCT), Ministério da Ciência e da Tecnologia, Portugal (iMed.ULisboa UIDB/04138/2020; SAICTPAC/0019/2015, PTDC/QUI-QOR/29967/2017); LISBOA-01-0145-FEDER-029967, LISBOA-01-0145-FEDER32085, and PTDC/QUI OUT/3989/2021.

References

1. G. Ulrich, R. Ziessel and A. Harriman, *Angew. Chem. Int. Ed.* 2008, **47**, 1184 – 1201.
2. Y-L. Rao and S. Wang, *Inorg. Chem.* 2011, **50**, 12263–12274.
3. D. Frath, J. Massue, G. Ulrich and R. Ziessel, *Angew. Chem. Int. Ed.* 2014, **53**, 2290 – 2310.
4. J.W. Tomsho and S.J. Benkovic, *J. Org. Chem.* 2012, **77**, 2098 – 2106.
5. R. Chan-Navarro *et al.*, *Dye. Pigment.* 2013, **99**, 1036 – 1043.
6. Selected examples: a) F.M F. Santos *et al.*, *Chem. Eur. J.* 2016, **22**, 1631; b) F.M.F. Santos *et al.*, *ChemPhotoChem* 2018, **2**, 1038; c) F.M.F. Santos *et al.*, *Chem. Eur. J.* 2020, **26**, 14064.

New chitin derived furanic platforms as bio-based synthons

Rafael F. A. Gomes,[1,2]* Bruno M. F. Gonçalves,[1] Késsia H. S. Andrade,[1] Bárbara B. Sousa,[2,3] Nuno Maulide,[4] Gonçalo J. L. Bernardes,[2,3]* Carlos A. M. Afonso[1]*

[1]Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisbon, Portugal; [2]Yusuf Hamied Department of Chemistry, University of Cambridge CB2 1EW Cambridge, United Kingdom; [3]Instituto de Medicina Molecular, João Lobo Antunes Faculdade de Medicina da Universidade de Lisboa 1649-028 Lisboa, Portugal; [4]Institute of Organic Chemistry, University of Vienna, 1090 Vienna, Austria
**rafael.gomes@campus.ul.pt*

The demand for new biomass-derived fine and commodity chemicals propels the discovery of new methodologies and synthons. Amongst the several examples, furanic platforms obtained from lignocellulosic biomass have emerged as a cornerstone for the sustainable development of new valuable chemicals, as a replacement for oil-based products, and as a starting material for the preparation of "drop-in" chemicals. In fact, furfural is currently being produced in over 250 kTonne/year with over 80 synthons being prepared from it.[1] Despite this, a major limitation of these furans is the lack of nitrogen (Figure 1A). Often introducing external nitrogen requires non-sustainable sources, the most common being ammonia. Knowing that circa 1.5% of the total world energy consumption is used to produce ammonia, which is then introduced in fine and commodity chemicals, several academia and industry-based groups have turned their attention to nitrogen-rich biomass sources.[2,3] Besides lignocellulosic biomass, chitin is one of the most abundant waste byproduct. Whereas furfural and 5-hydroxymethylfurfural are cornerstones of sustainable chemistry, 3-acetamido-5-acetyl furan (3A5AF), an N-rich furan obtained from chitin biomass, remains unexplored. This may be explained for the lack of efficient and simple methods for its preparation, amoung other reasons. Here we developed novel routes for acetamido furans, such as 3A5AF and 3-acetamido-5-furfuryl aldehyde (3A5F), and demonstrated the utility of these synthons as a source of bio-derived nitrogen-rich heteroaromatics, carbocycles, and as a bioconjugation reagent (Figure 1B).[3]

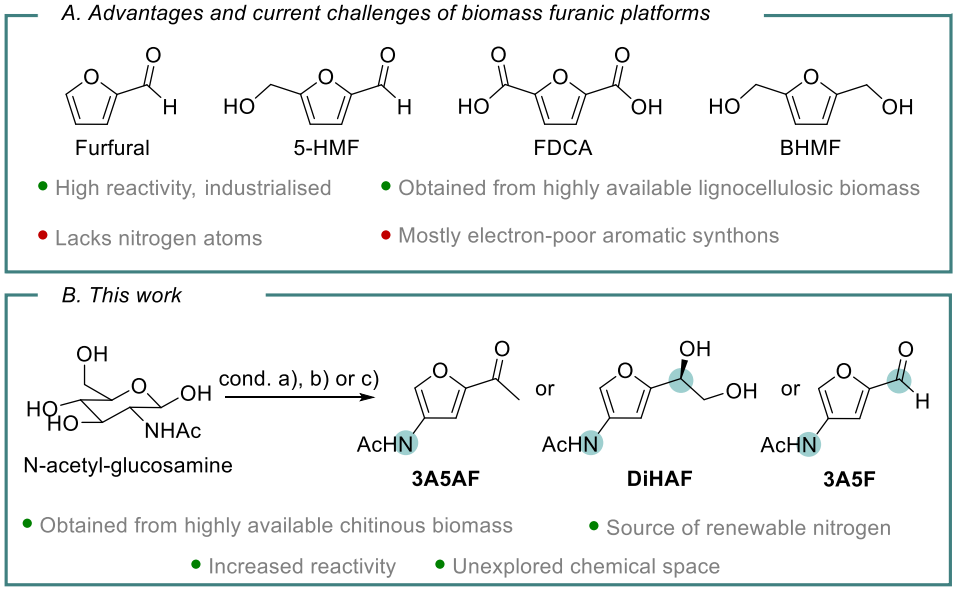


Figure 1: Overview of biomass derived furanics.

Acknowledgements
The authors acknowledge Fundação para a Ciência e Tecnologia (FCT) for financial support (PTDC/QUI-QOR/32008/2017, UIDB/04138/2020, UIDP/04138/2020). Doctoral FCT studentship SFRH/BD/143583/2019 to B.B.S and SFRH/BD/148211/2019 to K.H.S.A. The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 951996.

References
1. L. T. Mika, E. Cséfalvay, Á. Németh, Chem Rev 2018, **118**, 505–613.
2. M. Appl, in Ullmann's Encyclopedia of Industrial Chemistry, 2011.
3. X. Zhang, E. A. Davidson, D. L. Mauzerall, T. D. Searchinger, P. Dumas, Y. Shen, Nature 2015, **528**, 51–59.
4. Rafael F. A. Gomes and coworkers, Angewandte Chemie – VIP, 2023, Accepted Article, DOI:10.1002/anie.202304449

C_2 hydrocarbons production via oxidative coupling of methane over ABO_3 perovskites (A = La, Pr, Sm, Dy, Yb and B = Mo, Mn, Ga and In)

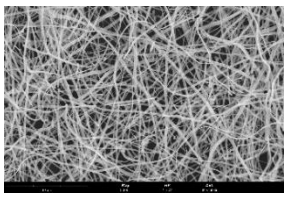
Joana F. Martinho[1,*], Joaquim B. Branco[1,2], Ana C. Ferreira[2]

[1]Centro de Química Estrutural, Institute of Molecular Sciences, Lisbon, Portugal; [2]Departamento de Engenharia e Ciências Nucleares Instituto Superior Técnico, Universidade de Lisboa, Campus Tecnológico e Nuclear, Estrada Nacional 10, ao km 139.7, 2695-066 Bobadela, Portugal

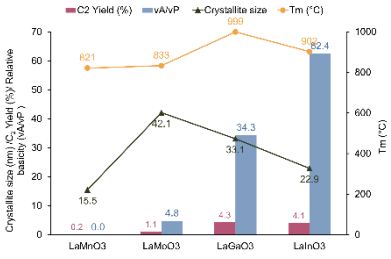
**joana.martinho@ctn.tecnico.ulisboa.pt*

Methane and nitrous oxide are by-products that arise from industrial processes with a notorious harmful impact on the environment. Methane is also a known player in the energetic sector and N_2O has proven to be a valuable reactant in some oxidation processes, such as OCM.[1, 2] Nowadays, the oxidative coupling of methane (OCM) emerges as a crucial approach for the direct methane conversion into higher hydrocarbons, such as ethane and ethylene and the type of oxidant seems to play a key role.[3] However, the development of a catalyst with enhanced high temperature stability is a major challenge that is yet to be addressed. Perovskites (ABO_3) are a class of materials widely used as catalysts for methane conversion reaction and oxidation reactions of various compounds, and their structural and chemical properties make them ideal candidates for the OCM reaction. It was expected that the oxygen behavior and the properties of the surface oxygen species of the catalyst could be easily controlled through the substitution of the A and B site elements.[4,5] Therefore, the main objectives of this work were: i) the synthesis and characterization of nanostructured perovskites of the type ABO_3 (A = La, Pr, Sm, Dy and Yb; B = Mo, Mn, In and Ga) and ii) the correlation of their catalytic behavior on OCM, using nitrous oxide as an oxidant, aiming C_2 production, with their intrinsic properties.

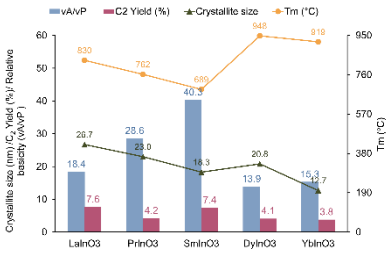
Perovskites were prepared by the electrospinning technique and the epoxide addition method aiming at the synthesis of compounds with different morphologies (nanofibers and nanoparticles, respectively). Figure 1a shows a selected SEM image of the obtained nanofibers. It was also observed that the catalytic performance of the nanostructured perovskites is influenced by both the d- and f-block element, as illustrated in Figure 1b and c, respectively. The best results were those obtained over lanthanum, indium, and gallium. Their catalytic behavior depends not only on their redox (Tm) and acid-base properties (vA/vP), but also on their crystallite size. The combination of a higher lattice oxygen mobility (lower Tm) and higher basicity (higher vA/vP) enhances the catalysts activity. Furthermore, the perovskites' catalytic behavior proved also to be dependent on their morphology, where the nanofibers showed an enhanced C_2 yield when compared to the aerogels.



a) SEM image of $LaInO_3$



b) OCM: d-block element effect



c) OCM: f-block element effect

Figure 1. SEM and OCM behavior over ABO_3 (A = La, Pr, Sm, Dy and Yb; B = Mo, Mn, In and Ga).

Acknowledgements

Joana F. Martinho acknowledges FCT for the PhD grant (2021.05472.BD).

References

1. Jones, M. W., et al; *Sci Data* **2023**, 10, 155.
2. Ferreira, A. C., et al; *Mol. Catal*. **2017**, 443, 154-164.
3. Schwach, P. et al. *Chem. Rev*. **2017**, 117(13), 8497-8520.
4. Moure C., et al; *Prog. Solid State Ch.* **2015**, *43*, 123-148.
5. Helen Annal Therese, G. et al; *J. Appl. Electrochem* **2005**, *35*, 459-6

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Extracting zeolite preparation data from scientific papers in PDF automatically

D. P. Costa*, M. L. Frazão, M. F. Ribeiro, P. S. F. Mendes

Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, Lisbon 1049-001, Portugal
daniel.pereira.costa@tecnico.ulisboa.pt

Zeolites are crystalline aluminosilicate used in different catalytic processes as catalysts, but their characteristics are not straightforward to tune since the physical processes that occur during the zeolite synthesis are very complex and difficult to describe.[1] Due to their complex nature a machine learning model correlating the preparation conditions with the zeolite properties would be the perfect approach to describe the zeolite preparation. To create such model, a large amount of data would be needed. Such data is scattered through literature that is doubling every 5 years.[2] The zeolite field is not an exception, with 24 708 papers found searching for "Zeolite Synthesis" in *Web of Knowledge* (12/06/2023). The data needed can be presented in different parts of the article like text, tables and figures. Scientific publications are published in PDF, which is not a machine-readable type of format. Hence, this work produced a pipeline that allows the extraction of data from scientific publications in PDF to be used in machine learning models.

The first part of the pipeline, named PDF Transformer, transforms a PDF document into various JSON files, a format that is machine-readable and can be analyzed by all programming languages. Each JSON file contains information about a different part of the article, (i) the text body, (ii) metadata, (iii) references and (iv) tables, figures and their respective legends. The metadata and references are extracted using specific open-source python libraries and software, while the text body, table and images are extracted using masks that can visually identify and distinguish different parts of the article. An example of the pipeline output is represented in Figure 1. The output of the PDF Transformer can be further analyzed using simply keyword searching or advanced text-mining techniques to extract information.

To test the pipeline reference datasets like *TableBank,* Pub1M were used to test the table detection and table structure detection achieving accuracy scores over 95%. The arXiv repository was used to test the extraction of metadata, being able to extract the *doi* correctly more than 99% of the time. A handmade dataset containing 68 articles about zeolites was used to evaluate the overall performance of the pipeline. In this dataset it was observed that tables and text are successfully retrieved in more than 90% of the cases, being the error cases mostly in old papers that have been digitalized with OCR and have bad quality. We have used the pipeline to extract data about the desilication, a post preparation treatment, of ZSM-5 zeolite. In this use case, a keyword search was used to identify the experimental part and relevant tables containing the zeolite properties. This way, an initial dataset from V. Blay *et al.*[3] containing 116 experimental points was increased to 237. Then, this improved dataset was used to create machine learning models, correlating the properties of the initial zeolite and the treatment conditions with the properties of the final zeolite.

In conclusion the pipeline developed can be used to extract data from scientific papers and create datasets to train machine learning models. This will describe complex processes like zeolite preparation to better guide the design of such materials.

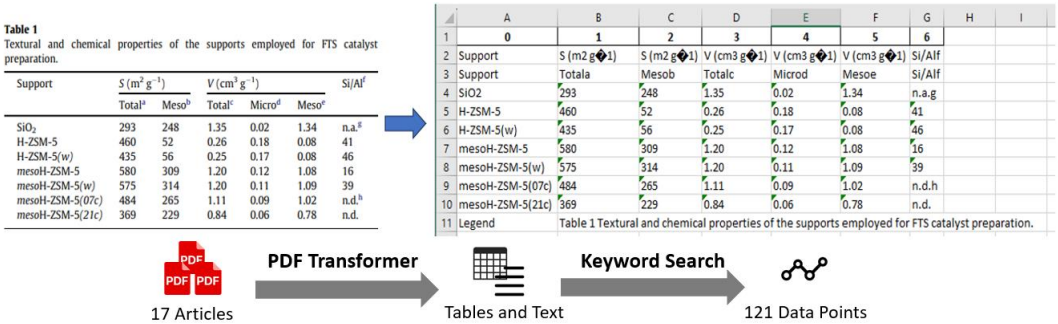


Figure 1: Output of an extracted table and diagram about the mining of

Acknowledgements
We thank to Fundação para a Ciência e Tecnologia (FCT) for funding PhD scholarship nr. 2022.11605.B

References

1. T. Derbe, S. Temesgen and M. Bitew, *Adv. Mater. Sci. Eng.*, , DOI:10.1155/2021/6637898.
2. P. O. Larsen and M. von Ins, *Scientometrics*, 2010, **84**, 575–603.
3. V. Blay, T. Yokoi and H. González-Díaz, *J. Chem. Inf. Model.*, 2018, **58**, 2414–2419.

Natural Deep Eutectic Solvents from fundamentals to applications

M. E. Rodruigues[1], L. K. Ashqer[1], L. Al Fuhaid[1], A. Rousseva[1], F. Tavares[1], M. F. Nava-Ocampo[1], R. Verpoorte[2], Y. Choi[2], S. S. Bucs[1], L. Fortunato[1], J. Vrouwenvelder[1], G. J. Witkamp[1], A. S. F. Farinha[1,*]

[1]Water Desalination and Reuse Center, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia.
[2]Institute Biology Leiden, Leiden University, Leiden, The Netherlands.
**andreia.farinha@kaust.edu.sa*

Natural deep eutectic solvents are a new class of green solvents with unique physicochemical properties that distinguish them from conventional solvents[1,2] These natural solvents are prepared by mixing two or more primary metabolites in specific ratios, forming a liquid with a melting point substantially lower than its constituents. NADES can be used as green solvents for different applications, for example, from conservation of biological samples to biomolecule extraction.[3]
In this communication we will be discussing our work in fundamental characteristic of hydrophilic and hydrophobic NADES, preparation, characterizations and stability (Figure 1).[4] We will also discuss the use of such solvents in different applications, such as biofilm cleaning and as agents to extract concentrate trace metals from waters.[5]

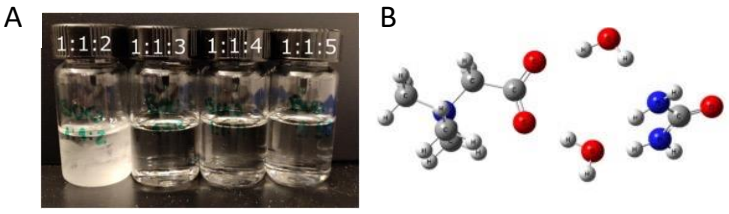


Figure 1: A) Betaine:Urea:Water mixture at different water molar ratios starting from 1:1:2 up until 1:1:5; and **B)** structural conformations of B:U:W 1:1:2 based on the minimum energy obtained by computational modelling. All the atoms are represented in different colors: oxygen (red), hydrogen (light grey), carbon (dark grey) and nitrogen (blue).

Acknowledgements
The team thanks the King Abdullah University of Science and Technology (KAUST) and Water Desalination and Reuse Center (WDRC) for all the support in the developing of our research.

References

1. Y. H. Choi, J. van Spronsen, Y. Dai, M. Verberne, F. Hollmann, I. W.C.E. Arends, G. J. Witkamp, R. Verpoorte, Plant Physiol. **2011**,1701.
2. Q. Zhang, K. De Oliveira Vigier, S. Royer and F. Jérôme, Chem. Soc. Rev., **2012**, 41, 7108.
3. Y. Dai, J. van Spronsen, G. J. Witkamp, R. Verpoorte and Y. H. Choi, Anal. Chim. Acta, **2013**, 766, 61.
4. M. F. Nava-Ocampo, L. Al Fuhaid, A. Santana, S. S. Bucs, R. Verpoorte, Y. Hae Choi, G. J. Witkamp, J. S. Vrouwenvelder, A. S. F. Farinha, Journal of Molecular Liquids, **2021**, 117655.
5. M. F Nava-Ocampo, L. Al Fuhaid, R. Verpoorte, Y. Hae Choi, M. CM van Loosdrecht, J. S. Vrouwenvelder, G. J. Witkamp, A. S. F. Farinha, S. S. Bucs, Water Research, **2021**, 117323.

Biorecovery of critical elements from fluorescent lamp wastes using the marine macroalga *Ulva* sp.

João Pinto*, João Colónia, Nicole Ferreira, Thainara Viana, Daniela Tavares, Jéssica Jacinto, Bruno Henriques, Eduarda Pereira

Department of chemistry, University of Aveiro, Aveiro, Portugal; LAQV-REQUIMTE – Associated Laboratory for Green Chemistry, University of Aveiro, Aveiro, Portugal
**joao.pedro.pinto@ua.pt*

Intensive efforts have been made by the scientific community to capitalize on the recovery of technologically critical elements such as the Rare Earth Elements (REE) from waste and to reduce the environmental, economic, and societal impacts currently associated with their mining and processing. However, there is still a lack of environmentally friendly and efficient techniques for their recovery.[1] Biosorption has been proposed as a cheap, simple and environmentally friendly technique for pre-concentration of REE from wastes such as fluorescent lamp waste (FLW), a promising target for the recycling of these elements due to its abundance and high concentrations of different REE.[2]

The present study evaluated the potential of fresh *Ulva* sp. to remove and pre-concentrate Yttrium (Y) from real FLW. The initial waste consisted mainly of yttrium oxides (49%) and calcium hydroxides/phosphates (23%). Sorption was studied in a dilute solution obtained by acid leaching of FLW with 2 M HNO_3 and under different conditions of salinity (10 – 30), initial element concentration (20 – 120 mg L^{-1}), and sorbent dosage (3 – 9 g L^{-1}). The experiments follwed a Box-Behnken design (Figure 1) and the results were modelled using the response surface methodology. Lower salinity and higher sorbent mass improved sorption efficiency (max. removal of 52% and 32% for initial concentrations of 20 and 120 mg L^{-1}). Higher Y concentrations accelerated the sorption kinetics, reaching equilibrium after 3 h. The Y accumulated on the algal tissue (maximum of 22 mg g^{-1}) was not affected by the algal dosage. The results show that the sorption parameters can be further optimized, highlighting the potential of algal sorbents in the recovery of REE from real waste. Including *Ulva* sp. biosorption into an Y recovery process can thus contribute to a green and circular economy, and offset the negative effects of primary ore mining.

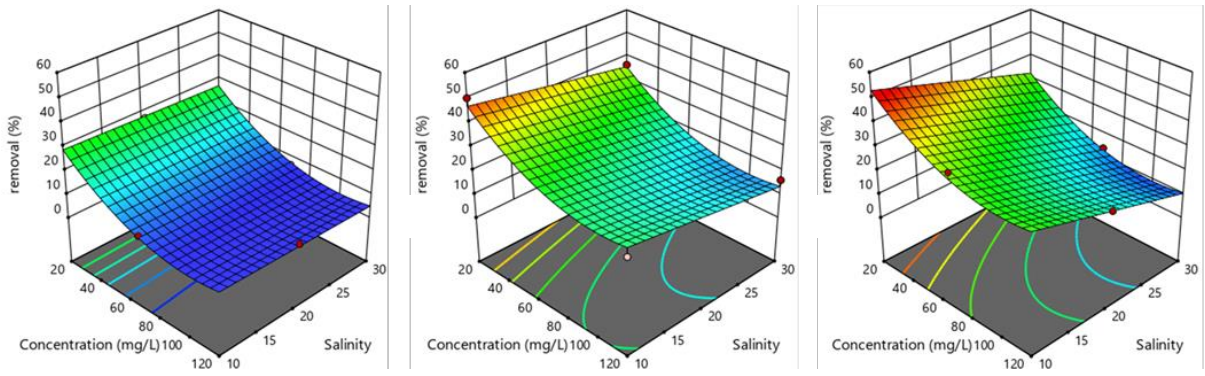


Figure 1. Surface responses for the removal (%) of Y with algal dosages of 3 g L^{-1} (left), 6 g L^{-1} (center) and 9 g L^{-1} (right).

Acknowledgements
Bruno Henriques acknowledges FCT for the research contract (CEECIND/03511/2018) under the CEEC Individual 2018, while João Pinto and Jessica Jacinto acknowledge their PhD grant (2020.05323.BD and UI/BD/151290/2021, respectively). Thanks are also due to the financial support to REQUIMTE (UIDB/50006/2020) to FCT/MEC through national funds, and the co-funding by the FEDER, within the PT2020 Partnership Agreement and Compete 2020.

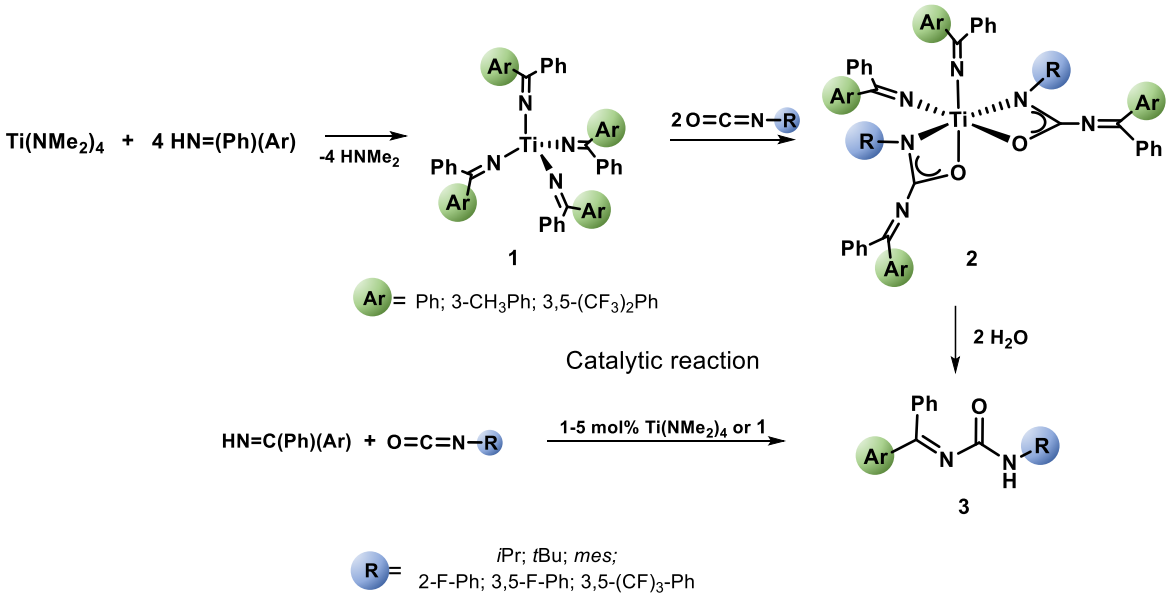
References
1. Rodríguez-Padrón, D., ALOthman, Z.A., Osman, S.M., Luque, R. Recycling electronic waste: Prospects in green catalysts design. Curr. Opin. Green Sustain. Chem. 25 (2020) 100357.
2. Yurramendi, L., Gijsemans, L., Forte, F., Aldana, J.L., del Río, C., Binnemans, K. Enhancing rare-earth recovery from lamp phosphor waste. Hydrometallurgy 187 (2019) 38–44.

Titanium-catalysed synthesis of Imineureas

César P. Reis*, Vânia André, Ana M. Martins, Pedro Pinheiro, Maria João Ferreira

Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001, Lisboa, Portugal
**cesarpifrereis@tecnico.ulisboa.pt*

Imineureas are interesting compounds that find applications in industry and pharmacology.[1] We report here the titanium-catalysed synthesis of these compounds using ketimide supported complexes.[2,3]
[$Ti(NMe_2)_4$] reacts with 4 equiv. of HN=C(Ph)(Ar) (Ar = Ph; 3-CH_3Ph; 3,5-$(CF_3)_2$Ph) to afford complexes **1** (Scheme 1) in good yield When coordinated to titanium, ketimide ligands are susceptible to attack by isocyanates, a reactivity pattern that is similar to one previously reported for thorium.[4] This led to the isolation of complexes **2**, with two inserted ketimide ligands (Scheme 1). The new ligands formed in these complexes can be released with the addition of a proton source (H_2O or $HN=CPh_2$), leading to the formation of the imineurea (**3**) (stoichiometrically or catalytically, respectively). The catalytic reaction also works in the presence of commercially available $Ti(NMe_2)_4$ (Scheme 1).



Scheme 1: Pathway reaction for the formation of **3**

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for a fellowship to C.P.R. (PD/BD/152271/2021). Centro de Química Estrutural (CQE) and Institute of Molecular Sciences (IMS) acknowledge the financial support of Fundação para a Ciência e Tecnologia (Projects UIDB/00100/2020, UIDP/00100/2020, and LA/P/0056/2020, respectively).

References
1. R. Ronchetti, G. Moroni, A. Carotti, A. Gioiello, E. Camaioni, RSC Med. Chem. 2021, **12**, 1046–1064.
2. M. J. Ferreira, A. M. Martins, Coord. Chem. Rev. 2006, **250**, 118–132.
3. K. Naktode, J. Bhattacharjee, H. P. Nayek, T. K. Panda, Inorganic Chemistry, 2016, **55**, 1142-1153.
4. E. Lu, W. Lewis, A. J. Blake, S. T. Liddle, Angew. Chemie-Int. 2014, **53**, 9356–9359.

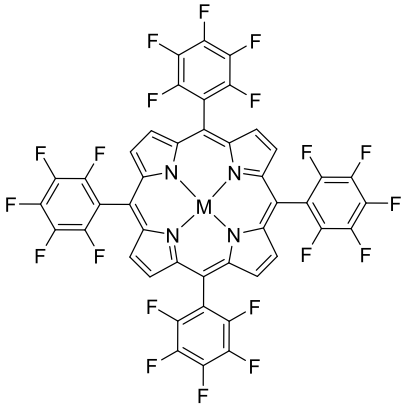
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The *meso*-tetrakis(pentafluorophenyl)porphyrin: a platform for heterogeneous catalysts

Mário M. Q. Simões

LAQV-REQUIMTE & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
msimoes@ua.pt

The skeleton of the *meso*-tetrakis(pentafluorophenyl)porphyrin free-base, H_2(TPFPP), besides the direct metalation into the corresponding metalloporphyrins, active homogeneous catalysts by their own, allowed us to develop a number of interesting chemical transformations on the macrocycle, which turned to be essential for several applications, including catalysis.
Fluoride being the most reactive leaving group in nucleophilic aromatic substitutions, the presence of four fluorine atoms at the o- and m-positions of each H_2(TPFPP) aryl ring turns nucleophilic substitution of the p-fluorine atoms on those meso-aryl rings a useful and straightforward reaction in the presence of appropriate nucleophiles. Indeed, the combined electron-attracting effects of the four fluorine substituents allows the reaction to proceed so readily. Lastly, the new macrocycles turned to be essential for the preparation of different materials, which were studied as heterogeneous catalysts under different conditions. This communication intends to highlight the main achievements within the last years, focusing on heterogeneous catalysis mainly.[1-12]



M = 2H; metal

Acknowledgments
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project UIDB/50006/2020 | UIDP/50006/2020.

References

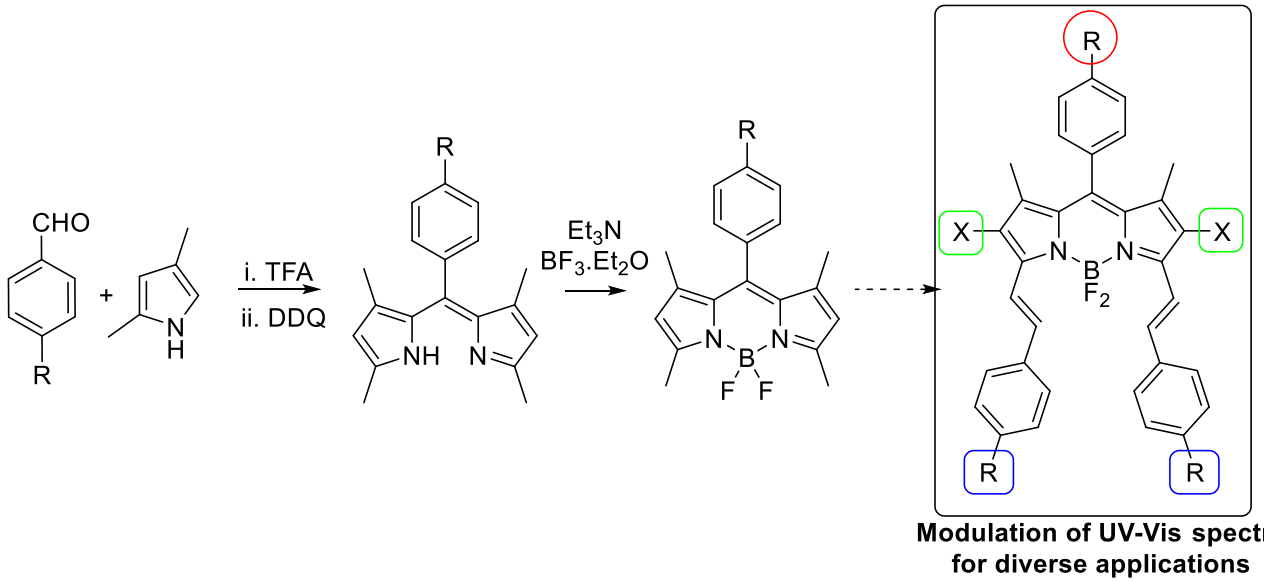
1. Simões, M. M. Q. et al. *J. Porphyr. Phthalocyanines* 2009, **13**, 589-596.
2. Simões, M. M. Q. et al. *Pure Appl. Chem.* 2013, **85**, 1671-1681.
3. Castro, K. A. D. F. et al. *Catal. Sci. Technol.* 2014, **4**, 129-141.
4. Castro, K. A. D. F. et al. *Appl. Catal.* A 2015, **503**, 9-19.
5. Castro, K. A. D. F. et al. *Inorg. Chem.* 2015, **54**, 4382-4393.
6. Castro, K. A. D. F. et al. *J. Catal.* 2016, **344**, 303-312.
7. Pereira, C. F. et al. *Molecules* 2016, **21**, 1348.
8. Simões, M. M. Q. et al. in Handbook of Porphyrin Science; Kadish, K. M., Smith, K. M., Guilard, R. (Eds.), World Scientific Publishing: Singapore, 2016, 197-306.
9. Castro, K. A. D. F. et al. *Inorg. Chim.* Acta 2017, **455**, 575-583.
10. Castro, K. A. D. F. et al. *ChemCatChem* 2017, **9**, 2939-2945.
11. Castro, K. A. D. F. et al. *Polyhedron* 2019, **158**, 478-484.
12. Castro, K. A. D. F. et al. *Eur. J. Inorg Chem* 2021, 2857-2869.

meso-Aryl-1,3,5,7-tetramethyl BODIPY dyes revisited: A systematic approach for synthetic optimization

Alexandre P. Felgueiras[1,*], Juliana S. F. Cebola[1], Kleber Thiago de Oliveira[2], Mario J. F. Calvete[1], Mariette M. Pereira[1]

[1]*CQC, Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal;*
[2]*Departamento de Química, Universidade Federal São Carlos, SP 13565-905, São Carlos, Brasil;*
**alexandrefel42@gmail.com*

4,4-Difluoro-4-bora-3a,4a-diaza-s-indacenes, commonly known as BODIPYs, are a versatile class of chromophores with a wide range of applications, including as fluorescent indicators, biological labels, tunable laser dyes, potential photodynamic therapy agents.[1] Nevertheless, their synthesis remains challenging, and there is still room for improvement. Therefore, in this work, we describe our approach to the optimization of the synthesis of *meso*-aryl-1,3,5,7-tetramethyl BODIPY cores (Scheme 1), with critical analysis of each relevant methodology parameter. Each individual reaction step was followed by NMR spectroscopy and, reaction parameters, like temperature, reaction time, reagents concentration, and/or solvents were attuned with basis on some methods found in the literature.[2,3] We managed to improve most of evaluated parameters for the synthesis of *meso*-aryl-1,3,5,7-tetramethy BODIPY cores that used greener solvents, higher concentrations, much lower reaction times and with similar or higher overall yields, when compared with the literature. Our approach opens the way for an improved and sustainable BODIPY synthesis, with prospects for up-scaled synthesis.



Scheme 1: Synthetic route to *meso*-aryl-1,3,5,7-tetramethy BODIPYs

Acknowledgements
The authors thank FCT (Fundação para a Ciência e Tecnologia), QREN/FEDER (COMPETE Programa Operacional Factores de Competitividade) for funding through projects UIDB/00070/2020, UIDP/00070/2020, UIDB/00313/2020, UIDP/00313/2020 and UIDB/00285/2020, and PRR - Recovery and Resilience Plan and the European Union (EU) Next Generation Funds, for funding through Project Nº 6979 - PRODUTECH R3 [Recuperação-Resiliência-Reindustrialização] following NOTICE N.º 02/C05-i01/2022, Component 5 – Capitalization and Business Innovation - Mobilizing Agendas for Business Innovation. A. P. Felgueiras also thanks FCT for the PhD grant 2022.11799.BD.

References

1. N. Boens, B. Verbelen and W. Dehaen, *European J. Org. Chem.*, 2015, **2015**, 6577–6595.
2. M. Baruah, W. Qin, C. Flors, J. Hofkens, R. A. L. Vallée, D. Beljonne, M. Van der Auweraer, W. M. De Borggraeve and N. Boens, *J. Phys. Chem. A*, 2006, **110**, 5998–6009.
3. M. H. R. Beh, K. I. B. Douglas, K. T. E. House, A. C. Murphy, J. S. T. Sinclair and A. Thompson, *Org. Biomol. Chem.*, 2016, **14**, 11473–11479.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Influence of proton transfer on the luminescence of organic dyes

Samuel Guieu[1,2,*], Luís F. B. Fontes[1,2], Cátia I. C. Esteves[1], Ana F. N. Borges[1], Raquel Nunes da Silva[1], João Rocha[2], Artur M. S. Silva[1]

[1]LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal
[2]CICECO-Aveiro Institute of Materials and Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal
**sguieu@ua.pt*

The dynamic nature of proton transfer and its effect on the photophysical properties of organic dyes is an attractive strategy to create responsive probes and materials. If the dyes have an intramolecular hydrogen bond offering the possibility of tautomerism, their photophysical behaviour may become more difficult to rationalize, and this may impede their applications.
Different series of intramolecularly hydrogen-bonded organic dyes have been synthesized and characterized (Figure 1). Their structures have been varied using different backbones (chalcone,[1,2] pyridine,[3,4] phenol,[3] aniline[4]) decorated with donor and acceptor substituents, to perceive the influence of each substitution on their photophysical properties. The susceptibility of these moieties to pH variations has also been studied, elucidating that the level of protonation had a significant effect on the emission intensity and colour.[4] The assignment of each emission band was made using DFT and td-DFT calculations, that were in agreement with the experimental results, allowing the rationalization of the emissive processes.
This study emphasizes the versatility of organic dyes, which can be synthetized and tuned effortlessly, in order to have the desired proton transfer modulation and subsequent emission response.

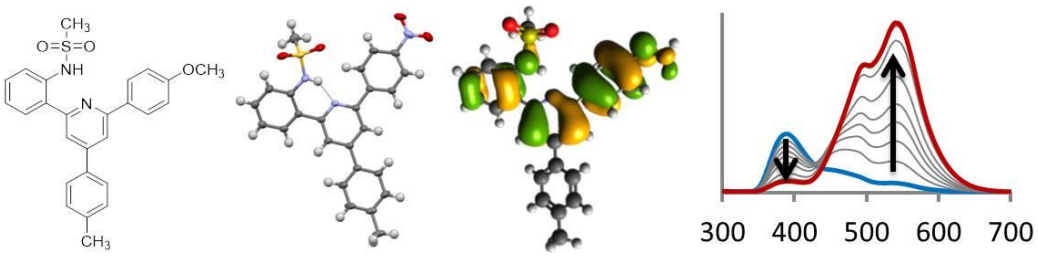


Figure 1: Illustration of the chemical structure, crystal structure, molecular orbitals and emission spectra of the dyes.

Acknowledgements
Thanks are due to University of Aveiro, FCT/MCTES, Centro 2020 and Portugal2020, the COMPETE program, and the European Union (FEDER program) via the financial support to the LAQV-REQUIMTE (UIDB/50006/2020 & UIDP/50006/2020), to the CICECO-Aveiro Institute of Materials (UID/CTM/50011/2019, UIDB/50011/2020 & UIDP/50011/2020), to the projects PAGE “Protein aggregation across the lifespan” (CENTRO-01-0145-FEDER-000003, RNS research contract - BPD/UI98/6327/2018). SG is supported by national funds (OE), through FCT, I.P., in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. LFBF thanks the FCT for his PhD grant (SFRH/BD/150663/2020).

References
1. C.I.C. Esteves, L.F.B. Fontes, A.F.N. Borges, J. Rocha, A.M.S. Silva, S. Guieu, *Chem. Proc.*, 2021, **3**, 29.
2. C.I.C. Esteves, L.F.B. Fontes, A.F.N. Borges, J. Rocha, A.M.S. Silva, S. Guieu, *Dyes & Pigm.*, 2022, **202**, 110275.
3. L.F.B. Fontes, R. Nunes da Silva, A.M.S. Silva, S. Guieu, *ChemPhotoChem*, 2020, **4**, 5312-5317.
4. C.I.C. Esteves, L.F.B. Fontes, J. Rocha, A.M.S. Silva, S. Guieu, *Chem. Eur. J.*, 2022, **28**, e202201844.

Metalloproteins from pathogenic bacteria - Targets for new antibiotics

Sofia R. Pauleta

Microbial Stress Lab, UCIBIO – Applied Molecular Biosciences Unit, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal; Associate Laboratory i4HB - Institute for Health and Bioeconomy, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
sofia.pauleta@fct.unl.pt

The emergence of pathogenic bacterial strains that are resistant to most available antibiotics is a concern for public health. Thus, there is a need to develop new antimicrobial compounds but also to identify novel molecular systems that are unique to the bacteria and can be the target for these compounds. Under this scope, we are studying metalloenzymes that are responsible for the anaerobic respiration and detoxification of copper, mechanisms that are important for infection and contribute to its virulence.
In *Neisseria gonorrhoeae*, the copper nitrite reductase is responsible for the production of NO, which is required to prevent epithelium exfoliation, while bacterial peroxidase, a di-haem peroxidase, can be used to detoxify H_2O_2 and use it as an alternative electron acceptor under anaerobic conditions[1]. These enzymes have been characterized using different spectroscopic and biophysical techniques[2,3]. The bacterial peroxidase has been structurally characterized in the active state and with azide, an inhibitor, bound to the active site[2]. In addition, we will show for the first time that this enzyme is also catalytically active towards peroxynitrite, with a high affinity.
In *Escherichia coli*, a quinol bacterial peroxidase, a non-classical bacterial peroxidase[1], has been characterized biochemically and its kinetic parameters determined[4]. The role of the additional haem at the N-terminal has been assessed by mutating its axial ligand, which changes its reduction potential. This variant enzyme has lower catalytic activity and it is less thermostable than the wild-type[5]. The model structure obtained using AlphaFold2 has been used to identify residues involved in the catalysis and electron transfer pathway (Figure 1).

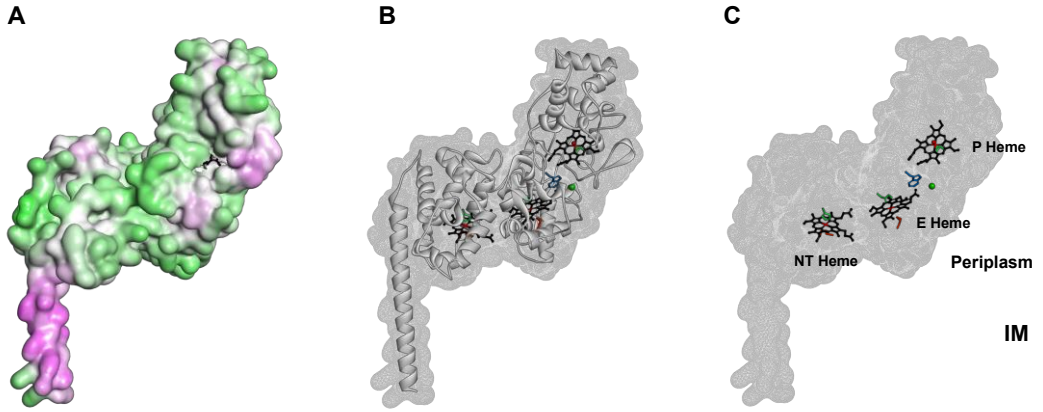


Figure 1: *E. coli* bacterial peroxidase represented (A) with its surface colored by hydrophobicity (purple), or showing the (B) backbone and (C) the relative position of its three haems.

Acknowledgements
This research was funded by Fundação para a Ciência e Tecnologia, I.P. (FCT) through a project grant to SRP (PTDC/BIA-BQM/29442/2017). This work was also supported by national funds from FCT in the scope of the project UIDP/04378/2020 and UIDB/04378/2020 of the Research Unit on Applied Molecular Biosciences-UCIBIO and the project LA/P/0140/2020 of the Associate Laboratory Institute for Health and Bioeconomy-i4HB.

References
1. D. S. Barreiro, R. N. S. Oliveira, S. R. Pauleta, *Coord. Chem. Rev*., 2023, **485**, 215114.
2. C. S. Nóbrega, A. L. Carvalho, M. J. Romão, S. R. Pauleta, *Int. J. Mol. Sci*., 2023, **24**, 6246.
3. D. S. Barreiro, R. N. S Oliveira, S. R. Pauleta, *bioRxiv*., 2022, DOI: 10.1101/2022.04.07.487406.
4. C. S. Nóbrega, B. Devreese, S. R. Pauleta, *Biochem. Biophys. Acta.*, 2018, **1859**, 411-422.
5. R. N. S Oliveira, S. R. M. M. de Aguiar, S. R. Pauleta, *Molecules*, 2023, **28**, 4598.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Detection of mutations in epidermal growth factor receptor using gold nanoparticle aggregation

A. Nuekaew[1,*], C. Lemos[1], R. Franco[2,3], M. Enea[1], E. Pereira[1]

[1]LAQV, REQUIMTE, Departamento de Química e Bioquímica Faculdade de Ciências da Universidade do Porto Porto 4169-007, Portugal; [2]Associate Laboratory i4HB - Institute for Health and Bioeconomy, School of Science and Technology, Universidade NOVA de Lisboa, 2819-516 Caparica, Portugal; [3]UCIBIO – Applied Molecular Biosciences Unit, Departamento de Química, School of Science and Technology, Universidade NOVA de Lisboa, 2819-516 Caparica, Portugal
**up202111277@edu.fc.up.pt*

Gold nanoparticles (AuNPs) have been known to exhibit improved optical and spectral properties compared to the bulk materials that make them suitable for biodetection. AuNPs can be easily synthesized and its properties can be fine-tuned by controlling its shape and size and combining with biomolecules for specific detection of DNA, RNA, antigen and antibodies.[1] In this work, we have developed and optimized a simple, selective and rapid detection assay, using spherical AuNPs, for a common mutation occurring in exon 19 of the epidermal growth factor receptor (EGFR), present in non-small cell lung cancer cells[2].
AuNPs were synthesized using the citrate-reduction method.[3] Au nanoprobes were obtained by functionalization with the specific thiolated oligonucleotide (16 bp), using a pH-assisted method[4]. Both AuNPs and Au nanoprobes were characterized by ultraviolet-visible spectrophotometry, dynamic light scattering (DLS) and electrophoretic light scattering (ELS) to assess their colloidal stability and size dispersion.
In the development of the detection assay, experimental parameters, such as the ratio of oligonucleotide on the AuNP surface and the salt concentration for aggregation, were established. Finally, the nanoprobes were incubated with three different synthetic target DNAs: complementary to the nanoprobe (normal DNA), non-complementary (mutated DNA) and a random non-complementary DNA. The nanoprobe successfully and selectively hybridized with the complementary/normal DNA in contrast to the mutated or random (non-complementary) DNA. Obtained results were based on color change from red to blue, depending on the aggregation state (Figure 1). We also establish the range of DNA concentration and the range of salt concentration optimal for differential detection. In conclusion, this work is an effective possibility for a straightforward, fast, and inexpensive alternative for the detection of DNA sequences related to lung cancer, leading to a potential platform for an early diagnosis of lung cancer patients.

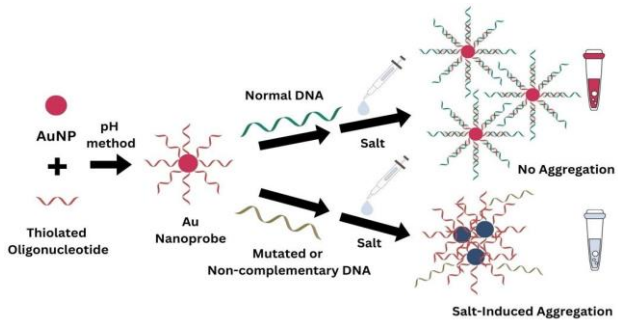


Figure 1: Detection assays using selective aggregation of gold nanoparticles in the presence of target DNAs which includes normal, mutated, and non-complementary DNAs upon the addition of salt.

Acknowledgements
This research was funded by Portuguese funds from Fundação para a Ciência e a Tecnologia, I.P. (FCT-MCTES), in the scope of the projects UIDB/50006/2020 and UIDP/50006/2020 of the Associate Laboratory for Green Chemistry (LAQV); and UIDP/04378/2020 and UIDB/04378/2020 of the Research Unit on Applied Molecular Biosciences (UCIBIO); LA/P/0140/2020 of the Associate Laboratory Institute for Health and Bioeconomy (i4HB). We thank O. Flores and C. Clemente from STABVida, Portugal, for their company interest on this type of diagnosis. M.E. thanks LAQV for her Post-Doc grant ref. REQUIMTE 2022-06. A. Nuekaew also acknowledged the Erasmus+: Erasmus Mundus program of the European Union for supporting our mobility and collaboration with specialized researchers, thus advancing our research.

References
1. M. Peixoto de Almeida, E. Pereira, P. Baptista, I. Gomes, S. Figueiredo, L. Soares and R. Franco, in *Comprehensive Analytical Chemistry*, eds. M. Valcárcel and Á. I. López-Lorente, Elsevier, 2014, vol. 66, pp. 529–567.
2. H. Lee, T. Kang, K.-A. Yoon, S. Y. Lee, S.-W. Joo and K. Lee, *Biosens. Bioelectron.*, 2010, **25**, 1669–1674.
3. I. Ojea-Jiménez, N. G. Bastús and V. Puntes, *J. Phys. Chem. C*, 2011, **115**, 15752–15757.
4. X. Zhang, T. Gouriye, K. Göeken, M. R. Servos, R. Gill and J. Liu, *J. Phys. Chem. C*, 2013, **117**, 15677–15684.

How to reduce the problematic CO_2? Lessons from Biology

L. B. Maia*, J. J. G. Moura

LAQV, REQUIMTE, NOVA School of Science and Technology | FCT NOVA, Portugal
**luisa.maia@fct.unl.pt*

Formate dehydrogenases (FDH) are enzymes that catalyse the reversible two-electron oxidation of formate to CO_2 (eq. 1).[1,2] The class of metal-dependent FDHs comprises only prokaryotic enzymes that hold different redox-active centres and whose active site harbours one molybdenum or one tungsten atom that mediates the formate oxidation/CO2 reduction. Due to its ability to reduce CO_2, FDH have been the centre of intense research to develop innovative, "greener" and more efficient devices to convert the problematic CO_2 into added-value compounds.[2,3]

$$CO_2 + 2e^- + H^+ \rightleftharpoons HCOO^- \qquad (1)$$

In this communication, the ability of the molybdenum-containing FDH from *Desulfovibrio desulfuricans* (Dd FDH) to reduce carbon dioxide will be discussed. The Dd FDH was found to be one of the most efficient carbon dioxide reducers so far described in the literature, with a k_{cat} of 47s^{-1} and a K_m^{CO2} of 16μM [4] and a novel FDH reaction mechanism was proposed (Figure 1)[4,5]: formate oxidation and carbon dioxide reduction proceed through hydride transfer, through a mechanism where the sulfo group of the oxidised and reduced molybdenum centre (Mo^{6+}=S and Mo^{4+}-SH, respectively) are suggested to be the direct hydride acceptor and donor, respectively.

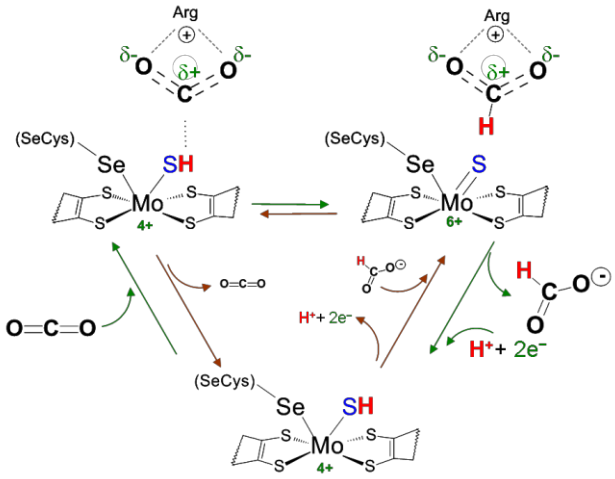


Figure 1: Proposed FDH reaction mechanism.[4,5]

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020) and PTDC/BTA-BTA/0935/2020, which are financed by national funds from FCT/MCTES. LBM thanks to FCT/MCTES, for the CEEC-Individual Program Contract.

References

1. L. Maia *et al.*, Molybdenum and tungsten-containing enzymes: an overview, The Royal Society of Chemistry, 2017, pag 1-80. (read it here: http://docentes.fct.unl.pt/lblm/files/mo_w_enzymes-rsc_book-chap_1.pdf)
2. L. Maia *et al.*, *Inorg. Chim. Acta*, 2017, **455**, 350-363. (read it here: https://docentes.fct.unl.pt/lblm/files/ica-2017-455-350.pdf)
3. L. Maia *et al.*, Carbon Dioxide Utilisation -The Formate Route, Springer, 2021, pag 29-81. (read it here: https://docentes.fct.unl.pt/lblm/files/co2_utilisation-formatedehydrogenases-maia.pdf)
4. L. Maia *et al.*, *J. Am. Chem. Soc.*, 2016, **138**, 8834-8846. (read it here: http://docentes.fct.unl.pt/lblm/files/jacs-2016-138-8834.pdf)
5. D. Niks et al., *J. Biol. Chem.*, 2016, **291**, 1162-1174. (DOI: 10.1074/jbc.M115.688457)

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Contribution of non-ionic interactions on bile salt binding by chitooligosaccharides: potential hypocholesterolemic activity

Filipe Coreta-Gomes[1,2*], Maria J. Moreno[2], Carlos Geraldes[2,3], Cláudia Nunes[4], Manuel A. Coimbra[1]

[1]LAQV-REQUIMTE, Chemistry Department, University of Aveiro, 3810-193 Aveiro, Portugal; [2]Coimbra Chemistry Center - Institute of Molecular Sciences (CQC-IMS), Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal; [3]Department of Life Sciences, Faculty of Science and Technology, University of Coimbra, Calçada Martim de Freitas, 3000-393 Coimbra, Portugal; [4]CICECO-Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, University of Aveiro, 3810-193, Aveiro, Portugal
**filipecoreta@ua.pt*

Cholesterol related diseases are within the deadliest and incapacitant worldwide.[1] The regulation of cholesterol levels in blood, namely through diet may hold back the development of cardiovascular diseases, such as atherosclerosis. Soluble polysaccharides from different sources such as arabinogalactans and galactomannans extracted from coffee,[2,3] and laminarans and fucoidans from algae[3] were shown to have hypocholesterolemic potential. This effect was attributed to the sequestration of BS mostly by non-ionic interactions with polysaccharides. On the other hand, positively charged chitooligosaccharides have been suggested to sequestrate bile salts, although the nature of the chitooligosaccharides-bile salts binding is usually linked with the ionic interaction. However, at physiological intestinal pH range (6.4 to 7.4) and considering chitooligosaccharides pKa, they should be mostly uncharged, highlighting that other type of interaction might be of relevance.

In this work, aqueous solutions of chitooligosaccharides with an average degree of polymerization of 10 and 90% deacetylated, were characterized regarding their effect on bile salt sequestration and cholesterol bioaccessibility. Chitooligosaccharides were shown to bind bile salts to a similar extent as the cationic resin colestipol, both decreasing cholesterol accessibility as measured by NMR at pH 7.4.[4] A decrease in the ionic strength leads to an increase in the binding capacity of chitooligosaccharides, in agreement with the involvement of ionic interactions. Nevertheless, when the pH is decreased to 6.4, the increase in charge of chitooligosaccharides is not followed by a significant increase in bile salt sequestration. This corroborates the involvement of non-ionic interactions, which was further supported by NMR chemical shift analysis and by the negative electrophoretic mobility attained for the bile salt-chitooligosaccharide aggregates at high bile salt concentrations. These results highlight that chitooligosaccharides non-ionic character is a relevant structural feature to aid in the development of hypocholesterolemic ingredients.

Acknowledgements
This research was funded by Fundação para a Ciência e a Tecnologia (FCT)/MCTES for the support to the research units QOPNA (FCT UID/QUI/00062/2019), LAQV-REQUIMTE (UIDB/50006/2020 & UIDP/50006/2020), CICECO (UIDB/50011/2020; UIDP/50011/2020 & LA/P/0006/2020) and CQC (UIDB/00313/2020 & UIDP/00313/2020); and also supported by the projects PTDC/QUI-OUT/29373/2017 and POCI 01-0145-FEDER-031032, through national funds (OE) and where applicable co-financed by the FEDER, by the Operational Program of Competitiveness and Internationalization (POCI), within the PT2020 Partnership Agreement. F.M.C.G. was supported by research contract framed on PTDC/QUI-OUT/29373/2017 and LAQV-REQUIMTE (UIDB/50006/2020) projects. C.N. was funded by national funds (OE), through FCT, I.P., within the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19.

References

1. I. M. V. Silva, F. Machado, M. J. Moreno, C. Nunes, M. A. Coimbra and F. Coreta-Gomes, *Molecules*, 2021, **26**, 1–17.
2. F. M. Coreta-Gomes, G. R. Lopes, C. P. Passos, I. M. Vaz, F. Machado, C. F. G. C. Geraldes, M. J. Moreno, L. Nyström and M. A. Coimbra, *Nutrients*, 2020, **12**, 437.
3. C. L. Pires, I. M. V. Silva, M. A. Coimbra, M. J. Moreno and F. Coreta-Gomes, *Foods*, 2022, **11**, 2935.
4. F. Coreta-Gomes, I. M. V. Silva, C. Nunes, I. Marin-Montesinos, D. Evtuguin, C. F. G. C. Geraldes, M. João Moreno and M. A. Coimbra, *J. Colloid Interface Sci.*, 2023, **646**, 775–783.

Red color stabilization of anthocyanins with lignosulfonates from the pulp industry

Ana Rita Pereira[1], Carina Costa[2], Victor de Freitas[1], Nuno Mateus[1], Alírio Rodrigues[2], Joana Oliveira[1*]

[1]LAQV - REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal; [2]LSRE-LCM and ALiCE - Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal.
**jsoliveira@fc.up.pt*

Natural colorants are gradually replacing synthetic dyes due to consumers' awareness and demand for natural products. Anthocyanins are water-soluble pigments found in Nature and are among the most commonly used natural red colorants in Food Industry. Anthocyanins can confer a wide range of colors (red, violet & blue) to flowers, fruits, and some legumes. Yet, the application of anthocyanin-based colorants into different food matrices can be challenging, as these compounds are sensitive to pH, temperature, oxygen, and light which are involved in different processing, formulation, and storage conditions. Industries are investing in the development of new processes to decrease anthocyanin's color loss and to produce more stable and appealing colors.[1]

This work presents the red color stabilization of anthocyanins with a lignosulfonate obtained from softwood sulfite liquor (SSL, 11.3% w/w_{liquor}). Lignin is the second most abundant natural biopolymer and is stable, nontoxic, inexpensive, and biodegradable. Lignosulfonate was obtained after ultrafiltration and freeze-drying of the softwood sulfite liquor composed of a mixture of 90 % spruce (softwood material) and 10 % beech (hardwood biomass). The sulfonation degree was determined based on the electrostatic interaction between a cationic surfactant (CTAB) and the anionic lignosulfonate. Moreover, the surface charge of lignosulfonates was evaluated by measuring the potential zeta at different pH values. The results showed an increase in the negative surface charge along with the pH due to the ionization of sulfonic and phenolic hydroxyl groups. Knowing that the negatively charged groups of lignosulfonates can interact with the positive charge of the flavylium cation of anthocyanins, the interaction of lignosulfonates with anthocyanins was studied in a pH range between (0 and 4). The results showed that the association constant increased with the pH between pH 0-2, due to the increase in the amount of negatively charged groups in the lignosulfonate structure that are able to interact with the flavylium cation form of the anthocyanin. Bearing this, the results obtained so far show that this biopolymer can be used to stabilize the red color of anthocyanins to be incorporated into different matrices.

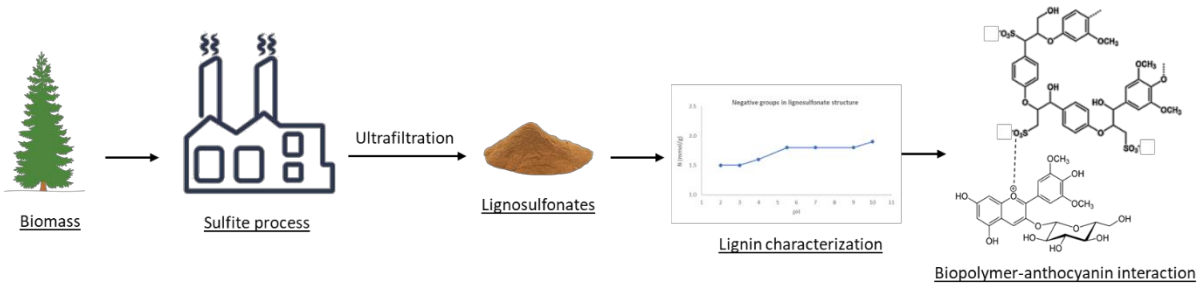


Figure 1: Isolation and characterization of a lignosulfonate for interaction with anthocyanins

Acknowledgments
The authors thank the AgriFood XXI I&D&I project (NORTE-01-0145-FEDER-000041) co-financed by European Regional Development Fund (ERDF), through the NORTE 2020 (Programa Operacional Regional do Norte 2014/2020). A.R.P. gratefully acknowledges her doctoral grant from FCT (SFRH/BD/146549/2019). J.O would like to thank her contract CEEC 2022.00042.CEECIND/CP1724/CT0017) from FCT. This work was financially supported by LA/P/0045/2020 (ALiCE), UIDB/50020/2020, and UIDP/50020/2020 (LSRE-LCM), funded by national funds through FCT/MCTES (PIDDAC).

Funding
This research is supported by the Associated Laboratory for Sustainable Chemistry, Clean Processes, and Technologies LAQV through national funds from UIDB/50006/2020 and UIDP/50006/2020.

References
1. H. E. Khoo, A. Azlan, S. T. Tang and S. M. Lim, *Food Nutr Res* 2017, **61**, 1361779.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Self-assembled binary structures of Mn(III), Fe(III) and metal-free porphyrins in catalytic hydrogenation assisted by sunlight

G. A. Corrêa*, S. L. H. Rebelo

LAQV/REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, 4169-007 Porto, Portugal.
**up201900612@edu.fc.up.pt*

The use of non-noble metal-based catalysts and mild conditions is an important step in the attainment of efficient and eco-sustainable reduction reactions. Porphyrins have unique properties that make them attractive in the preparation of functional biomimetic materials.[1] The ionic self-assembly of oppositely charged porphyrins allows the preparation of binary materials with well-defined shapes and sizes, in a simple and eco-sustainable method. (Metallo)porphyrins carrying different substituents and metal ions, lead to materials with varied morphologies and properties, in which cooperative processes can occur between the oppositely charged (metallo)porphyrins, which can be relevant for biomimetic applications.
The removal of phenols from wastewater is of importance due to its toxicity to humans, but their high solubility and stability in water affect the efficiency of many biological and chemical process of water treatment.[2] In this work, binary materials of iron(III), manganese(III) or metal-free porphyrins were prepared by ionic self-assembly and characterized by SEM, XPS and XRD. The reduction of 4-nitrophenol, a pollutant commonly found in wastewater, to 4-aminophenol, a precursor in the synthesis of pharmaceuticals, is used as model reaction to evaluate the catalytic activity of the materials in the presence of simulated solar light and NaBH4 as reductant (Figure 1).[3,4] After 5 minutes a 90% conversion was obtained for material carrying positive Mn(III) and negative Fe(III) porphyrins, with good performance after reuse studies. This catalytic activity is comparable to that of catalysts based on noble metals.

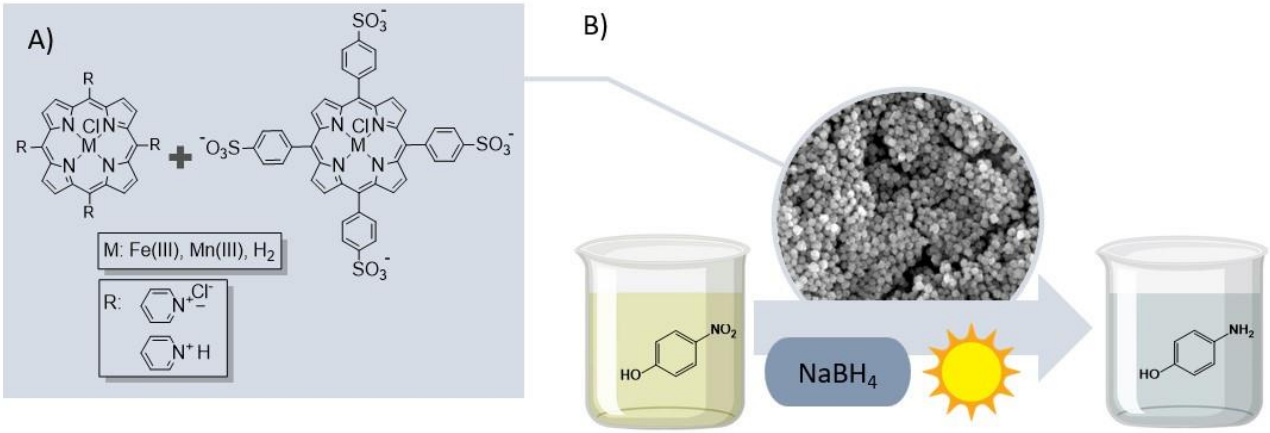


Figure 1: A) Porphyrins used as tectons in ionic self-assembly reactions; B) Light-assisted catalytic hydrogenation of 4-nitrophenol.

Funding
This work was financial supported with funding from FCT/MCTES (UIDP/50006/2020) through national funds.

Acknowledgements
The work was supported through the projects UIDB/50006/2020 and UIDP/50006/2020, funded by FCT/MCTES (Fundação para a Ciência e Tecnologia/Ministério da Ciência, Tecnologia e Ensino Superior). S.L.H. Rebelo thanks FCT for funding through program DL 57/2016—Norma transitória (Ref. REQUIMTE/EEC2018/30) and G.A. Corrêa thanks FCT for her PhD grant (UI/BD/154487/2022).

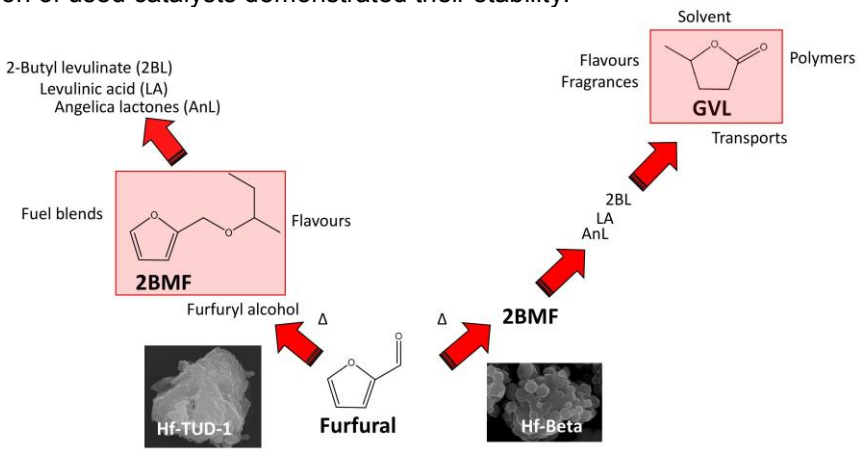
References
1. C. Frigerio, J.P.G. Santos, P. Quaresma, S.L.H. Rebelo, A. Gomes, P. Eaton, E. Pereira, P.A. Carvalho, J.A. Shelnutt, L. Jiang, H. Wang, C.J. Medforth, Tetrahedron, 2016, **72**, 6988-6995.
2. V. Kavitha, K. Palanivelu, Chemosphere, 2004, **55**, 1235-1243.
3. G.A. Corrêa, M.P. Loureiro, I. Kuźniarska-Biernacka, C. Freire, S.L.H. Rebelo, Materials Today Sustainability, 2022, **19**, 100195.
4. G.A. Corrêa, B. de Castro, S.L.H. Rebelo, Catalysis Today, 2023, **418**, 114149.

Hafnium-containing modified zeolites or silicates for catalytic transfer hydrogenation of furfural to useful bioproducts

M. M. Antunes[1,*], A. F. Silva[1], C. D. Bernardino[1], A. Fernandes[2], M. Pillinger[1], F. Ribeiro[2], A. A. Valente[1]

[1]Department of Chemistry, CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Aveiro, Portugal; [2]Centro de Química Estrutural, Instituto Superior Técnico, Av. Rovisco Pais, University of Lisbon, 1049-001 Lisboa, Lisboa, Portugal
**margarida.antunes@ua.pt*

Biofuels with net zero CO_2 emissions are expected to substitute fossil fuels, which are responsible for the negative anthropogenic emissions. These biofuels might be obtained from vegetable biomass (VB) which is the most prominent renewable source of energy on Earth. VB is mainly composed of carbohydrates which after hydrolysis and dehydration reactions lead to furanic aldehydes Furfural (Fur) and 5-hydroxymethylfurfural (Hmf). Fur is an important chemical platform to a plethora of valuable bioproducts via catalytic transfer hydrogenation (CTH) using alcohols as H-donors under relatively moderate conditions. A Hf-containing TUD-1 prepared by hydrothermal synthesis [1] and a hierarchical intracrystalline Beta material prepared by top-down strategies [2] promoted CTH and acid reactions, leading mainly to furanic ethers and to the versatile bioproduct γ-valerolactone (GVL), respectively (Scheme 1). Mechanistic studies, kinetic modelling, solid state spectroscopic characterisation and catalyst stability studies led to assessments on the catalytic roles and potential of the prepared materials to produce the target bioproducts. The furanic ether, 2-(sec-butoxymethyl)furan (2BMF), was formed in up to 63 % yield at 88 % Fur conversion and 150 ºC/4 h using Hf-TUD-1, while the hierarchical zeotype Hf-Beta led to GVL yields up to 73 % from Fur at 180 ºC. Recycling runs and characterisation of used catalysts demonstrated their stability.



Scheme 1- Catalytic transfer hydrogenation of Furfural to γ-valerolactone (GVL) and 2-(sec-butoxymethyl)furan (2BMF) in the presence of Hf-Beta (right) and Hf-TUD-1(left).

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The positions held by MMA and AF were funded by national funds (OE) through FCT, IP, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of article 23 of the Decree-Law 57/2016 of 29 August, changed by Law 57/2017 of 19 July. The position held by AFS was funded by Project POCI-01-0145-FEDER-030075 (COMPETE 2020 Operational Thematic Program for Competitiveness and Internationalization) co-financed by national funds through the FCT/MCTES and the European Union through the European Regional Development Fund under the Portugal 2020 Partnership Agreement. The NMR spectrometer used is part of the National NMR Network (PTNMR) and is partially supported by Infrastructure Project No 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).

References
1. M. M. Antunes, A. F. Silva, C. D. Bernardino, A. Fernandes, F. Ribeiro, A. A. Valente, *Molecules*, 2021, **26**, 7203.
2. M. M. Antunes, A. F. Silva, A. Fernandes, M. Pillinger, F. Ribeiro, A. A.Valente, J. Catal., 2022, **406**, 56-71.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

(Photo)Oxidative transformation of biomass derived molecules into valuable products

I. Kuźniarska-Biernacka[1,*], M. Monteiro[1], P. Miranda[1], A. F. Peixoto[1], A. C. Santos[2], W. Maniukiewicz[3], B. Valentim[2], A. Guedes[2], C. Freire[1]

[1]REQUIMTE/LAQV, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal; *[2]Earth Science Institute – Porto pole, Department of Geosciences, Environment and Spatial Plannings, Faculty of Sciences, University of Porto, Rua do Campo Alegre s/n, 4169– 007 Porto, Portugal; [3]Institute of General and Ecological Chemistry, Lodz University of Technology, Żeromskiego 116, 90-924 Łódź, Poland. *iwonakb@fc.up.pt*

Lignocellulosic biomass, obtained from agriculture and forestry residues, is an important, cheap and abundantly available biomass feedstock to produce fuels and platform chemicals. The 5-hydroxymethyl-2-furfural (HMF) is one of top platform molecules obtained from lignocellulosic glucose and can be transformed by catalytic oxidation to useful compounds such as 2,5-diformylfuran (DFF). DFF can be used as monomer for the synthesis of furan-based biopolymers, as intermediate for the production of pharmaceuticals and other many applications.[1,2] for the production of plastics. The conventional catalytic oxidation of HMF to DFF usually demands the presence of noble metals (Au, Pt, Ru),organic hazard solvents (toluene) and toxic oxidants like NaOCl, $BaMnO_4$, pyridine-$Pb(OAc)_4$ trimethylammonium chlorochromate.[3]

Photocatalysis is an economical and cleaner strategy that holds a great potential for organic synthesis. Several attempts have been made to photocatalytically oxidize HMF selectively to DFF, using metal or metal oxide-based photocatalysts including Nb_2O_5, bimetallic Au−Ru nanoparticles supported on reduced graphene oxides, ultrathin Ni/CdS nanosheets.

Here, a novel natural polymer-based hybrids assembling particles obtained from coal fly ash (CFA; core), a biopolymer (support) and a transition metal oxide semiconductor (photo active sites) were used as efficient and sustainable (photo)catalysts for oxidation of HMF. The hybrid CFA-materials obtained from coal fly ash fractions (Carbon-rich, C-CFA or Silica-rich, Si-CFA), natural biopolymer (chitosan, CS) and semiconductor metal oxide (BiOBr or $MnFe_2O_4$) were prepared by ionic gelation of CS. The metal oxides were obtained by hydrothermal or co-precipitation method. The semiconductive oxides as well as the hybrid CFA-materials were characterized by physicochemical methods (X-ray Fluorescence, XRF; X-ray Diffraction, XRD; Scanning Electron Microscope, SEM; Raman Spectroscopy and Infrared Spectroscopy, FTIR). All techniques confirmed the successful preparation of semiconductors and hybrids.

The materials were tested as photocatalysts for oxidation of HMF in water or acetonitrile, under UV-A, (low power, 15 W lamp) irradiation. For comparison the conventional catalytic oxidation tests (in the presence of tert-Butyl hydroperoxide (tBuOOH), oxidant) in acetonitrile were also performed. The catalytic processes were monitored (products identification and quantification) by HPLC or GC chromatography. The materials show activity in (photo)oxidation of HMF and the best performance was found for BiOBr containing hybrid CFA-material in the presence of tBuOOH at 100 °C (substrate conversion 91%, DFF selectivity 80%).

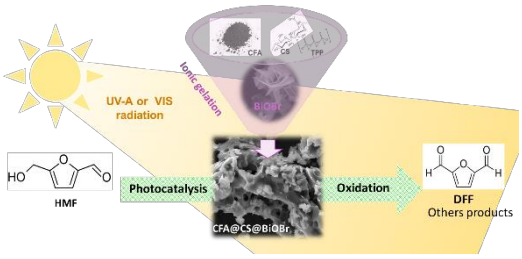


Figure 1: Schematic illustration of application of composite in photooxidation of HMF

Funding:
This work was financial supported with funding from FCT/MCTES (UIDP/50006/2020 and UIDP/04683/2020) through national funds.

Acknowledgements:
The authors also thank FCT for the projects DRI-India/0315/2020 (Insub), EXPL/CTM-CTM/0790/2021 (PhotoBioTrans), POCI-01-0145-FEDER-007690. ACS for PhD scholarship SFRH/BD/131713/2017 and COVID/BD/151941/2021. IKB for funding through program DL 57/2016 – Norma transitória REQUIMTE/EEC2018/14. A.F.P. also thanks FCT for the individual contract (Refs. 2020. 01614.CEECIND/CP1596/CT0007). Pego power plant (Portugal) for ash samples.

References:

1. Y. E. Jad, G. A. Acosta, T. Govender, H. G. Kruger, A. El-Faham, B. G. de la Torre and F. Albericio, *ACS Sustainable Chemistry & Engineering*, 2016, **4**, 6809-6814.
2. F. Menegazzo, T. Fantinel, M. Signoretto, F. Pinna and M. Manzoli, *Journal of Catalysis*, 2014, **319**, 61-70.
3. D. Zhao, T. Su, Y. Wang, R. S. Varma and C. Len, *Molecular Catalysis*, 2020, **495**, 111133.

Synthesis of β-functionalized porphyrin-Ir(III) complexes as photosensitizer agents towards cancer cells

Nuno M. M. Moura[1,*], Ana T. P. C. Gomes[2], Kelly A. D. F. Castro[3], M. Graça P. M. S. Neves[1]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal; [2]Universidade Católica Portuguesa, Faculdade de Medicina Dentária, Centro de Investigação Interdisciplinar em Saúde, 3504-505 Viseu, Portugal; [3]Department of Biomolecular Sciences, Faculty of Pharmaceutical Sciences of Ribeirão Preto, University of São Paulo, SP, Brazil
**nmoura@ua.pt*

The development of new transition metal complexes (TMCs) is emerging as an attractive research area owing to the potential application of these complexes in different fields.[1] In the last decade, a special attention is being given to ruthenium- and iridium-based compounds as potential alternatives to platinum-based drugs due to their improved therapeutic action.[2] The physicochemical features displayed by tetrapyrrolic macrocycles, namely *meso*-tetraarylporphyrins render them particularly appealing to be considered as ligands in the metal coordination process. These macrocycles are being successful used in a wide range of fields (e.g. supramolecular chemistry, catalysis, electronic materials, sensors and medicine).[3] being particularly relevant their role as photosensitizers (PS) in photodynamic therapy (PDT).[4] PDT arises as a promising alternative to common therapeutic procedures used against oncological and non-oncological disorders. This is a non-invasive, localized, and low-cost approach, with high selectivity for tumor cells. The procedure requires the light activation of a PS at a specific wavelength, in the presence of dioxygen, in order to generate cytotoxic reactive oxygen species (ROS), namely singlet oxygen ($^1O_2$) able to destroy the malignant cells.[5]
Herein, we report the preparation and characterization of iridium(III) complexes of β-functionalized porphyrin derivatives bearing bipyridine or terpyridine ligand units. The combination of porphyrin derivatives with iridium(III) ions induced singular features and, consequently, allowed the improvement of the PDT effect of these molecules as PS against cancer cells.[6,7]

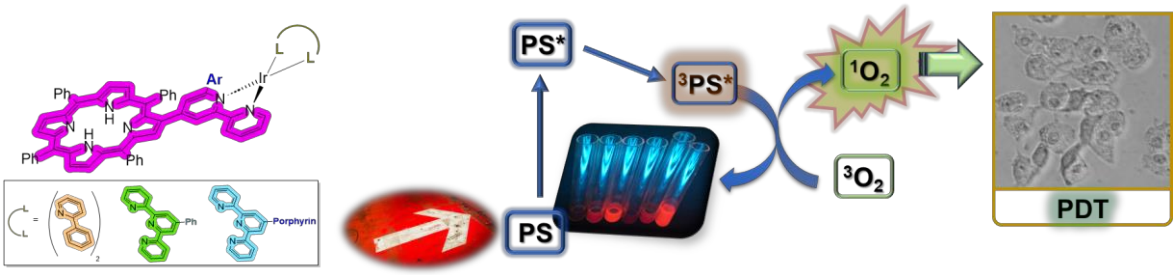


Figure 1: Porphyrin-Ir(III) complexes photosensitizers in PDT against cancer cells.

Acknowledgements
This work received support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) through national funds, and to the Portuguese NMR Network. NMM Moura thanks FCT for funding through program DL 57/2016 – Norma transitória (CDL-CTTRI-048-88-ARH/2018).
Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020, and the FCT project PORP2PS (EXPL/QUI-QOR/0586/2021). K.A.D.F. Castro thanks CNPq for her post-doctoral scholarship (Process: 201107/2014-7). NMM Moura thanks FCT for funding through program DL 57/2016 – Norma transitória (CDL-CTTRI-048-88-ARH/2018).

References
1. J. Li, T. Chen, *Coord. Chem. Rev.*, 418 (2020) 213355.
2. B. Kar, N. Roy, S. Pete, P. Moharna, P. Paira, *Inorg. Chim. Acta*, 512 (2020), 119858.
3. K.M. Kadish, K.M. Smith, R. Guilard, Handbook of Porphyrin Science, Vol. 10-12, World Scientific: Singapore, 2010.
4. A. T. P. C. Gomes, M. G. P. M. S. Neves, J. A. S. Cavaleiro, *An. Acad. Bras. Cienc.*, 90 (2018) 993–1026.
5. B. Yang, Y. Chen, J. Shi, *Chem. Rev.*, 119 (2019) 4881–985.
6. N. M. M. Moura, K. A. D. F. Castro, J. C. Biazzotto, J. A. Prandini, C. Lodeiro, M. A. F. Faustino, M. M. Q. Simões, R. S. da Silva, M. G. P. M. S. Neves, *Dyes Pigments*, 205 (2022) 110501.
7. N. M. M. Moura, C. Lodeiro, M. G. P. M. S. Neves, J. A. S. Cavaleiro, C. F. Ribeiro, R. Fernandes, A. T. P. S. C. Gomes, *Photochem. Photobiol. Sci.*, (2023), *submitted*.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Validation of a methodology to quantify several elements in fruits according to ISO 17025

E. Pereira[1,2*], D. Santos[1], N. Ferreira[1], T. Viana[1], J. Pinto[1], D. Tavares[1,2], B. Henriques[1]

[1]LAQV-REQUIMTE – Associated Laboratory for Green Chemistry, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [2]Central Laboratory of Analysis, University of Aveiro, 3810-193 Aveiro, Portugal
**eduper@ua.pt*

Fruits are a vital type of food for human well-being and health, that have in their constitution several macronutrients and essential micronutrients (e.g. magnesium, iron, zinc)[1]. Adequate ingestion of essential mineral nutrients is crucial for the organism, yet the possible presence of potentially toxic elements poses a threat to public health[2]. The surveillance of the presence of the described elements using analyses performed with quality control is necessary to guarantee values supported by the legislation. Despite its relevance, information regarding the presence of essential and potentially toxic elements in fruits, and validation of analytic methodologies that allow the quantification of such elements in these food matrices, is still scarce in the literature. The attainment of reliable measurement results is decisive to ensure the food quality required by law. For that purpose, chemical analyses of foods must be performed in accredited laboratories where results are extensively subjected to quality control, using validated methods or performing method validation[3]. This approach seeks to ensure that the obtained results are correct and that the quality criteria are verified.

The main objective of this work was to validate a methodology for the quantification of elements in fruits, through multielement analysis techniques such as optical emission spectrometry and mass spectrometry associated with inductively coupled plasma (ICP-OES and ICP-MS). A set of method performance characteristics including selectivity, sensibility, limits of detection (LOD) and quantification (LOQ), working range, trueness, precision, and repeatability, were evaluated.

A single digestion method, based on HNO_3 and H_2O_2 in conjunction with microwave (elevated temperature and pressure), was applied to fruits to decompose the samples and solubilize macro, micro, and potentially toxic elements. The elements were then quantified by ICP-OES and ICP-MS.

In this work, several elements were evaluated and validated. The validation parameters, previously mentioned, were studied and the quality criteria was fulfilled. The measurement uncertainty for the method was also evaluated. All validation parameters studied in this work fulfilled the stipulated requirements, which are in accordance with the association of accredited laboratories in Portugal (RELACRE), resulting in the corresponding declaration of the suitability of the method.

The blank (with values < LOD), fortification samples (percentages of recovery always between 80 – 120 %), certified reference material (bias < 10 %), and food samples results met the performance requirements defined by RELACRE.

The validated methodology was applied to banana, apple, and pear samples. The comparison between the three fruits showed that K is the most abundant mineral (11.2 mg g^{-1} in dry weight concentration in banana), followed by Mg, Ca, Fe, Mn, Zn and Cu. All the potentially toxic elements studied (As, Cd, Pb, Hg) were below the quantification limit, apart from Hg, which was present in very small concentrations (0.9 to 3.0 ng g^{-1}), highlighting that the consumption of the analyzed fruits is safe.

Acknowledgements
Nicole thanks the Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior for her PhD grant ref. 2022.13017.BD. Bruno Henriques acknowledges FCT for the research contract (CEECIND/03511/2018) under the CEEC Individual 2018.

References

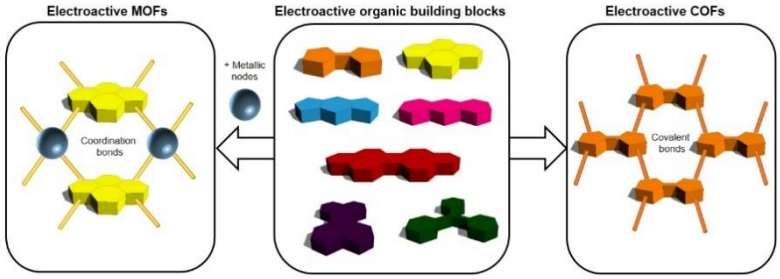
1. E. Xu, J. Wang, J. Tang, S. Ruan, S. Ma, Y. Qin, W. Wang, J. Tian, J. Zhou, H. Cheng and D. Liu, *Food Chem.*, 2022, **369**, 130900.
2. A. Londonio, E. Morzán and P. Smichowski, *Food Chem.*, 2019, **284**, 149–154.
3. C. C. Almeida, D. dos S. Baião, P. de A. Rodrigues, T. D. Saint'Pierre, R. A. Hauser-Davis, K. C. Leandro, V. M. F. Paschoalin, M. P. da Costa and C. A. Conte-Junior, *Front. Nutr.*, 2022, **9**, 801.

Exploiting the versatility of electroactive organic building blocks for the construction of functional framework materials

Manuel Souto

Department of Chemistry, CICECO – Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal
manuel.souto@ua.pt

Besides their inherent porosity, Metal-Organic Frameworks (MOFs) and Covalent Organic Frameworks (COFs) may also incorporate tunable physical (electrical, optical and magnetic) properties which strongly depend on the selected building blocks, becoming very attractive for their implementation as integral components in electronic devices.[1] For example, combining the intrinsic porosity of COFs and electrical conductivity may give rise to multiple applications such as (opto)electronics and energy storage.[2] In recent years, electroactive organic molecules have emerged as promising building blocks for the design and construction of functional porous frameworks such as MOFs or COFs for a wide range of applications (Figure 1).[3] In the first part of the presentation, I will focus on the electrical and photophysical properties of a family of perylene-based MOFs,[4] as well as on the tunable luminescence of an organic radical-based MOF.[5] In the second part, I will present the synthesis and electrical properties of a series of redox-active tetrathiafulvalene (TTF)-based COFs using different extended conjugated linkages. Finally, some TTF-based COFs were explored as organic cathode materials for lithium batteries.



Scheme 1: Schematic representation of the construction of metal–organic frameworks (MOFs) and covalent organic frameworks (COFs) based on electroactive organic building blocks.

Acknowledgements
This work has received funding from the European Research Council (ERC) under the European Union's Horizon Europe Framework Programme (ERC-2021-Starting Grant, grant agreement no. 101039748-ELECTROCOFS). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, Grants UIDB/50011/2020 and UIDP/50011/2020, financed by national funds through the FCT/MEC and when appropriate co-financed by FEDER under the PT2020 Partnership Agreement. We thank FCT for funding the project PTDC/QUI-ELT/2593/2021.

References
1. M. D. Allendorf, R. Dong, X. Feng, S. Kaskel, D. Matoga and V. Stavila, *Chem. Rev.*, **2020**, 120, 8581.
2. M. Souto, D. F. Perepichka, *J. Mater. Chem. C*, **2021**, *9*, 1066
3. M. Souto, K. Strutyński, M. Melle-Franco and J. Rocha, *Chem. Eur. J.*, **2020**, 26, 10912.
4. a) G. Valente *et al. Mol. Syst. Des. Eng.* **2022**, *7*, 1065. b) G. Valente *et al. Inorg. Chem.* **2023**, 62, 7834.
5. G. Valente, P. Ferreira, *et al.* **2023**, *submitted.*

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

All-solid-state thermally-chargeable textile supercapacitors based on CNTs and PEDOT:PSS-doped PVA/H_3PO_4 electrolyte

Joana S. Teixeira[1,2*], Rui S. Costa[2], André M. Pereira[2], Clara R. Pereira[1]

[1]REQUIMTE/LAQV, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto (FCUP), Rua do Campo Alegre s/n, 4169-007, Porto, Portugal; [2]IFIMUP – Institute of Physics for Advance Materials, Nanotechnology and Photonics, Department of Physics and Astronomy, FCUP, Faculty of Sciences, University of Porto, Rua do Campo Alegre s/n, 4169-007, Porto, Portugal
**joanafsteixeira@hotmail.com*

The continuous growth of the smart electronics clothing market, combined with the Internet of Things paradigm, has led to a new demand for self-powered devices that are capable of collecting residual thermal energy from different sources (*e.g.*, industry or the human body itself), convert it into electrical energy and store the produced energy.[1] The novelty of this technology, known as thermally-chargeable supercapacitors (TCSCs), is the combination of both thermal energy harvesting (based on Soret effect) and supercapacitive energy storage functionalities in a single multitasking textile device. One of the current challenges of this technology is the design of novel electrolytes with higher ionic conductivity that allow improving both thermal energy harvesting and energy storage performance, simultaneously.[2]

This work reports the fabrication of TCSCs using new redox-active solid-gel electrolytes based on poly(vinyl alcohol) (PVA)/orthophosphoric acid (H_3PO_4) doped with poly(3,4-ethylenedioxythiophene) : polystyrenesulfonate (PEDOT:PSS). The solid-gel electrolytes were prepared using different wt% of PEDOT:PSS within PVA/H_3PO_4, ranging from 0 to 25%. The textile electrodes were prepared through the coating of knitted cotton fabrics with multiwalled carbon nanotubes (CNTs) *via* an eco-friendly and scalable dip-pad-dry process. Sandwich-type devices were fabricated using two textile electrodes assembled one against the other with the as-prepared solid-gel electrolyte in between (TCSCs will be denoted as CNT_PVA_X, X = wt% of PEDOT:PSS). For comparison, a device based on undoped PVA/H_3PO_4 electrolyte was prepared (denoted as CNT_PVA).

The textile electrodes presented an electrical resistance of 2.14 Ω cm^{-2} and a CNT loading of 8.9 wt% after 7 dip-pad-dry steps.

The CNT_PVA_10 device (using 10 wt% PEDOT:PSS) presented the highest specific capacitance among all devices, which was 2.0× higher than that of CNT_PVA (3.69 F g^{-1} *vs*. 1.89 F g^{-1}), and similar working potential of 1.21 V. Moreover, it reached 2.7× higher energy density than CNT_PVA device, of 1.05 W h kg^{-1} at a power density of 51.73 W kg^{-1}. Studies to prove the simultaneous energy storage and ionic thermal energy harvesting of the TCSCs under different temperature gradients (ΔT) are ongoing. For each device, a temperature gradient is established between both electrodes, and the output potential (order of mV) is measured over time.

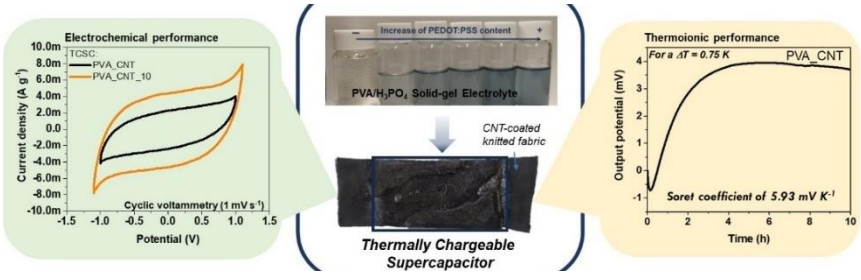


Figure 1. *i-V* cycles of PVA_CNT and PVA_CNT_10 (left); TCSC and photographs of PEDOT:PSS-based electrolytes (middle); Thermoionic measurement of PVA_CNT at ΔT = 0.75 K.

Funding
This work was financially supported with funding from FCT/MCTES (UIDP/50006/2020) through national funds.

Acknowledgements:
The authors thank the projects PTDC/CTM-TEX/4126/2021, UIDB/50006/2020, LA/P/0008/2020, UIDB/04968/2020 and UIDP/04968/2020 financed by Portuguese funds through FCT/MCTES. JST and CRP thank FCT for funding through PhD scholarship (SFRH/BD/145513/2019) and Individual Call to Scientific Employment Stimulus (2021.04120.CEECIND/CP1662/CT0008), respectively.

References

1. A. Kundu and T. S. Fisher, *Electrochim. Acta*, 2018, **281**, 357–369.
2. J. S. Teixeira, R. S. Costa, A. L. Pires, A. M. Pereira and C. Pereira, *Dalt. Trans.*, 2021, **50**, 9983–10013.

Prediction of molecular properties of metal-containing drugs using machine learning models

V. Vigna[1,*], T. F. Cova[2], A. C. Pais[2], E. Sicilia[1]

[1]*University of Calabria, Arcavacata di Rende (CS), I-87036, Italy*
[2]*Universidade de Coimbra, Coimbra, 3004-535, Portugal*
**vincenzo.vigna@unical.it*

Over the past few years, the field of pharmaceutical exploration and prediction of molecular characteristics of drugs have undergone significant transformations with the emergence of machine learning.[1] This innovative approach combines computational power with empirical data, unlocking their combined potential. By utilizing vast datasets, machine learning algorithms can extract invaluable insights, uncover hidden patterns, and make projections regarding molecular behavior, toxicity, and even forecast useful molecular attributes such as solubility, reduction potential and other electronic properties. Through the integration of a diverse range of molecular descriptors[2], employing clever feature engineering techniques, and leveraging advanced modeling methods, machine learning enables efficient screening of a vast chemical space, streamlining the identification of potential drug candidates deserving further investigation. Here we present the results of the application of machine learning to the prediction of key molecular properties of metal containing compounds as anticancer drugs.

Figure 1: Exploring metal-based drug properties using Machine Learning.

Acknowledgements
The authors acknowledge Fundação para a Ciência e a Tecnologia (FCT), the Portuguese Agency for Scientific Research for the financial support through project UIDP/00313/2020. Tania Cova also acknowledges the Junior Researcher Grant CEECIND/00915/2018 assigned by FCT.

References
1. S. Dara, S. Dhamercherla, S. Jadav, C. Babu and M. Ahsan, Artif. Intell, Rev., 2022, 55, 1947–1999
2. S. Raghunathan, U. D. Priyakumar, *Int. J. Quantum Chem.,* 2022, 122, e26870

Memories Ferreira da Silva

O Laboratório Ferreira da Silva: crónica de uma reconstrução desejada

Marisa Monteiro

Museu de História Natural e da Ciência da Universidade do Porto, Praça Gomes Teixeira, 4099-002 Porto, Portugal
mmonteiro@reit.up.pt

No ano em que decorrem cem anos sobre o falecimento do notável químico e professor António Joaquim Ferreira da Silva, dá-se a conhecer à comunidade dos químicos portugueses a existência do Laboratório que perpetua a sua memória, requalificado e integrado num roteiro cultural e de História da Ciência onde também se incluem os laboratórios congéneres das Universidades de Coimbra e Lisboa, sendo que o conjunto dos três equipamentos foi recentemente recipiente de um *EuChemS Historical Landmarks Award*.

Para a requalificação do Laboratório Ferreira da Silva, local de aprendizagem de química analítica para muitas gerações de estudantes das Faculdades de Ciências, Engenharia e Medicina da Universidade do Porto, foi escolhido um período de duas décadas da sua existência, entre 1927 e 1949. Enquadrada por uma intervenção arquitetónica de grande envergadura em torno de estruturas originais existentes (bancadas e hottes), uma exposição de artefactos históricos recupera as ligações deste laboratório a Ferreira da Silva e a uma das suas maiores realizações – o Laboratório Químico Municipal do Porto.

Figura 1: O Laboratório entre as intervenções de 1927 e 1949 (Fonte: Universidade do Porto, Álbum - 1937) e em março de 2021 (Foto: João Soares / TVU)

References

1. Academia Politécnica do Porto, *Annuario da Academia Polytechnica: Anno lectivo de 1901-1902*, Imprensa da Universidade, Coimbra, 1902.
2. J. F. Alves e R. C. Alves, Ferreira da Silva e o Laboratório Químico Municipal do Porto (1884-1917), Revista Estudos do Século XX, 2012, **12**, 13-30.
3. Aguiar e J. Salgado, Variedades, Rev. Chim. Pura e Appl. Série I, Anno 4, 1908, **11**, 356-59.
4. Laboratorio Químico da Academia Polytechnica, Registo da correspondência expedida (1904-09-23/1911-11-11), https://arquivo.up.pt/details?id=202655.
5. Laboratorio Químico Municipal e Laboratorio Químico da Academia Polytechnica, Livro de cópia dos relatórios de analyses chimico-legaes, IV, (1907-04-06/1911-08-24), https://www.up.pt/arquivo/details?id=210147.
6. M. C. Lourenço e A. Carneiro, A propósito do Laboratorio Chimico do Museu de Ciência da Universidade de Lisboa..., *Boletim da Soc. Portuguesa de Química,* 2006, **103**, 63–70.
7. M. Monteiro e Luís Bernardo, The “Ferreira da Silva” Chemistry Laboratory: a Valuable Asset in a University Collection, *University Museums and Collections Journal*, 2012, **5**, 31-37, https://edoc.hu-berlin.de/handle/18452/18578.
8. J. P. Salgado, A Química na Academia Politécnica do Porto, in *O Ensino na Academia Politécnica,* Enciclopédia Portuguesa, Lda, Porto, 1937.
9. J. F. Silva, A extincção do Laboratorio Municipal, *Rev. Chim. Pura e Appl.* Série I, Anno 3, 1907, **6**, 209-306.
10. J. F. Silva, A Importancia da Dignidade da Sciencia e as Exigencias da Cultura Scientifica..., *Rev. Chim. Pura e Appl.* Série I, Anno 8, 1911, **3**, 69.
11. J. F. Silva, *O desfecho da questão do Laboratório Químico Municipal e Posto Fotométrico do Porto*, Imprensa Portuguesa, Porto, 1918.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Os zoilos e os templos das ciências

Manuel J. S. Monte

Universidade do Porto: DQB/FCUP/CICUP
mjmonte@fc.up.pt

A III série da *Revista de Química Pura e Aplicada* iniciou-se em 1924 com um volume composto por três números dedicados a homenagear Ferreira da Silva, cofundador em 1905 desta revista em colaboração com Alberto Aguiar e José Pereira Salgado. Nas palavras de Alberto Aguiar "o Dr. Ferreira da Silva não foi apenas um grande Químico, foi o criador da Química Portuguesa, dando-lhe um órgão de publicidade [a Revista] e um centro oficial de comunhão *scientífica* [a Sociedade de Química Portuguesa, atualmente designada Sociedade Portuguesa de Química]".[1]

A coragem e a dignidade científica de Ferreira da Silva eram reconhecidas por todos os que cultivavam o princípio da boa-fé. Homem de convicções fortes, envolveu-se com paixão em questões polémicas, como a suposta "salicilagem dos vinhos portugueses" e o caso "Urbino de Freitas". Ao longo da sua vida, colecionou muitos amigos e alguns adversários que o desgastaram com ataques soezes, enquanto não foram definitivamente derrotados. A sua grande luta foi com a Câmara Municipal do Porto que, em 1907, decretou a extinção do Laboratório Municipal, que funcionava sob a sua direção desde 1884. O laboratório Municipal era de facto a joia da coroa na sua estratégia de modernizar e higienizar o Porto, perseguindo os melhores padrões internacionais da época. Nas suas palavras "os laboratórios são hoje em dia os templos das ciências e aluí-los é obra do obscurantismo, obnóxia aos interesses gerais".[2] Refira-se que a escolha da palavra "templo", para designar alegoricamente "laboratório", já tinha sido usada por Pasteur,[3] um dos sábios venerados por Ferreira da Silva. Pasteur é também o autor da frase "não se perde no mundo nenhum bom esforço", que foi reproduzida por Ferreira da Silva, após o final feliz do incidente do Laboratório Municipal do Porto em 1916.

O combate enérgico que travou com os seus detratores mereceu, no discurso fúnebre proferido pelo então Reitor da Universidade de Coimbra, António Luís Gomes, o seguinte comentário referindo-se a Ferreira da Silva: "Este homem eminente que foi tamanho no saber como espezinhado por zoilos de toda a espécie".[4]

As mágoas acumuladas pelos tristes episódios decorrentes da extinção do Laboratório Municipal podem ter contribuído para a morte precoce que ocorreu passados 26 dias da sua jubilação.

Referências

1. A. Aguiar, Revista de Química Pura e Aplicada, III Série, I ANO, 1924, n.ºs 1 a 3, pág. 7 a 11.
2. Citado em: J. F. Alves, R. C. Alves "A. J. Ferreira da Silva – Nos Caminhos do Futuro", U. Porto, Porto (2011), P.164.
3. L. Pasteur, "Le budget de la science", *Revue des cours scientifiques,* 1er février 1868. Reproduit dans Ed. Raisons d'être, Paris (1947), p. 71.
4. A. Aguiar, Revista de Química Pura e Aplicada, III Série, I ANO, 1924, n.ºs 1 a 3, pág. 46.

Os alcalóides de Ferreira da Silva: Evolução do conhecimento da sua toxicologia

Fernando Remião

Laboratório de Toxicologia da Faculdade de Farmácia da Universidade do Porto

Ferreira da Silva foi Professor na Escola de Farmácia do Porto (precursora da Faculdade de Farmácia da Universidade do Porto), onde desde cedo colocou ao serviço da formação na área da Toxicologia todo o seu conhecimento sobre a pesquisa analítica dos alcaloides, assim como dos seus efeitos fisiopatológicos. Foram realmente vários os trabalhos na área da Toxicologia Analítica, nomeadamente o desenvolvimento de uma reação característica da cocaína, de uma nova reação para a identificação da eserina, ou, ainda, do aperfeiçoamento da composição do reagente de Lafon, para que este pudesse ser utilizado na pesquisa mais generalizada dos alcaloides.

No entanto, foi no notável "Caso Médico-Legal Urbino de Freitas" que Ferreira da Silva colocou todo o seu conhecimento ao serviço da Toxicologia Forense. Num grande escândalo da sociedade, implicou o então Lente Catedrático da Escola Médico-Cirúrgica do Porto, o médico Urbino de Freitas, na morte do seu sobrinho Mário Sampaio, naquilo que ficou registado na memória da cidade do Porto como o "Crime da Rua das Flores".

Ferreira da Silva, concluiu que a morte de Mário Sampaio se deveu a envenenamento pela morfina e delfinina, descrevendo ao pormenor[1] os métodos analíticos empregues para a identificação destes alcaloides nas perícias realizadas, os efeitos fisiológicos conhecidos à data para os mesmos, assim como os efeitos observados em rãs expostas aos extratos das vísceras da vítima. A apresentação focará uma análise dos efeitos observados e descritos por Ferreira da Silva à luz dos conhecimentos atuais, assim como descreverá os principais mecanismos envolvidos nos mesmos.

Referências

1. SOUTO, Agostinho António do; AZEVEDO, Joaquim Pinto de; PINTO, Manuel Rodrigues da Silva; SILVA, António Joaquim Ferreira da (1893a). O Caso Medico-Legal Urbino de Freitas – Observações e críticas. Relatórios. Documentos. Porto: Imprensa Portugueza.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Carbon materials for advanced water treatment

V. Calisto[1,*], D. L. D. Lima[1], É. M. L. Sousa[1], D. Pereira[1], V. Silva[1], M. V. Gil[2], M. Otero[3], V. Esteves[1]

[1] *CESAM & Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal*
[2] *Instituto de Ciencia y Tecnología del Carbono, INCAR-CSIC, Francisco Pintado Fe 26, 33011 Oviedo, Spain*
[3] *Departamento de Química y Física Aplicadas, Universidad de León, Campus de Vegazana, 24071 León, España*
**vania.calisto@ua.pt*

The development of effective and sustainable water treatment solutions is of utmost importance for the protection of aquatic resources, particularly due to the high prevalence of recalcitrant and potentially harmful organic micro-contaminants, such as pharmaceuticals, in aquatic environments. Carbon materials, namely biochars and activated carbons (AC), constitute very interesting options for the removal of pharmaceuticals from contaminated waters. Currently available commercial options rely on non-renewable feedstocks as precursors, which raises concerns due to possible mid/long-term shortage of raw materials and the sustainability of these fossil-based carbons. Also, these materials face some drawbacks concerning their difficult separation from the treated water which limits their global application.

In this work, carbon-rich residual biomass from agro-industrial activities were used for the development of highly microporous carbons, with subsequent application in advanced water treatment, using pharmaceuticals as case studies. The residual biomass was subjected to conventional, or microwave pyrolysis combined with chemical activation to obtain microporous carbons. The optimization of materials' production routes was privileged in order to identify more sustainable production routes, by optimizing low-energy processes, minimizing the use of chemical activation reagents, and promoting after-use regeneration strategies. In this sense, materials with distinct key features were obtained, namely, a) highly microporous activated carbon; b) O, N and S-functionalized activated carbon for improved interactions with specific target contaminants; c) activated carbon-magnetic iron oxides composites for easy recuperation from water, and d) photocatalysts obtained by magnetization of biochar doped with titanium dioxide.

The efficiency of these materials in the removal of pharmaceuticals from water, foreseeing their application in the advanced treatment of wastewater, was evaluated, considering their performance as adsorbents (for activated carbon, functionalized activated carbon and magnetic activated carbon composites) and photocatalysts in solar-driven degradation processes (for magnetic titanium dioxide-biochar composites). Experimental results in batch and continuous operation modes, either in single and competitive conditions, revealed that these biomass-based materials are very effective in the elimination/degradation of pharmaceuticals from water.

Acknowledgements

The authors acknowledge financial support to CESAM by Fundação para a Ciência e Tecnologia (FCT)/MCTES (UIDP/50017/2020+UIDB/50017/2020 +LA/P/0094/2020), through national funds. This work was developed within the project SYNERGY (2022.02028.PTDC), financially supported by national funds (OE), through FCT/MCTES. Diana Lima acknowledges funding from FCT under the Scientific Employment Stimulus (2022.00570.CEECIND). É.M.L. Sousa, D. Pereira and V. Silva thank for their PhD grants (2020.05390.BD, 2020.05389.BD, 2022.10472.BD, respectively), supported by national funds and FSE through FCT. M. V. Gil acknowledges support from a Ramón y Cajal grant (RYC-2017-21937) of the Spanish government and the Spanish State Research Agency, co-financed by the European Social Fund (ESF).

References

1. European Commission; *Olive Oil*, 2021 https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil_en#oliveoilintheeu.
2. Puig-Gamero, M.; Esteban-Arranz, A.; Sanchez-Silva, L.; Sánchez, P., *J. Environ. Chem. Eng.*, 2021**, 9**, 105374.
3. Diaz de Tuesta, J. L.; et al.; *J. Environ. Chem. Eng.*, 2021**, 9**, 105004.

Qualidade, autenticidade e segurança alimentar: o valioso contributo do Professor Ferreira da Silva

Isabel M. P. L. V. O. Ferreira

LAQV/REQUIMTE – Laboratório de Bromatologia e Hidrologia; Departamento de Ciências Químicas; Faculdade de Farmácia – Universidade do Porto

Na área da qualidade, autenticidade e segurança alimentar o contributo do professor António Joaquim Ferreira da Silva foi relevante e histórico. Os seus estudos nesta área conseguiram que, na sua época, a ciência passasse a ser vista pelo poder central como fundamental para a regulamentação alimentar, especialmente, no controlo da adulteração e falsificação de géneros alimentares e na garantia da sua autenticidade. As suas considerações sobre precisão e a sensibilidade dos métodos analíticos na fiscalização alimentar e sobre a necessidade de uma avaliação quantitativa, lançaram novas perspetivas sobre a política de segurança alimentar que era praticada na sua época. É de destacar o seu legado na harmonização de métodos de análise dos alimentos, limites de deteção e valores de referência para a quantificação de certas substâncias quimicamente analisadas.

Doutorado em Ciências Físico-Químicas e em Farmácia pelas faculdades de Ciências e de Farmácia da Universidade do Porto, em 1918 e 1922, respetivamente, é da sua autoria a obra "Análise dos vinhos elementares e autênticos da circunscrição do Norte de Portugal".

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A avaliação da autenticidade do Vinho do Porto ao longo dos tempos

Manuel Lima Ferreira, Paulo Barros, Natália Ribeiro

Instituto dos Vinhos do Douro e do Porto, I.P.

Constitui missão do Instituto dos Vinho do Douro e do Porto, I.P. (IVDP, IP), certificar, controlar, defender e promover as DOP Porto e DOP Douro, tendo como visão potenciar a qualidade, trabalhar no futuro, para um território sustentável, contribuindo para o incremento do negócio das DOP Porto e DOP Douro.

Neste contexto, a avaliação da autenticidade do Vinho do Porto tem assumido, ao longo da sua longa história, uma preocupação constante de toda a fileira envolvida, sendo determinante um conhecimento muito aprofundado da sua composição e das determinantes enológicas que a condicionam.

Desde a criação da Companhia Geral de Agricultura das Vinhas do Alto Douro, pelo Marquês de Pombal, em 1756, até aos nossos dias, muitos são os exemplos de contributos da comunidade científica, em muitos casos em articulação com as entidades oficiais do estado, para a garantia da autenticidade do Vinho do Porto. No final do séc. XIX e início do séc. XX, o Professor Ferreira da Silva, com os seus estudos sobre a questão da *salicilagem* do vinho do Porto, imprimiu um inestimável contributo para desbloquear um grave entrave às exportações de vinho do Porto para o Brasil, sendo um excelente exemplo da importância que assume o conhecimento científico em disputas comerciais.

Em 1933 é criado o Instituto dos Vinho do Porto, que em 2003 incorporou as funções referentes à Denominação de Origem Douro, passando a designar-se Instituto dos Vinhos do Douro e do Porto, I.P. Para veicular o conhecimento produzido sobre Vinho do Porto, tendo como enfoque a especificidade deste produto, a partir de 1940 começam a ser editados os Anais do Instituto do Vinho do Porto, depositário de vastíssima e relevante informação sobre a caracterização do produto, publicando, de forma inovadora, diversos métodos analíticos específicos para doseamentos de compostos físico-químicos em vinho do Porto. O foco da investigação realizada recaía nos problemas composicionais que iam surgindo como entraves ao comércio internacional.

Os progressos nas metodologias analíticas tiveram reflexo na resposta que era necessária, em cada momento, para fundamentar a argumentação técnico-científica necessária à resolução de diferendos no comércio internacional que tinham por fundamento aspetos composicionais.

Com maior especificidade e maior sensibilidade as metodologias entretanto desenvolvidas permitiram um mais amplo conhecimento da composição do vinho do Porto. O advento da polarimetria, da cromatografia em fase gasosa e depois em fase líquida, da espetroscopia cintilação líquida, da espetroscopia de absorção atómica, são disso exemplo.

O pioneirismo na acreditação do Laboratório do IVP pela Norma ISO 17025 (1994) e da Câmara de Provadores (1999) são bons exemplos da preocupação assente na atualidade técnica e na fiabilidade das determinações analíticas efetuadas na certificação dos produtos da Região Demarcada do Douro.

Na procura do conhecimento e na sensibilização para a especificidade da composição físico-química do Vinho do Porto, o Instituto dos Vinhos do Douro e do Porto, para melhor assegurar a autenticidade dos produtos vitivinícolas que certifica, tem recorrido ao Saber residente em universidades, com estas articulando ações comuns.

Na atualidade, aproveitando todo um importante património de informação qualitativa e quantitativa de vinhos e aguardentes cuidadosamente preservada aos longo do tempo, na qual se agregam dados sensoriais, informação espectral, cromatográfica, entre outras fontes de informação, o Instituto dos Vinhos do Douro e do Porto, I.P. tem progredido, de forma pioneira, na construção de modelos preditivos de apoio à decisão para a certificação de produtos, alicerçada na inteligência artificial.

Desta forma, procuramos dar continuidade e honrar o inestimável legado científico deixado pelo Professor Ferreira da Silva, progredindo no aperfeiçoamento de metodologias que nos permitam alargar o conhecimento sobre a composição dos produtos da Região Demarcada do Douro.

O passado como conhecimento para o futuro

Vicente Ferreira da Silva

É inquestionável que, a partir de um determinado momento, o homem foi gerador das circunstâncias. A sociedade, moldada num processo gregário, é uma dessas ocorrências. O indizível encontra-se na espécie humana. Todos somos feitos por partes de todos. O legado dos que nos antecederam, assim como os seus valores, fazem o alicerce para o que construiremos. O pensamento, materializado na ciência e no conhecimento, são o meio para tornar a sociedade melhor e mais justa.

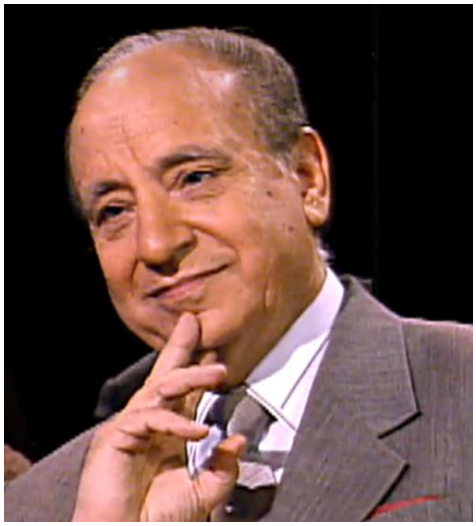
Memories Fraústo da Silva

Fraústo da Silva and the two cultures: Biographic note

Armando J. L. Pombeiro

Centro de Química Estrutural, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa
pombeiro@tecnico.ulisboa.pt

Professor João José Rodiles Fraústo da Silva was one of the most influential personages in science and culture in Portugal, a “man of the two cultures” who always prefered “to do” or “to make happen” instead of “to be”.



The The Portuguese Chemical Society, following a joint proposal of this author and his colleague José Moura, in recognition of Professor Fraústo´s outstanding role in those areas, has agreed to take important initiatives in his memory, namely the organization of this celebratory session within the National Meeting, the creation of a Prize under his name, the coinage of a medal and the publication of a special issue of the “Boletim” of the Society, all in the current year of 2023 as a celebration of the 90th anniversary of Prof. Fraústo da Silva´s birth.

This communication addresses a brief account of his biography, witnessed by the author as one of his disciples, illustrating aspects of his personality and some activities he developed along his so rich life in emblematic institutions in science, culture and public administration in our country.

Prof. Fraústo da Silva will remain as an inspiration, an example to follow and a Friend to rememberand.

References

1. A. J. L. Pombeiro, “Evocação Histórica do Académico João José Rodiles Fraústo da Silva”, Session of the Academy of Sciences of Lisbon, November 17th, 2022, in publication.
2. A. J. L. Pombeiro, “Protagonists in Chemistry: Prof. João J.R. Fraústo da Silva”, *Inorg. Chim. Acta*, 356 (2003) 1-5 (special issue dedicated to him). http://dx.doi.org/10.1016/S0020-1693(03)00330-X
3. A. Pombeiro, J. Moura, *In Memoria* “Um Adeus a Fraústo da Silva (1933-2022)”, *Química* (Boletim of the Portuguese Chemical Society), 2022, *46*, No. 166, 153-154.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Remembering Fraústo da Silva

José J. G. Moura

LAQV, REQUIMTE, Depart. of Chemistry, NOVA School of Science and Technology | FCT NOVA, Portugal
jose.moura@fct.unl.pt

Professor Fraústo da Silva left us recently. It was a time of great loss and much grief. Together with Armando Pombeiro, we felt that we had the duty to keep the various nuances of the man/scientist who marked us, and to join memories we shared, and to leave a testimony of the human impact he had on science and culture, bring to younger people the memory of an exemplary and inspiring Chemist.

We greatly appreciate the support of SPQ, which received with open arms the publication of a note/memoir and a special issue of the BOLETIM (to be published at the end of 2023) with contributions from many friends/reserachers (enormous participation), not forgetting the creation of the Prize Fraústo da Silva (to be attributed for the first time, in 2023, to Professor Carlos Geraldes, UC) and the special session to take place during the SPQ National Meeting, Aveiro, 24-26 July, 2023.

My contribution in this session will be personal, remembering some moments (including scientific) privileged by the contact with the Professor.

Professor JJR Fraústo da Silva with Armando Pombeiro and José Moura

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020 project) and PTDC/BTA-BTA/0935/2020, which are financed by national funds from Fundação para a Ciência e a Tecnologia/MCTES.

Metal complexes in biological media. Relevance of assessing their speciation

J. Costa Pessoa, I. Correia

Centro de Química Estrutural, Institute of Molecular Sciences and Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-Lisboa
joao.pessoa@ist.utl.pt

During evolution processes, nature incorporated several transition metal ions in living organisms so that several of the required tasks could be efficiently executed. Relevant examples are ions of Mo, Fe, Zn, Cu, Mn and V.[1, 2] In living beans metal ions may have structural and/or functional roles, either by themselves or upon interacting with biomolecules. Besides the understanding of their role in biological systems, researchers and pharmaceutical industry have also been seeking metal complexes as compounds useful for treatment and diagnosis of diseases.

When discussing interactions and biological effects of complexes of labile metal ions, such as those of Cu, V, Mn, Zn and Fe, researchers often assume that, when added to biological media, the complexes maintain their integrity. Mainly using examples of complexes of copper(II) and vanadium(IV and V) we demonstrate that often this is not correct. [2, 3] In fact, when these complexes of labile metal ions are added to biological media, they will undergo hydrolysis, exchange of ligands and/or redox reactions, these processes depending on the pH and concentration of the species present. As the concentration of the complex decreases or the number and concentration of potential ligands increases, more extensive hydrolysis and/or exchange of ligands will take place.

In this communication we highlight that when observing a biological effect upon addition of a metal complex, any proposal of which is the biologically active species or discussion of the mechanism of action, must take into account the speciation of these metal ions in the systems under study..

Acknowledgements
We thank the financial support of Fundação para a Ciência e Tecnologia (FCT) (projects UIDB/00100/2020, UIDP/00100/2020 and LA/P/0056/2020).

References

1. R. J. P. Williams, J. J. R. Fraústo da Silva, The Natural Selection of the Chemical Elements – The Environment and Life's Chemistry, Oxford University Press, Oxford, 1996.
2. R. J. P. Williams, J. J. R. Fraústo da Silva, The Chemistry of Evolution – The Development of our Ecosystem, Elsevier, Amsterdam, 2006
3. P. Nunes, I. Correia, F. Marques, A. P. Matos, M. M. C. Santos, C. G. Azevedo, J.-L. Capelo, H. M. Santos, S. Gama, T. Pinheiro, I. Cavaco, J. Costa Pessoa, *Inorg. Chem.*, 2020, **59**, 9116-9134.
4. P. Nunes, I. Correia, I. Cavaco, F. Marques, T. Pinheiro, F. Avecilla, J. Costa Pessoa, J. Inorg. Biochem., 2021, **217**, 111350.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

O Sudário de Turim, fonte de extraordinária informação científica

Victor M. M. Lobo

Departamento de Química, Universidade de Coimbra, 3004-535 Coimbra
vlobo@ci.uc.pt

Na Catedral de Turim, Itália, está um pano que a tradição diz ter envolvido o corpo de Jesus de Nazaré após a sua crucificação. Tem sido feito um grande trabalho científico para determinar a sua autenticidade, usando os mais avançados e complexos métodos de investigação. Estarei ao dispor para conversar sobre os fundamentos e capacidades científicas destes sofisticados métodos de análise química que nos garantem que o Sudário não pode ser uma fraude, bem como sobre a extraordinária informação científica que se tem tirado dessas análises baseadas na física, na química, na mineralogia, na botânica, na anatomia, etc. Por exemplo, temos uma imagem do rosto (que será mostrada) do homem do Sudário (H. S.) ; este teve morte por crucificação, os médicos podem, a partir desses registos, explicar as causas, e essa morte foi pela Páscoa e em Jerusalém; vê-se que tinha 175 +/- 2 cm; levou 120 chicotadas, com um chicote usado pelos romanos; caiu no solo numa rua provadamente de Jerusalém e, alem de bater com o joelho no chão, também se prova que bateu com a face e o nariz; vê-se o local, no corpo, onde os pregos foram espetados, bem como o local onde uma lança que o atravessou; o sangue é similar ao do pano de Oviedo, bem documentado desde o Séc. VIII e cujo percurso se conhece; ADN de Jerusalém; vêem-se muitas flores e 58 espécies de pólen que mostram ter sido na Páscoa, em Jerusalém, o H. S. ter tido uma coroa de uma planta com espinhos fortes, e depois ter o Sudário viajado por Edessa, Constantinopla, e Europa; tem resíduos de frutos usados em rituais fúnebres de Jerusalém; etc.

The undiscovered world of Werner complexes

Maria José Calhorda*, Nuno A. G. Bandeira

BioISI - Instituto de Biossistemas e Ciências Integrativas, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
**mjc@fc.ul.pt*

The study of Werner complexes was introduced in Instituto Superior Técnico in the 1960s by Fraústo da Silva. The first example in this communication addresses the two cationic complexes $[Co(NH_3)_6]^{2+,3+}$ and the initially puzzling question of why the Co(III) complex is a diamagnetic species (six paired d electrons), while the Co(II) complex is paramagnetic with three unpaired electrons (high spin). Why not only one (low spin)? Crystal field theory leaves some ambiguity, which can be answered with quantum chemistry. Both options for the Co(II) complex are shown in Figure 1, left, and feature different Co-N bond distances. A tantalizing prospect is also the deployment of *in silico* ligand design strategies to create near degeneracy in either spin state.

The second example deals with a cobalt complex synthesized in a mixture by Vortmann at the end of the XIX century[1] and later in Werner´s group, probably around 1909. It was surprisingly left on the shelf for almost one hundred years, when someone from Berke's group, who then occupied the same labs, found the vial. There were good crystals and the crystal structure could be determined,[2] but it was not possible to distinguish between OH and NH_2 groups (Figure 1, right) in the units bridging the two cobalt atoms in the binuclear species. A final interpretation of the nature of the ligands was provided by DFT calculations.[3] The O-O distance in the bridging O_2 units correlated very well with the qualitative bond order of the O-O bond associated with the electron count in their molecular orbitals.

These two stories illustrate the power of crystal field theory to understand the basic trends of metal-ligand bonds in Werner complexes and how molecular orbital calculations provide the complement.

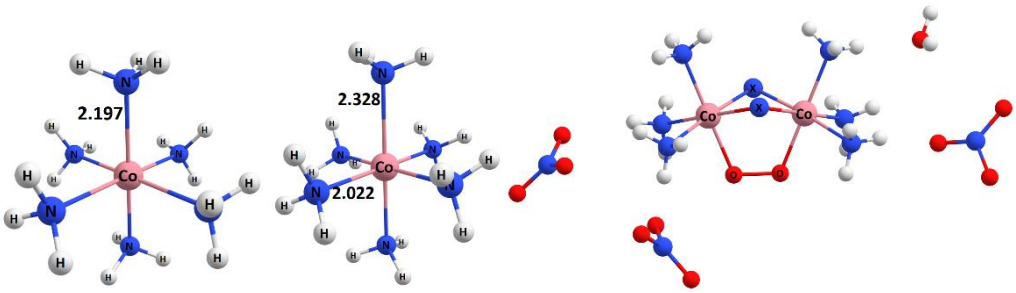


Figure 1: The molecular structure (bond distances in Å) of $[Co(NH_3)_6]^{2+}$ HS (left) and LS (center) and the binuclear Werner complex $[(NH_3)_6Co_2(\mu\text{-}O_2)(\mu\text{-}OH)(\mu\text{-}NH_2)]$ $[NO_3]_3.1.25(H_2O)$ (right).

References

1. G. Vortmann: Zur Kenntniss des Kobaltammonium Verbindungen. 11. Mittheilung. *Ber. Dtsch. Chem. Ges.* 1877, **10,** 1451-1459.
2. B. Spingler, M. Scanavy-Gregoriev, A. Werner, H. Berke, S. Lippard, Crystal Structure Determination of a (μ-Amido)(μ-hydroxo)(μ-superoxo)dicobalt(III) Complex from the Werner Collection, *J. Inorg. Chem.* 2001**, 40**, 1065-1066.
3. N. A. G. Bandeira, M. J. Calhorda, Electronic Structure and Hydrogen Bonding in a Dicobalt(III) Werner Complex, *Structural Chemistry,* 2005, **16**, 265-271.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A praise for denitrification

Isabel Moura

LAQV, REQUIMTE, NOVA School of Science and Technology | FCT NOVA, Portugal
isabelmoura@fct.unl.pt

As a guided tour to visit challenging landscapes, a concise review of the bioinorganic aspects of denitrification is outlined, with emphasis to structural and mechanistic aspects of the relevant enzymes involved in this complex pathway. Denitrification (or dissimilative nitrate reduction) is an anaerobic process used by some bacteria for energy generation, converting nitrate to dinitrogen. This process has relevant environmental implications. Nitrate accumulation and release of nitrous oxide in the atmosphere due to excess use of fertilizers in agriculture are two examples of environmental problems, where denitrification plays a central role. Reduction of nitrate to dinitrogen is accomplished by four different types of metalloenzymes (using a wide range of transition metals) that, in sequence, undergo four simple steps: nitrate is reduced to nitrite, then to nitric oxide, followed by the reduction to nitrous oxide and by a final reduction to dinitrogen. A surprising tour.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020 project) and PTDC/2022.01152, which are financed by national funds from Fundação para a Ciência e a Tecnologia/MCTES. Sofia R. Pauleta, Marta S.P.Carepo, Luísa B. Maia, Cristina Cordas and José J.G. Moura made relevant contributions.

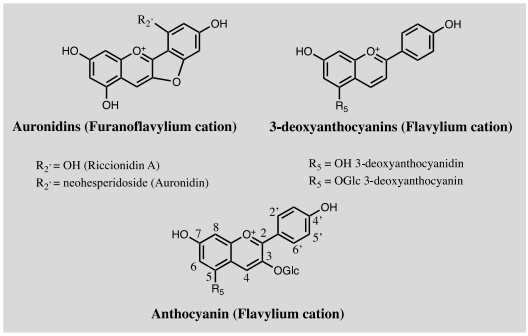
References
Metalloenzymes in Denitrification: Applications and Environmental Impacts, RSC Metallobiology Series No. 9. Eds I.Moura, J.J.G.Moura, S.R.Pauleta and L.B.Maia. The Royal Society of Chemistry (2017); DOI: 10.1039/9781782623762

O triunfo do azul na natureza e no antropoceno. Sobre a evolução (Química) dos sistemas de cor nas plantas. O caso das hortênsias

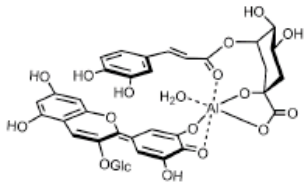
Fernando Pina

LAQV – REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
fp@fct.unl.pt

Comparando a árvore genealógica das plantas com a escala dos tempos geológicos, foi possível associar a evolução dos sistemas de cor das hepáticas aos furanoflavilios, fetos e musgos às 3-deoxy-antocianinas e angiospérmicas às antocianinas, Esquema 1A. Somente estas últimas dão a cor azul. No que respeita ao Antropoceno, a cor azul foi ausente nas pinturas rupestres do primeiro paleolítico, a última cor a ser usada nos tingimentos no neolítico, a última cor a aparecer nos LEDs e LASERs, depois do vermelho e do verde. As flores azuis adaptadas aos mercados só apareceram no final do Sec. XX por processos de engenharia genética. O caso das flores azuis das hortênsias que necessitam de Al(III), um metal cuja participação em algum processo biológico essencial não é conhecida, insere-se nesta problemática, Esquema 1B.[1]



A



B

Esquema 1: A- Evolução dos sistemas de cor nas plantas; B-Estrutura proposta para a cor azul das hortênsias.

References
F. Pina, N. Basílio, A. J. Parola, M. J. Melo, J. Oliveira, V. de Freitas, The Triumph of the Blue in Nature and in Anthropocene, *Dyes and Pigments*, 2023, **210**, 110925. https://doi.org/10.1016/j.dyepig.2022.110925

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Ligações de hidrogénio e outras interações não covalentes em química de coordenação

M. Fátima C. Guedes da Silva, Kamram T. Mahmudov

Centro de Química Estrutural - Institute of Molecular Sciences, and Departamento de Engenharia Química. Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1

Apesar da sua fraca intensidade (bem inferior à das ligações covalentes convencionais), as interações não-covalentes entre átomos/moléculas influenciam o design, a construção, a síntese e a estabilidade das estruturas químicas, as suas propriedades físico-químicas e aplicações.
Serão referidos casos específicos das ligações de hidrogénio, em particular as assistidas por ressonância e as assistidas por carga (do Inglês, RAHB e CAHB, respetivamente), e o modo como tais contactos podem ser ajustados pelo pH do meio e pela temperatura, influenciando a geração de unidades construtoras em agregados supramoleculares, a resolução de isómeros, a reatividade, etc.
Serão ainda discutidas as ligações de halogéneo (Ha) e as de calcogéneo (Ch), bem menos conhecidas. Estas interações (não-covalentes) baseiam-se na existência de regiões com potencial eletrostático positivo em posições opostas às das ligações covalentes envolvendo esses átomos. Tais interações permitem a criação de novos tipos de materiais com propriedades únicas e/ou com aplicações várias.

References

1. “Non-covalent Interactions in the Synthesis and Design of New Compounds”, A.M. Maharramov, K.T. Mahmudov, M.N. Kopylovich, A.J.L. Pombeiro (eds.), J. Wiley & Sons, 2016.
2. “Non-covalent Interactions in Catalysis”, K.T. Mahmudov, M.N. Kopylovich, M.F.C. Guedes da Silva, A.J.L. Pombeiro (eds.), Royal Sociey of Chemistry, 2019.

Living with Chemistry in a virtual world-"A Química na era da desmaterialização do conhecimento"

C. Teixeira

Centro de Química Estrutural, Institute of Molecular Sciences and Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av.Rovisco Pais, 1049-001 Lisboa, Portugal
clementina@tecnico.ulisboa.pt

Coordination Chemistry was the starting point for a STEAMD project, linking Science, Technology, Engineering, Art, Mathematics and Design. The first results (1993/4) were based on experimental crystal growth techniques by heterogeneous nucleation, the method "On the Rocks": rocks, minerals, shells and metallic wires with rough surfaces were used as substrates in aqueous solutions of metal complexes and other compounds known to produce large crystals. These substrates were hosting the crystals, but frequently reacted with the saturated solutions, creating new crystalline compounds and also acting as crystal habit modifiers. The time required to grow large crystals in aqueous solutions was decreased compared to other common methods such as the thread seeding technique. Compounds containing hydrogen and prone to establish hydrogen bonding are producing larger crystals and faster than the anhydrous compounds without this property, the most remarkable examples being NaCl and $K_3[Fe(CN)_6]$. The most popular salts are those of the alum and Tutton families, and ammonium dihydrogen phosphate (ADP), some of those also colored with food dyes. A collection of rigorous models of the crystal lattices by Miramodus Molecular Models® enables a better understanding of chemical bonds in these coordination compounds (1cm=1 Angström).

This kind of chemical laboratory sculptures led to a connection to Art, and to avoid the exposure to toxic metallic compounds (Cr, Ni, Co, Cu) further studies on side reactions, crystallization and habit modifiers were performed under a stereomicroscope Nikon® (Chemical Microscopy) producing beautiful photomicrographs in the range 10x-126x.

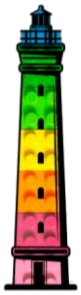
The results are being published in social network since April 2013 [1]. In 2016 Chemical Patterns were generated from these experiments by GeCla® program (Gerador e Classificador de Simetrias, Atractor, Mathematics). Since 2018, Science patterns were extended to other areas of knowledge and during the pandemic period of isolation new ones were produced by free applications from the Web (Facebook®, Instagram® [2], Google Play Apps®) in a virtual exhibition "Química, Arte e Inteligência Artificial"[3,4]. Some of the patterns were also printed on textiles (IST Microfashion, Artesãos do Século XXI [5]) and paper, and a large collection of origamis was presented in several exhibitions at public Libraries, Museums, Schools and Science fairs [6].

Professor Frausto da Silva's books on Inorganic Chemistry and Analytic Chemistry will enable a better understanding of these mechanisms of crystal growth and chemical reactions.

Acknowledgements
Fundação para a Ciência e a Tecnologia CQE - UIDB/00100/2020, UIDP/00100/2020; Institute of Molecular Sciences IMS - LA/P/0056/2020.

References

1. https://www.facebook.com/profClementinaTeixeira/, 9/6/2023
2. https://www.instagram.com/clementina_teixeira/, 9/6/2023
3. Teixeira, C., "Química, Arte e Inteligência Artificial", http://deq-la.tecnico.ulisboa.pt/2021/exposicao/exposicao.php, 9/06/2023
4. Teixeira, C., "Cristais Químicos, do Real ao Virtual", accepted for publication, https://www.researchgate.net/publication/360456594_Cristais_Quimicos_do_Real_ao_Virtual#fullTextFileContent, 9/6/2023
5. https://www.researchgate.net/publication/266175081_Artesaos_do_Seculo_XXI_-Artesanato_observado_ao_microscopio , 9/6/2023
6. https://www.researchgate.net/publication/351351022_Literalmente_aos_Papeis , 9/6/2023



Flash Communications

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Sustainable solar-driven photo-reactor for the removal of antibiotics from effluents using TiO_2/carbon quantum dots

Valentina Silva[1,*], V. L. Louros[1], C. P. Silva[2], M. Tacão[3], M. Otero[4], V. Calisto[1], Diana L. D. Lima[1]

[1]CESAM & Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; [2]Polytechnic University of Coimbra, Coimbra Health School, Department of General Sciences, Rua 5 de Outubro – S. Martinho do Bispo, Apartado 7006, 3046-854 Coimbra, Portugal; [3]CESAM & Department of Biology, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal; [4]Departamento de Química y Física Aplicadas, Universidad de León, Campus de Vegazana, 24071 León, España
**valentinagsilva@ua.pt*

In the last few years, there has been a growing concern about the development of efficient and sustainable treatments to remove antibiotics from contaminated effluents. These effluents must be treated before reuse or discharge into the natural environment so to avoid the increase of antimicrobial resistance – a major public health problem of the 21st century. The use of photocatalysts is considered as a promising strategy for the sustainable solar-driven removal of antibiotics from effluents. However, most of the proposed photocatalytic treatments have been studied at laboratory scale under simulated radiation. In this work, after having verified that titanium dioxide (TiO_2) coupled with carbon quantum dots (CQDs) (4% (*w*/*w*)) are efficient photocatalysts for the removal of antibiotics from water, these composite materials were tested in a tubular reactor operated under continuous flow mode (**Figure 1**) using natural solar radiation. In such conditions, the photodegradation of two antibiotics widely used in aquaculture, namely sulfadiazine (SDZ) and oxolinic acid (OXA), was studied in two different aqueous matrices, simulating fresh and brackish water, in the absence and presence of TiO_2/CQDs (4% (*w*/*w*). The use of this photocatalyst increased 103 times the SDZ degradation rate constant in simulated freshwater, while in simulated brackish water the increase was of 87 times. For OXA, the rate constant increase was not so pronounced, with 8 times in simulated freshwater and 6 times in simulated brackish water. Furthermore, the obtained results showed that the accumulated UV energy needed for SDZ removal using TiO_2/CQDs (4% (*w*/*w*) was less than 4 kJ L^{-1} in both simulated freshwater and simulated brackish water. Meanwhile, for OXA removal in presence of TiO_2/CQDs (4% (*w*/*w*), less than 5 kJ L^{-1} and around 15 kJ L^{-1} were respectively needed in simulated fresh and brackish water. Moreover, this study demonstrated that the proposed photocatalytic treatment was not only efficient in the removal of SDZ and OXA but also in the elimination of their antibacterial activity, either in PBS or SSS. Therefore, photocatalysis under continuous flow mode using TiO_2/CQDs constitutes a promising and sustainable treatment for antibiotics' efficient removal from aquaculture effluents.

Figure 1: Continuous flow photo-reactor used in this work.

Acknowledgements
Valentina Silva thank support by the Fundação para a Ciência e a Tecnologia (FCT) PhD Grant (2022.10472.BD). Diana Lima acknowledges funding from FCT under the Scientific Employment Stimulus (2022.00570.CEECIND). The authors acknowledge financial support to CESAM by FCT/MCTES (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020), through national funds.

Pumpkin peel phenolic extracts: optimized extraction and potential use as food preservatives

Maria G. Leichtweis[1,2,4], Adriana K. Molina[1,2], Spyridon A. Petropoulos[3], Márcio Carocho[1,2], Tânia C. S. P. Pires[1,2], Maria Inês Dias[1,2], Ricardo Calhelha[1,2], M. Beatriz P. P. Oliveira[4], Carla Pereira[1,2,*], Lillian Barros[1,2]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [3]Department of Agriculture Crop Production and Rural Environment, University of Thessaly, 38446 Volos, Greece; [4]REQUIMTE—Science Chemical Department, Faculty of Pharmacy, University of Porto, Rua Jorge Viterbo Ferreira no. 228, 4050-313 Porto, Portugal
**carlap@ipb.pt*

In the food industry, byproducts generated from food processing can be a significant source of valuable compounds that can be used for different applications, including food preservation. The aim of this study was to extract phenolic compounds from pumpkin peels of the Greek variety 'Leuka Melitis' in order to valorize this byproduct generated during pumpkin processing and promote sustainability and circular economy. Two different extraction techniques were compared: heat-assisted (HAE) and ultrasound-assisted (UAE) extraction. The extraction processes were optimized using response surface methodology (RSM) based on the Box-Behnken experimental design, using extraction time, temperature (HAE) or power (UAE), and ethanol concentration in the solvent as independent variables; whereas extraction yield (dry residue) and total phenolic content (Folin-Ciocalteu method) were used as dependent variables. In addition, to validate the potential application of the obtained compounds as food preservatives, the phenolic profile (HPLCDAD-ESI/MS), the antioxidant, antimicrobial, and cytotoxic properties of the optimal extract were also evaluated.
The optimization study demonstrated that UAE was more effective than HAE in both responses. This technique resulted in a two-fold increase in the concentration of phenolic compounds compared to the HAE, yielding 307 mg/g dw and 135 mg/g dw of total phenols, respectively, in the individual optimal variable conditions. In the global optimal conditions, although the UAE method required the highest power tested (400 W), it allowed the lowest extraction time (5 min) and only the use of water as solvent (0% ethanol), resulting in 1.1 g/100 g of dry residue and 120 mg/g dw of total phenols. On the other hand, the conventional extraction (HAE) facilitated energy and solvents saving, demanding only 30 °C and water as solvent, despite the increased extraction time (67 min), resulting in a yield of 0.9 g/100 g of dry residue and 106 mg/g dw of total phenols. Through the RSM, it was suggested that the ethanol concentration in the extraction solvent had the most significant impact on both dependent variables, with higher ethanol concentrations resulting in lower extraction yields, but higher phenolic content in the extracts. Regarding the experimental validation of the global optimal conditions by UAE, the results were satisfactory, since the extract presented a heterogenous profile of phenolic compounds, with six tentatively identified molecules, including three flavonoids, two phenolic acids, and one flavan-3-ol, in a total concentration of 1.525 ± 0.004 mg/g of extract. The extract revealed antihemolytic activity (IC_{50}: 540 ± 15 µg/mL) and inhibited lipid peroxidation (IC_{50}: 2510 ± 147 µg/mL), while it was effective against four bacteria and one fungus (at the maximum tested concentration of 10 mg/mL). Furthermore, it did not reveal cytotoxicity in a primary culture of non-tumor porcine liver cells, up to 400 µg/mL.
The results of this study demonstrate the potential use of pumpkin byproducts from the food industry to obtain extracts with a high content of bioactive compounds. In addition, the study highlights the efficiency of alternative extraction techniques in reducing byproduct waste, and solvents and energy consumption, while at the same time improve the added value of pumpkin crop within the circular economy context.

Acknowledgements
This research was partly funded by the Foundation for Science and Technology, P.I., (FCT, Portugal) through the national funds FCT/MCTES to CIMO (UIDB/00690/2020 and UIDP/00690/2020), SusTEC (LA/P/0007/2021), and UIDB/50006/2020. It also received national funding via FCT, P.I., through the institutional (M.I.D., R.C., C.P., L.B.) and individual (M.C., CEECIND/00831/2018) scientific employment program; and PhD grants (M.G., 2020.06706.BD, A.K.M., 2020.06231.BD). FCT, P.I., within the scope of the project PRIMA Section 2-Multi-topic 2019: PulpIng (PRIMA/0007/2019), as well as by the General Secretariat for Research and Technology of the Ministry of Development and Investments under the PRIMA Program (Prima2019-08). PRIMA is an Art.185 initiative supported and co-funded under Horizon 2020, the European Union's Program for Research and Plants 2022, 11, 800 16 of 18 Innovation.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Effective light-activated photosensitizers for photoinactivation of microorganisms

L. M. O. Lourenço[1,*], S. R. D. Gamelas[1], C. P. S. Ribeiro[2], C. Vieira[3], M. Bartolomeu[3], J. P. C. Tomé[2], A. C. Tomé[1], M. A. F. Faustino[1], A. Almeida[3]

[1]LAQV-Requimte, Department of Chemistry, University of Aveiro, Aveiro, Portugal; [2] CQE, Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal; [3]CESAM, Department of Biology, University of Aveiro, Aveiro, Portugal.
**leandrolourenco@ua.pt*

Among the various groups of microorganisms, bacteria and viruses can cause critical and persistent infections in humans.[1-3] The bacterial organization in biofilms, besides providing a pronounced advantage on microorganism survival when compared with planktonic forms, also promotes the development of higher resistance to conventional antimicrobial treatments.[2] Viruses have generally a greater capacity for mutation, especially RNA viruses, as was demonstrated by SARS-CoV2 virus mutations. This high viral mutation rate promotes the development of their resistance to traditional antivirals and establishes the resistance behaviour in virus populations, decreasing their susceptibility to some drugs.[3] Antimicrobial photodynamic treatments (aPDT) can be an efficient therapeutic alternative to eradicate microorganisms through the combination of a photosensitizer molecule (PS), dioxygen (O_2), and visible light to induce the formation of reactive oxygen species (ROS), as singlet oxygen ($^1O_2$), that leads to the cell death.[3-5] Having this in mind, water-soluble PS bearing cationic groups (e.g., porphyrin, chlorin, and phthalocyanine dyes) were synthesized, structurally characterized, and their aPDT efficiency towards bacteria (Gram-(-) bacterium *Escherichia coli* in planktonic and biofilm forms) and viruses (bacteriophage Φ6 or Phage Phi6, as a surrogate for RNA viruses) were assessed.

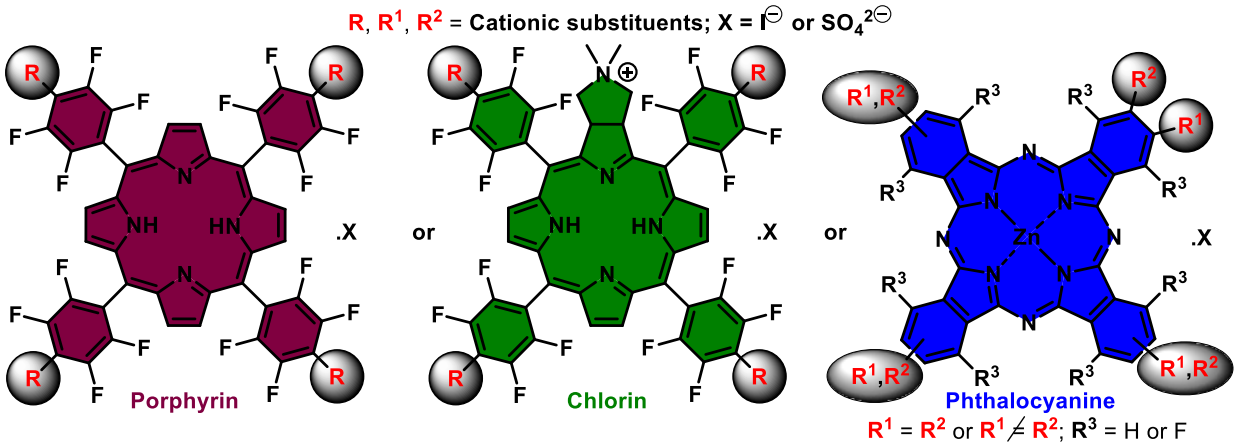


Figure 1: Cationic photosensitizers for photoinactivation of microorganisms.

Acknowledgements
Thanks to the University of Aveiro and FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) for the financial support to LAQV-Requimte (UIDB/50006/2020 and UIDP/50006/2020), CQE (UIDB/00100/2020 and UIDP/00100/2020), IMS (LA/P/0056/2020) and CESAM (UIDB/50017/2020 and UIDP/50017/2020), funded by FCT/MCTES through national funds. The authors also acknowledge FCT/MCTES for the national funds received through project P2020-PTDC/QUI-QOR/31770/2017. SG, CR, CV, and MB thank FCT for their grants (SFRH/BD/143549/2019, UI/BD/152798/2022, SFRH/BD/150358/2019, and SFRH/BD/121645/2016, respectively).

References

1. L. M. O. Lourenço, D. M. G. C. Rocha, C. I. V. Ramos, M. C. Gomes, A. Almeida, M. A. F. Faustino, F. A. A. Paz, M. G. P. M. S. Neves, Â. Cunha, J. P. C. Tomé, *ChemPhotoChem*, 2019, ***3***, 251–260.
2. C. Vieira, A. Santos, M. Q. Mesquita, A. T. P. C. Gomes, M. G. P. M. S. Neves, M. A. F. Faustino, A. Almeida, *J. Porphyrins Phthalocyanines*, 2019, ***23***, 534–545.
3. M. I. P. Santos, S. R. D. Gamelas, C. Vieira, M. A. F. Faustino, J. P. C. Tomé, A. Almeida, A. T. P. C. Gomes, L. M. O. Lourenço, *Dyes and Pigments*, 2021, ***193***, 109557.
4. J. M. D. Calmeiro, S. R. D. Gamelas, A. T. P. C. Gomes, M. A. F. Faustino, M. G. P. M. S. Neves, A. Almeida, J. P. C. Tomé, L. M. O. Lourenço, *Dyes and Pigments*, 2020, ***181***, 108476.
5. J. M. D. Calmeiro, C. J. Dias, C. I. V. Ramos, A. Almeida, J. P. C. Tomé, M. A. F. Faustino, L. M. O. Lourenço, *Dyes and Pigments*, 2020, ***173***, 107410.

Multifunctional g-C_3N_4-TiO_2-based treatment with photocatalytic and superhydrophillic/hydrophobic properties for building materials

M. Luna[1,2,3,*], C. G. Silva[1,2], J. M. Gatica[4], M. J. Mosquera[3], J. L. Faria[1,2]

[1]University of Porto, LSRE–LCM – Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Rua Dr. Roberto Frias s/n, Porto, 4200-465, Portugal; [2]University of Porto, ALiCE – Associate Laboratory in Chemical Engineering, Rua Dr. Roberto Frias s/n, Porto, 4200-465, Portugal; [3]University of Cadiz, Department of Physical Chemistry, Avda. República Saharaui, s/n, Puerto Real, 11510, Spain; [4]University of Cadiz, Department of Materials Science, Metallurgy Engineering and Inorganic Chemistry, Avda. República Saharaui, s/n, Puerto Real, 11510, Spain
**manuelluna@fe.up.pt*

The combination of hydrophobic treatments with photocatalysts has been proposed for producing multifunctional coatings with photocatalytic and hydrophobic properties for the integral protection of building materials.[1] Since water has a harmful effect on building materials promoting the decay, reducing the water ingress inside the pore structure is one of the most effective method for building protection.[2] On the other hand, the presence of a photocatalyst allow to obtain building materials self-cleaning, depolluting and self-sterilizing properties[3] that help maintain the aesthetical features of the buildings. The hydrophobicity promotes this antifouling capacity due to the repellency of water based staining agents and the self-cleaning effect of rain removing the dirty deposited in the surface. However, a hydrophobic surface can have higher affinity for non-polar substances promoting certain types of staining and the adherence of microorganism. TiO_2 can solve this disadvantage due to its photoinduced hydrophilicity that can produce a surface superhydrophilic effect promoting the oleophobicity.[4]

The present work investigates the use of TiO_2 modified with of graphitic carbon nitride (g-C_3N_4) to deal with the main drawback of the TiO_2 employment on buildings, its low activity under visible light. This photocatalyst has been incorporated in an alkoxysilane/alkylalkoxysilane sol that produces an organically modified silica (ORMOSIL) that act as binder promoting the adhesion of the photocatalyst to the building material and provide the hydrophobic properties. This sol was applied by brush on cement mortar samples penetrating inside the substrate pore structure and producing the g-C_3N_4-TiO_2-ORMOSIL coating on the material surface.

The treated samples exhibited an initial hydrophobic behavior with contact angles around 125° but after irradiation with UV-vis they became superhydrophilic with angles lower than 6º. Despite the high surface hydrophilicity, the hydrophobic properties were maintained inside the treated material reducing the total water uptake of cement mortar in more than 97% and the water absorption coefficient in more than 99%. The superhydrophillic samples showed a superior stain resistance against oily dirty compared to hydrophobic sample, whereas their stain resistance against hydrophilic dirty was preserved. The photocatalytic properties of the treated samples were evaluated by degradation of Rhodamine B stains, presenting the g-C_3N_4-TiO_2 based treatment better results under visible light compared to the equivalent treatment containing TiO_2. Additionally, the substrate-treatment compatibility was also evaluated. g-C_3N_4-TiO_2 treatment produced minimal color changes in the mortar that are imperceptible to the naked eye whereas the TiO_2 treatment causes a clear surface whitening. The obtained coating presented a homogenous structure that completely covered the mortar surface and it was strongly adhered, which is crucial to ensure the durability of this multifunctional treatment.

Acknowledgements
This work was financially supported by LA/P/0045/2020 (ALiCE – Associate Laboratory in Chemical Engineering), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM – Laboratory of Separation and Reaction Engineering- Laboratory of Catalysis and Materials), funded by national funds through FCT/MCTES (PIDDAC). and the Ministry of Science and Innovation of Spain/FEDER Programme of the EU (PID2020-115843RB-I00/ AEI/10.13039/501100011033). M. Luna thanks the Spanish Government for his Margarita Salas grant (2021-067/PN/MS-RECUAL/CD) supported by the European Union-NextGenerationEU.

References
1. D. Colangiuli, A. Calia and N. Bianco, *Constr. Build. Mater.*, 2015, **93**, 189–196.
2. J. Zhao, X. Gao, S. Chen, H. Lin, Z. Li and X. Lin, *Compos. Part B Eng.*, 2022, **243**, 110104.
3. J. Chen and C. S. Poon, *Build. Environ.*, 2009, **44**, 1899–1906.
4. L. A. M. Carrascosa, R. Zarzuela, N. Badreldin and M. J. Mosquera, *ACS Appl. Mater. Interfaces*, 2020, **12**, 19974–19987.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Silica-based supported ionic liquids as multimodal chromatographic supports for the isolation of recombinant proteins

L. S. Castro*, G. S. Lobo, M. C. Neves, A. Q. Pedro, M. G. Freire

CICECO – Aveiro Institute of Materials, Chemistry Department, University of Aveiro, Aveiro, Portugal
**l.castro@ua.pt*

Over the last decades, the development of innovative medicines such as protein-based biopharmaceuticals improved treatments for several pathologies such as infectious diseases. Among them, interferon alpha-2b (IFNα-2b), which is a 17 kDa protein that has been used in the treatment of chronic hepatitis C, has had a considerable impact on the global therapeutic proteins market for the last 30 years [1,2]. Despite biopharmaceuticals' multiple advantages over traditional pharmaceuticals, their complex manufacturing processes still pose significant obstacles to their widespread application. Considering that the manufacturing of biopharmaceuticals must provide products with high purity levels, the downstream processing step is nowadays the main bottleneck in the global production process, mostly due to the absence of cost-effective methods for the recovery and purification of recombinant proteins from the complex biological media in which they are produced. With this challenge in mind and in order to fulfill the gap between costs and efficiency in the downstream processing of biopharmaceuticals, the main goal of this work was to develop novel chromatographic supports and evaluate their performance for the purification of recombinant therapeutic proteins. To this end, ionic liquids were covalently immobilized in spherical silica microparticles and applied as novel synthetic chromatographic ligands for the purification of recombinant IFNα-2b biosynthesized from *Escherichia coli*. Spherical silica was chosen due to its packing properties, which enable them to work as chromatographic supports in gravity-flow columns. During the development of this work, imidazolium- and quaternary ammonium chloride-based ILs with different alkyl chain lengths were investigated, being found that the imidazolium-based materials present an improved performance for the isolation of the target protein. Furthermore, due to the ability of the prepared materials to bind IFNα-2b in conditions mainly favoring electrostatic or hydrophobic interactions, a multimodal behavior is attributed to the prepared materials. Overall, the immobilized ionic liquids are herein described as versatile and efficient chromatographic supports for the purification of recombinant proteins form complex *Escherichia coli* lysates.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The NMR spectrometers used in this work are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). Augusto Q. Pedro and Márcia C. Neves acknowledge FCT respectively, for the research contracts CEECIND/02599/2020 and CEECIND/00383/2017 under the Scientific Stimulus – Individual Call. Leonor S. Castro acknowledges FCT for her PhD grant 2020/05090/BD.

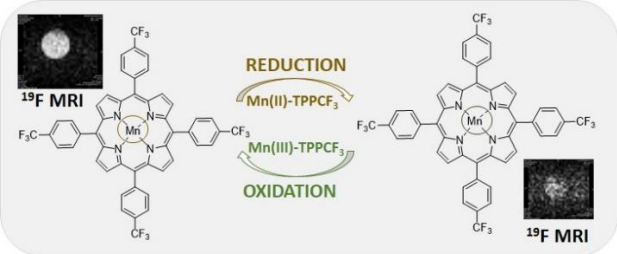
References
1. Castro, L. S. *et al.* Interferon-Based Biopharmaceuticals: Overview on the Production, Purification, and Formulation. *Vaccines* **9**, 328 (2021).
2. Walsh, G. & Walsh, E. Biopharmaceutical benchmarks 2022. *Nat. Biotechnol.* **40**, 1722–1760 (2022).

Fluorinated Mn(III)/(II)-porphyrin with redox-responsive ^{1}H and ^{19}F relaxation properties

Sara M.A. Pinto*[1,2], Daniela S. S. Teixeira[1,2], Sandra C. C. Nunes[1,2], Joseany M. S. Almeida[1,3], Zoltan Garda[4], Agnés Pallier[4], Alberto A. C. C. Pais[1,2], Christopher M. A. Brett[1,3], Éva Tóth[4], Mariette M. Pereira[1,2], Carlos F. G. C. Geraldes[2,5]

[1]Department of Chemistry, University of Coimbra, Rua Larga Largo D. Dinis, 3004-535 Coimbra, Portugal; [2]Coimbra Chemistry Center, University of Coimbra, Rua Larga Largo D. Dinis, 3004-535 Coimbra, Portugal; [3]CEMMPRE, University of Coimbra, Pinhal de Marrocos, 3030-788 Coimbra, Portugal; [4]Centre de Biophysique Moléculaire, CNRS, UPR 4301, Université d'Orléans, Rue Charles Sadron, 45071 Orléans Cedex 2, France; [5]Molecular Physical Chemistry R&D Unit, Department of Chemistry, University of Coimbra, Rua Larga, 3004-535 Coimbra, Portugal
**smpinto@qui.uc.pt*

In all healthy tissues, both the intracellular and extracellular redox environment are tightly regulated, ensuring the proper working of the biological systems. Their alterations due to the reduction of O_2 levels have been associated with several pathologies, including chronic inflammation, tissue ischemia, and neoplastic growth. Therefore, the detection of hypoxic cells is crucial for early diagnosis allowing early disease treatment.[1-4] Previously, we demonstrated the potential of Mn(III)/Mn(II) porphyrins as redox contrast agents for ^{1}H NMR.[5] Herein, we extend the potential of Mn(III)/Mn(II) porphyrins to dual ^{1}H and ^{19}F detection.[6] We report the synthesis of Mn(III)/Mn(II)-TPP-*p*-CF_3, ^{1}H and ^{19}F NMR properties for both redox states, the kinetics of Mn(III) reduction in the presence of ascorbate and Mn(II) re-oxidation in the presence of atmospheric oxygen, performed by UV-Vis spectrophotometry, ^{1}H relaxivities were measured in a water/DMSO mixture and ^{19}F MRI phantom images acquired in both redox states.



Scheme 1

Acknowledgements
This work was supported by FCT (Fundação para a Ciência e Tecnologia), QREN/FEDER (COMPETE Programa Operacional Factores de Competitividade) through projects UIDB/00070/2020, UIDP/00070/2020, UIDB/00313/2020, UIDP/00313/2020 and UIDB/00285/2020, and by the French Academy of Science *via* the Prix Mariano Gago 2022. The authors thank Portuguese NMR Network for access to the UC-NMR facility which is supported in part by FEDER – European Regional Development Fund through the COMPETE Programme (Operational Programme for Competitiveness) and by National Funds through FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) through grants RECI/QEQ-QFI/0168/2012, CENTRO-07-CT62-FEDER-002012, and also through support to Rede Nacional de Ressonância Magnética Nuclear (RNRMN) and to Coimbra Chemistry Centre through grant UID/QUI/00313/2019. Zoltán Garda has received funding from the European Union's Horizon 2021 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 101065389.

References
1. Rubartelli, M.T. Lotze, *Trends Immunol*., 2007, 28, 429-436.
2. D.J. Hausenloy, D.M. Yellon, J. Clin. Invest. 2013, 123, 92-100.
3. E.H. Sarsour, M.G. Kumar, L. Chaudhuri, A.L. Kalen, P.C. Goswami, Antioxid. Redox Signaling 2009, 11, 2985-3011.
4. V. Mirabello, F. Cortezon-Tamarit, S.I. Pascu, Front. Chem. 2018,6, 27.
5. S.M.A. Pinto, M.J.F. Calvete, M.E. Ghica, S.Soler, I. Gallardo, A. Pallier, M.B.Laranjo, A.M.S. Cardoso, M.M.C.A. Castro, C.M.A. Brett, M.M. Pereira, E. Tóth, C.F.G.C. Geraldes, *Dalton Trans*., 2019, 48, 3249-3262.
6. S.M.A. Pinto, A.R.R. Ferreira, D.S.S. Teixeira, S.C.C. Nunes, A.L.M.B. Carvalho, J.M.S. Almeida, Z. Garda, A. Pallier, A.A.C.C. Pais, C.M.A. Brett, É. Tóth, M.P.M. Marques, M.M. Pereira, C.F.G.C. Geraldes, *Chem.Eur.J.* (submitted).

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Depolymerization of polyester and polycarbonate plastic waste catalyzed by molybdenum, zinc and manganese compounds

Ana C. Fernandes*, Daniel L. Lourenço, Tamára A. H. Branco, Carlota M. Alfaia

Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
**anacristinafernandes@tecnico.ulisboa.pt*

Plastics, as versatile materials, have found widespread applications in our daily lives ranging from packaging and textiles to building, transportation, and others. Nowadays, society has become completely dependent on plastic. To avoid the negative impact of plastic on the environment and on human health and to improve the circular economy, the search for new and cost-efficient methods for the depolymerization of plastic waste into value-added compounds is extremely desirable.

In recent years, reductive depolymerization has emerged as an excellent alternative methodology for the valorization of plastic waste and has gained strength as it allows to transform plastic waste into value-added products, which cannot be obtained by other recycling processes.[1] Catalysts play a key role in the reductive depolymerization of plastic waste. They should be highly active, inexpensive, Earth-abundant, stable to air, moisture and, if possible, commercially available. In this context, the search for non-toxic and cheap catalysts is very important for the sustainability of the industrial depolymerization process.

In continuation of our work on the conversion of plastic waste into value-added products by reductive depolymerization,[2-5] in this communication we report new catalytic systems for the valorization of polyester and polycarbonate waste into a variety of valuable products using molybdenum, zinc and manganese catalysts with good to excellent yields.

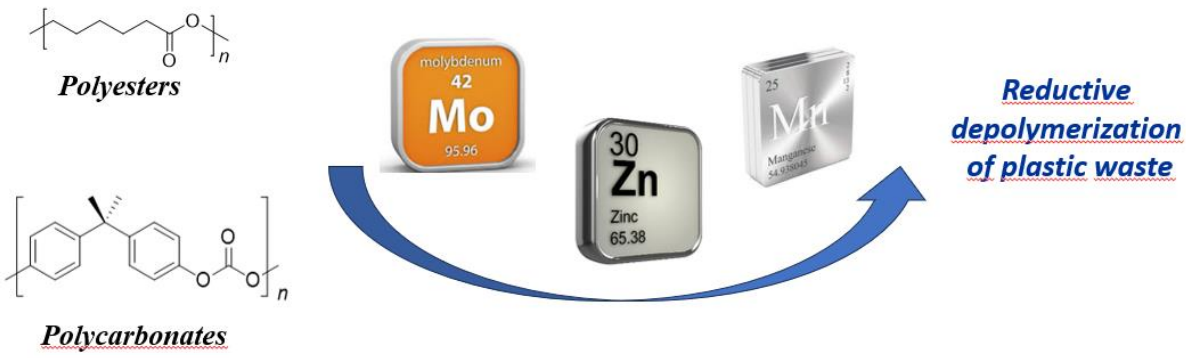


Figure 1: Reductive depolymerization of plastic waste catalyzed by molybdenum, zinc and manganese compounds.

Acknowledgements
This research was supported by Fundação para a Ciência e Tecnologia (FCT) through projects PTDC/QUI-QOR/0490/2020, UIDB/00100/2020, UIDP/00100/2020 and LA/P/0056/2020. DLL thanks to FCT for the grant.

References

1. A. C. Fernandes, *Green Chem*. 2021, ***23***, 7330-7360.
2. B. F. S. Nunes, M. C. Oliveira, A. C. Fernandes, *Green Chem.* 2020, ***22***, 2419-2425.
3. A. C. Fernandes, *ChemSusChem* 2021, ***14***, 4228-4233.
4. D. L. Lourenço, A. C. Fernandes, *Catalysts* 2022, ***12***, 381, 5.
5. D. L. Lourenço, A. C. Fernandes, *Molecular Catal.* 2023*,* ***542****, 113128.*

Self-assembled peptide-based photothermal hydrogels: cancer theranostic combining MRI and thermo-chemotherapy

T. Pereira[1,*], M. I. Bañobre-López[2], L. Hilliou[3], E. M. S. Castanheira[4], P. M.T. Ferreira[1], J. A. Martins[1]

[1]Centre of Chemistry, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal; [2]International Iberian Nanotechnology Laboratory (INL), Av. Mestre José Veiga s/n, 4715- 330 Braga, Portugal; [3]Institute for Polymers and Composites, Department of Polymer Engineering, University of Minho, Campus de Azurém,4800-058 Guimarães, Portugal; [4]Centre of Physics, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
**teresa97pereiraa@gmail.com*

A new library of succinic acid *N*-capped dehydropeptide-hydrogelators (**Figure 1**) was prepared and characterized by the different spectroscopic techniques.[1] Rheological studies showed that succinic acid *N*-capped dehydropeptide-based self-assembled hydrogels display high elasticity, thermal and mechanical stability, injectable and self-healing properties. Novel nanoparticles, based on tannic acid-Fe^{3+} complexes, were prepared and characterised regarding size and charge. The nanoparticles were studied as contrast agents for T_{1w} MRI (3 T, 120 MHz, 37 ºC) and by photothermia with the appliance of a laser radiation (808 nm, 1 W/cm^2). Hydrogels with incorporated nanoparticles (*composite* hydrogels) retain the rheological properties of the pristine hydrogels. Phantoms and $T_{1,2}$ relaxation maps reveal that incorporation of the nanoparticles into the hydrogels results in a slight decrease of the relaxivity (r_1, mM^{-1}s^{-1}) comparing to the nanoparticles in aqueous solution. The heating capacity (SAR, W/g) of the iron nanoparticles and of the *composite* hydrogels, upon laser irradiation (808 nm, 1W/cm^2) was studied. Although the nanoparticles incorporated into the hydrogels show a moderate reduction of heating efficacy, the hydrogel temperatures attained upon laser irradiation (*circa* 40 ºC) are still suitable for cancer photothermia. The *composite* hydrogels were tested as well as potential agents for photothermia-triggered drug delivery. Injectable and self-healing properties allied to photothermia and MRI reporting properties make these *composite* hydrogels promising theranostic cancer platforms.[1]

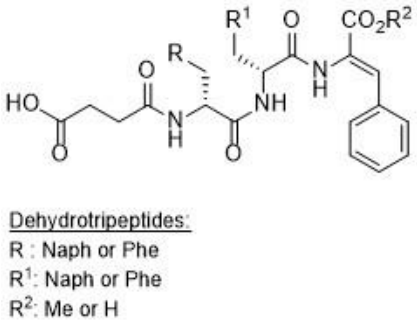


Figure 1: General chemical structure of the dehydrotripeptides.

Acknowledgements
The authors acknowledge the FCT under the Project PTDC/QUI-QOR/29015/2017 and CQ/UM UID/QUI/00686/2013 and UID/QUI/0686/2016 projects.
T. Pereira acknowledges FCT for funding the PhD grant 2021.07290.BD.

References
1. Teresa Pereira, 2021, master thesis.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Biobased and wood inspired nanocomposite films for active packaging

José M. Silva[1,*], Carla Vilela[1], Pedro C. Branco[2], João Martins[3], Mara G. Freire[1], Armando J. D. Silvestre[1], Carmen S. R. Freire[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal.
[2]RAIZ – Instituto de Investigação da Floresta e Papel, 3800-783 Eixo, Aveiro, Portugal.
[3]Biotek S.A., 6030-223 Vila Velha de Ródão, Portugal
**jose.miguel.silva@ua.pt*

In recent years, the increasing concern about the environmental impact of petroleum-based single use plastics, such as food packaging films or trash bags, has driven the industry and the scientific community to explore alternative biobased and biodegradable materials as possible packaging solutions.[1] In this sense, the concept of active biobased packaging arises as an eco-friendly alternative that not only can minimize the ecological footprint, but also can help to improve the safety, quality and shelf-life of the packaged foods.[2,3]
In this context, the current work aimed to prepare functional wood inspired biopolymeric nanocomposite films by solvent casting of suspensions containing beechwood xylans, nanofibrillated cellulose and lignosulfonates (magnesium or sodium salts). To demonstrate their potential for active packaging applications, the optical properties, antioxidant activity, mechanical performance, thermal stability, and moisture uptake capacity of the obtained biobased films were assessed, and a proof-of-concept of their applicability in preserving fresh cut fruit stored at 4 ºC carried out. All films presented good homogeneity and translucency, as well as thermal stability up to 153 °C allowing for common sterilization procedures. The films showed good mechanical properties (Young's modulus = 1.1 – 3.8 GPa and tensile strength at break up = 12.7 – 14.0 MPa), antioxidant capacity (DPPH scavenging = 71.6 – 82.4%) and UV protection (transmittance values ≤ 18.6% (200 – 400 nm)). Besides, the prepared films have the ability to delay the browning and weight-loss of packaged fresh fruits stored at 4 °C for 7 days. All these results, show the potential of using low-cost and eco-friendly resources for the development of sustainable active food packaging materials.

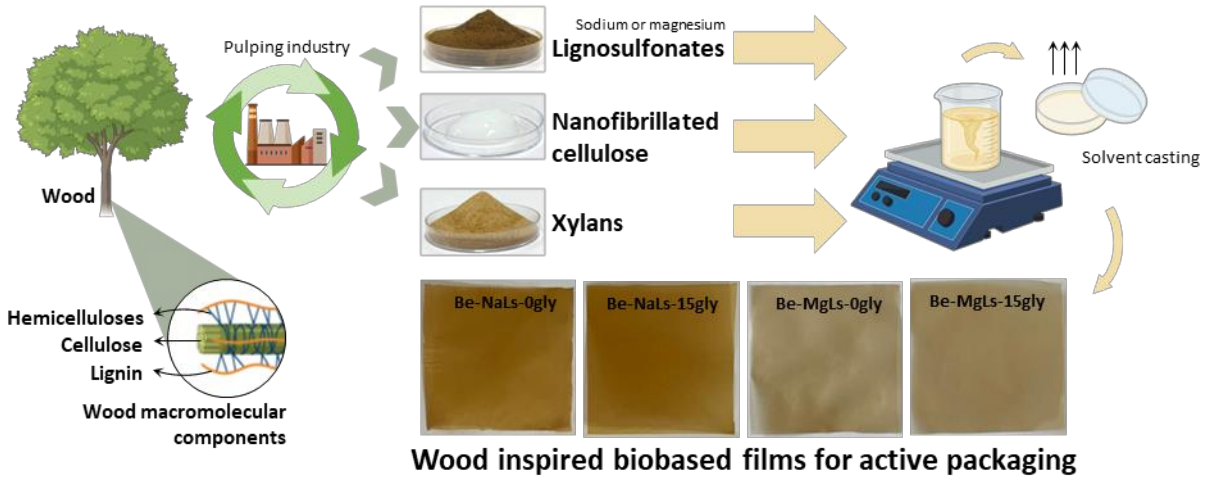


Figure 1: Schematic illustration of the preparation of the biobased films.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The authors would also like to acknowledge Celbi – Celulose da Beira Industrial, SA and The Navigator Company for funding the PhD scholarship of J.M.S. FCT is also acknowledged for the research contracts under Scientific Employment Stimulus to C.V. (CEECIND/00263/2018 and 2021.01571. CEECIND) and C.S.R.F. (CEECIND/00464/2017).

References
1. G. Fiorentino, M. Ripa, S. Ulgiati, *Biofuels, Bioprod. Biorefining*, 2017, **11**, 195–214.
2. C. Vilela, M. Kurek, Z. Hayouka, B. Röcker, S. Yildirim, M. D. C. Antunes, J. Nilsen-Nygaard, M. K. Pettersen, C. S. R. Freire, *Trends Food Sci. Technol.*, 2018, **80**, 212–222.
3. J. Shi, R. Zhang, X. Liu, Y. Zhang, Y. Du, H. Dong, Y. Ma, X. Li, P. C. K. Cheung, F. Chen, *Carbohydr. Polym.*, 2023, **301**, 1–11.

Pectic polysaccharides as an acrylamide mitigation strategy – Competition between reducing sugars and sugar acids

C. Passos[1*], S. Petronilho[1,2]; K. Kukurová[3], Z. Ciesarová[3], S. Rocha[1]; M. A. Coimbra[1]

[1]LAQV/REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [2]CQ-VR, Department of Chemistry, UTAD, 5001-801 Vila Real, Portugal; [3]National Agricultural and Food Centre, Food Research Institute, Slovakia
**cpassos@ua.pt*

Acrylamide (AA) is a food contaminant in thermally processed products that is object of tight control. The main route for AA formation is the reaction between reducing sugars and asparagine. As foods pH modulates AA formation, cooking under the lowest pH is a possible mitigation strategy, if it does not compromise the expected sensorial characteristics of food.
In this work pectic polysaccharides were used as an acidic ingredient in biscuits dough, allowing acrylamide mitigation. Biscuits were prepared with galacturonic acid (GalA) in monomeric (Figure 1, left), oligomeric, and polymeric forms. Therefore, it was possible to test the competition between sugar aldehyde and carboxylic groups in acrylamide formation, while evaluating its impact in the biscuits characteristics such as taste and colour (Figure 1, right)[1]. A simple methodology for acrylamide quantification without derivatization was also developed using headspace-solid phase microextraction and gas chromatography-mass spectrometry (HS-SPME/GC-MS) with detection and quantification limits of 27.4 µg/kg and 91.5 µg/kg of biscuits, respectively[2]. Addition of 1% GalA to biscuits dough leads to 95% increase in AA content, whereas biscuits prepared with 2% pectinic acid had 55% of decrease. When replacing sucrose with fructose, that lead to an increased AA levels above the benchmark of 150 µg/kg recommended by EFSA for children, the addition of pectic polysaccharides had an effective AA mitigation effect, lowering AA levels (116 µg/kg) below the indicative values. Thus, pectinic acid can be used as an additive to bakery dough, mitigating the formation of acrylamide due to its acidity effect. Furthermore, the developed HS-SPME/GC-MS methodology was successfully used in biscuits with low AA levels when mitigation strategies were applied.

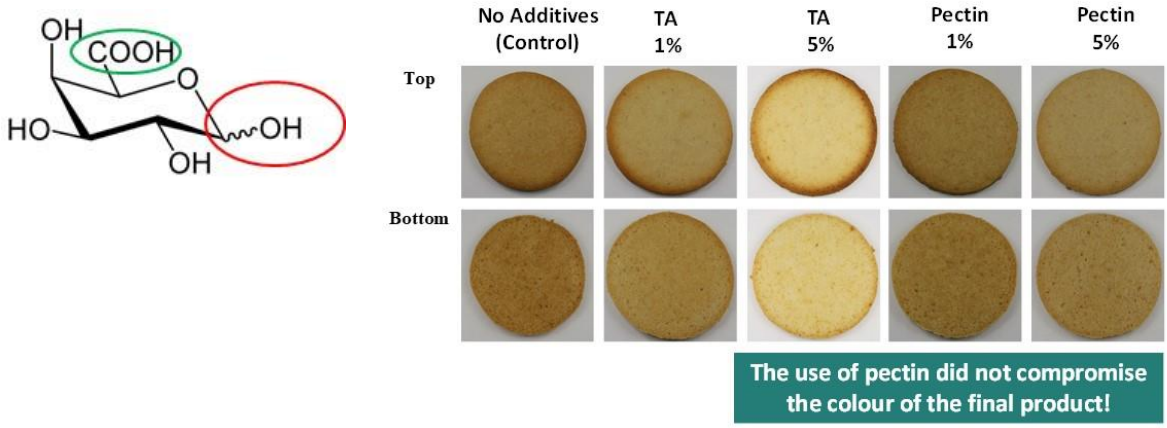


Figure 1: Left) Galacturonic acid (GalA). Right) The appearance of biscuits (top and bottom): Control, biscuits prepared with the addition of tartaric acid (TA), and commercial pectin at 1 and 5% (w/w in relation to flour weight).

Acknowledgments
Thanks are due to the UA and FCT/MCTES for the financial support of LAQV-REQUIMTE (UIDB/50006/2020 + UIDP/50006/2020) research unit and CQ-VR at UTAD Vila Real (UIDP/00616/2020) through PT national funds and, where applicable, co-financed by the FEDER, within the PT2020, Compete 2020, and also NORTE 2020, under the PT 2020, through ERDF and FSE. FCT is also thanked for the post-doc grant SFRH/BPD/117213/2016 (SP) and contract CEECIND/01873/2017 (CP).

References

1. Passos, C.P.; Ferreira, S.S.; Serôdio A.; Basil, E.; Marková L.; Kukurová, K.; Ciesarová, Z.; Coimbra, M.A., Pectic polysaccharides as an acrylamide mitigation strategy – Competition between reducing sugars and sugar acids. *Food hydrocolloids* 2018**, 81**, 113-119.
2. Passos, C.P.; Petronilho S.; Serôdio, A.F.; neto, A.C.M., Torres, D. Rudnitskaya, A.; Nunes, C.; Kukurová K.; Ciesarová, Z.; Rocha, S.M.; Coimbra, M.A., Hs-spme gas chromatography approach for underivatized acrylamide determination in biscuits. *Foods*, 2021, **10**, 2183.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

An improbable rotaxane: cucurbit[7]urils and blue box binding to a flavylium axle with high stability and stimuli responsiveness

André Seco[1]*, Nathan Mcclenaghan[2], A. Jorge Parola[1], Nuno Basílio[1]

[1] *Associated Laboratory for Green Chemistry - LAQV, REQUIMTE, Chemistry Department - NOVA School of Science and Technology, 2829-516 Monte de Caparica, Portugal*
[2] *CNRS/Univ. Bordeaux, Institut des Sciences Moléculaires, Talence, France*
**am.seco@campus.fct.unl.pt*

Rotaxanes are among the most well-known families of host-guest systems, the simplest of them consist of a macrocyclic host capable of binding to a "longitudinal" guest, like a wheel around an axle. A simpler form of rotaxanes are pseudo-rotaxanes that, unlike the formers, cannot prevent the macrocycle from leaving the axle, being in an equilibrium governed only by the binding constant[1]. In this work we compared the interactions of two different axles comprising a 2-hydroxychalcone/flavylium photoswitch and either a cationic or an anionic tail group with two macrocycles: the famous *cyclobis(paraquat-p-phenylene)*, a.k.a. Stoddart's blue box and cucurbit[7]uril (CB7). The use of the these photoswitches is not innocent since we can use light to promote the transformation of the 2-hydroxychalcone moiety into the flavylium cation and explore the different affinities that they possess towards both macrocycles, as shown in previous works where the much higher affinity of CB7 towards the flavylium form coupled with the pH dependency of the system was explored to control the position of the macrocycle along the axle[2]. Now we added the blue box to the system and saw that when in the chalcone form, a [3]pseudo-rotaxane is formed, with one macrocycle of each type. This assembly can then be irradiated at the right pH to form a [4]rotaxane thanks to the addition of a second CB7, possible due to the higher affinity towards the flavylium, as depicted in figure 1.
It is also a very curious association since the flavylium species has only a very poor affinity towards the blue box alone, but in the presence of two CB7s, it forms this highly stable and highly fluorescent (Φ_f=0.42) association where the CB7s prevent the blue box from exiting the axle, and all this happening in aqueous media which is one of the big challenges in the field for this kind of assemblies.

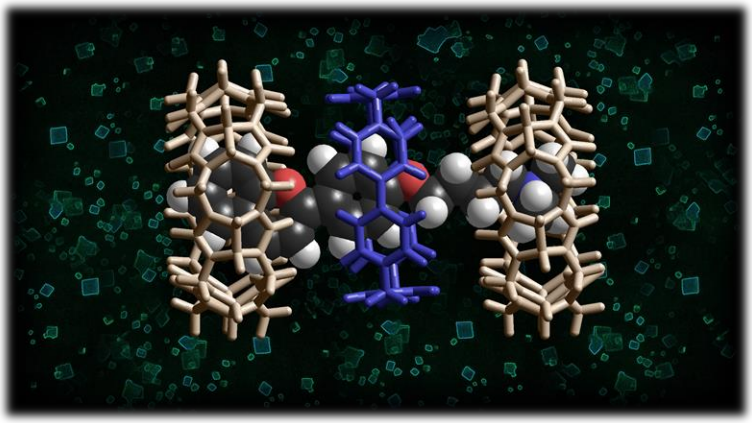


Figure 1: Representation of the quaternary rotaxane with a flavylium derivative axle inside a blue box and two cucurbit[7]uril macrocycles.

Acknowledgements
This work was supported by the Associated Laboratory for Sustainable Chemistry, Clean Processes and Technologies – LAQV through national funds from Fundação para a Ciência e Tecnologia, FCT/MCTES, under project UIDB/50006/2020. A.S. also acknowledges FCT for his doctoral grant (2020.07313.BD).

References
1. V. Balzani, *et al*, Angew. Chem. Int. Ed., **2000**, 39, 3348.
2. A. Seco, *et al, Chem. Eur. J.*, **2021**, 27, 16512.

Advancing brain tumor therapy with solid lipid nanoparticles

Maria Mendes[1,2], João Basso[1,2], José Sereno[3,4], Maria António[5], Ana L. Daniel-da-Silva[5], Tânia Cova[2], Sandra Nunes[2], Maria Luísa Ramos[2], Ana Fortuna[1,3], Miguel Castelo-Branco[3,4], Amílcar Falcão[1,3], João Sousa[1,2], Alberto Pais[2], Carla Vitorino[1,2]

[1]Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal
[2]Coimbra Chemistry Centre, Institute of Molecular Sciences, Department of Chemistry, University of Coimbra, Coimbra, Portugal
[3]Coimbra Institute for Biomedical Imaging and Translational Research (CIBIT), University of Coimbra, Coimbra, Portugal
[4]Institute of Nuclear Sciences Applied to Health (ICNAS), University of Coimbra, Coimbra, Portugal
[5]CICECO-Aveiro Institute of Materials, Chemistry Department, University of Aveiro, Aveiro, Portugal
csvitorino@ff.uc.pt

Our research is focused on advancing the treatment of glioblastoma (GB), a highly lethal form of brain tumor, through the use of ultrasmall nanostructured lipid carriers (usNLCs). These solid lipid nanoparticles have shown great potential for targeted drug delivery to specific sites, especially in the challenging environment of GB[1].

One of our main goals is to develop a surface conjugated prototype of usNLCs designed for targeted drug delivery against tumor cells and their microenvironment. We have conducted extensive co-encapsulation studies of the complementary therapies atorvastatin and curcumin to investigate their colloidal properties, stability, and release behavior in the usNLCs. In addition, we examined the effects of modifying usNLCs with hyaluronic acid conjugates, envolving the peptides cRGDfK and H7k(R2)2, and folic acid on GB cells. This analysis included evaluation of cytotoxicity, internalization, uptake mechanism, and hemolytic properties.

The usNLCs showed favorable biodistribution, tolerability, and efficacy in GB-bearing mice, as demonstrated by magnetic resonance imaging and spectroscopy. In addition, the modified usNLCs showed improved targeting to the brain and reduced elimination by the excretory organs. Of note, mice treated with usNLCs exhibited inhibited tumor growth, whereas non-encapsulated therapeutics resulted in tumor growth of over 181% over the same period.

In another approach, we developed hybrid nanoparticles (HNPs) by combining usNLCs (organic moiety) with gold nanorods (inorganic moiety). These HNPs were specifically designed to improve existing therapies by using both chemical and physical strategies. By using transferrin as an active targeting agent, we were able to target the HNPs to the blood-brain barrier. Our results showed higher cytotoxicity and uptake in glioblastoma cells compared to non-targeted nanoparticles, with preferential accumulation in the brain and prolonged mean residence time. *In vivo* experiments in an orthotopic human glioblastoma model revealed significantly improved antitumor efficacy, including a remarkable 4.10-fold inhibition of tumor volume, prolonged lifespan of animals, and better tolerability compared to TMZ.

Overall, our results highlight the promising potential of surface modification strategies to improve the performance of lipid nanoparticles. These advances provide new avenues to address the urgent medical needs associated with GB and bring us closer to a more effective treatment for this devastating disease.

Acknowledgements
This research was funded by the Portuguese Foundation for Science and Technology (FCT) through the project UID/QUI/00313/2020 (CQC). Maria Mendes and João Basso also acknowledge FCT for the grants (SFRH/BD/133996/2017 and COVID/BD/152172/2021, and SFRH/BD/149138/2019), respectively.

References

1. Basso, J.; Mendes, M.; Silva, J.; Sereno, J.; Cova, T.; Oliveira, R.; Fortuna, A.; Castelo-Branco, M.; Falcão, A.; Sousa, J.; Pais, A.; Vitorino, C., Peptide-lipid nanoconstructs act site-specifically towards glioblastoma growth impairment. *European journal of pharmaceutics and biopharmaceutics : official journal of Arbeitsgemeinschaft fur Pharmazeutische Verfahrenstechnik e.V* **2020,** *155*, 177-189.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of a Loop-mediated isothermal amplification (LAMP) assay for detecting *Styphnolobium japonicum* as *Ginkgo biloba* adulterant

Vânia Rodrigues[1,2,§], Mónica Honrado[1,2,3,§], Joana Santos[1,2], Mª Alice Pinto[1,2], Joana S. Amaral[1,2,*]

*[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Bragança, Portugal; [2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Portugal; [3]LAQV-REQUIMTE & Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, Aveiro, 3810-193, Portugal; [§]contributed equally; *jamaral@ipb.pt*

Ginkgo biloba (L.) is a widely used medicinal plant for its pharmacological properties associated with its composition in flavonol glycosides and terpene trilactones (bilobalide and ginkgolides). Currently, *G. biloba* and extracts thereof can be used either in traditional herbal medicinal products, plant food supplements or as medicines. Due to the high demand of this species in the global market, its value has been increasing together with the potential for economically motivated adulteration. According to the literature, one of the type of frauds associated with ginkgo products is the deliberate substitution (total or partial) of this species by others of lower cost. Among those, *Styphnolobium japonicum* (L.) Schott (syn. *Shopora japonica*) is reported to be one of the most prone species to be used as adulterant due to its profile in flavonol aglycones similar to that obtained in *G. biloba* analysis following the traditional acid hydrolysis. Therefore, different approaches have been proposed for the detection of *S. japonicum* in ginkgo products, either based on chromatographic analysis or relying on DNA-based methods. Previously, the use of a real-time species-specific polymerase chain reaction (PCR) has been proposed to this aim[1].However, this approach is not suitable to be used in the field or in point-of-need (e.g., customs or as a screening tool for the industry) as it requires the use of a thermocycler with fluorescence detection. Therefore, this work aims at proposing a fast, simple and suitable methodology to be used in the field for the specific detection of *S. japonicum* DNA based on a colorimetric isothermal amplification assay, known as loop-mediated isothermal amplification (LAMP).

To that purpose, a set of 6 primers, namely 2 outer primers (F3 and B3), 2 inner primers (FIP and BIP), and 2 loop primers (LF and LB) were designed targeting the internal transcribed spacer 2 (ITS2) of nuclear ribosomal DNA (GenBank accession: HQ229005.1). The specificity of the designed external primers was first assessed *in silico* and then by PCR amplification using DNA extracted with the Nucleospin Plant II commercial kit from a total of 49 medicinal plants, confirming the absence of cross-reactivity with the tested species. The LAMP assay was performed using a T100 thermocycler (Bio-Rad Laboratories, USA) and was first optimized regarding the primers concentration, amplification temperature (58, 60, 62, 65 and 68 °C), and the reaction time (10, 20, 30, 40, 50, and 60 min), with best results being obtained at 68ºC for 40 min. The optimized reaction mixture contained 0.2 µM of each B3 and F3, 1.6 µM of each FIP and BIP, and 0.4 µM of each LF and LB primers, WarmStart Colorimetric LAMP 2x Master Mix (DNA&RNA) (New England Biolabs; MA, USA), 1 µL of genomic DNA and nuclease-free water to perform a total reaction volume of 10 µL. The results were first checked visually since the reaction mixture contains phenol red as a pH indicator, which changes the color from pink to yellow when positive DNA amplification is achieved. For further confirmation, the LAMP products were subjected to a 2% agarose gel electrophoresis for 1h at 85 V, to check for the presence of the typical patterns obtained in LAMP amplification. Positive amplification was obtained with *S. japonica* extracts while negative results were observed with *G. biloba* DNA. To establish the relative limit of detection of the assay, binary mixtures containing known amounts of powdered *S. japonica* (25%, 10%, 5%, 1.5%, 0.15%, 0.05%, 0.01%) in *G. biloba* were prepared.

Overall, the developed LAMP assay showed to be fast, selective, and highly sensitive since the absolute and relative limit of detection were determined as 10 pg of *S. japonica* DNA and 0.01% *S. japonica* in *G. biloba*.

Acknowledgements

To the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CIMO (UIDB/00690/2020 e UIDP/00690/2020) and SusTEC (LA/P/0007/2020) and for financing the project "POIROT: novel methods and approaches for detecting the illegal addition of Pharmaceutical drugs and bOtanIcal adulteRatiOn in planT food supplements" (PTDC/SAU-PUB/3803/2021). M. Honrado acknowledges the PhD scholarship funded by the FCT (2021.08119.BD).

References

1. L. Grazina, J.S. Amaral, J. Costa, I. Mafra. J. Food Compos. Anal., 2021, **100**, 103891.

Novel photo-responsive calixarenes for the control of transport of hydrophilic peptides across synthetic and cellular membranes

J. N. Martins[1*], B. Raimundo[1], A. Rioboo[2], Y. Folgar-Cameán[2], J. Montenegro[2], N. Basílio[1]

[1]*Laboratório Associado para a Química Verde (LAQV), Rede de Química e Tecnologia (REQUIMTE), Departamento de Química, Faculdade de Ciencias e Tecnologia, Universidade NOVA de Lisboa, 2829-516, Caparica, Portugal.*
[2]*Centro Singular de Investigación en Química Biolóxica e Materiais Moleculares (CIQUS), Departamento de Química Orgánica, Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain*
jmn.martins@campus.fct.unl.pt

Transport of both small and large hydrophilic biomolecules across lipidic membranes is essential for the maintenance of several processes in biological environments and is usually facilitated by stimulus responsive membranes.[1] Supramolecular synthetic transporters are crucial to understand and manipulate the passage of these effector molecules across membranes. Stimulus-responsive artificial transporters displaying photomodulated activity are particularly appealing due to the advantages of using light as a stimulus, which include remote application, a high degree of spatiotemporal precision, and, in most cases, no production of chemical waste.[2]

In this work, we introduce a novel photoswitchable calixarenes for the light-controlled transport activation of cationic peptide cargos across model lipid bilayers and inside living cells. Our approach was based on rationally designed *p*-sulfonatocalix[4]arene receptors equipped with a hydrophobic azobenzene arm, which recognize cationic peptide sequences at the nM range. Activation of membrane peptide transport is confirmed, in synthetic vesicles and living cells, with higher efficiency of transport for calixarene activators featuring the azobenzene arm in the *E* configuration (Figure 1). Therefore, this method allows the modulation of the transmembrane transport of peptide cargos upon *Z*−*E* photoisomerization of functionalized calixarenes using 500 nm visible light. These results showcase the potential of photoswitchable counterion activators for the light-triggered delivery of hydrophilic biomolecules and pave the way for potential applications in remotely controlled membrane transport and photopharmacology applications of hydrophilic functional biomolecules.[3]

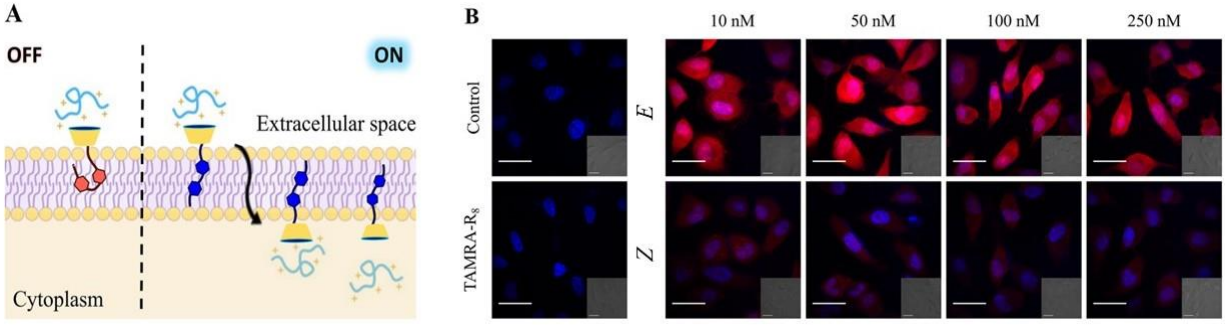


Figure 1: (A) Schematic representation of oligoarginine intracellular delivery by both isomers. (B) Confocal fluorescence microscopy images of the cellular uptake of 3 μM TAMRA-R8 (in red) facilitated by *E*/*Z*-calixarene activator. Hoechst stained nuclei can be seen in blue and differential interference contrast (DIC) images are presented as insets. Control experiments of TAMRA-R8 in the absence of a calixarene activator are also included. Scale bars, 50 μm.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (projects UIDB/50006/2020 and UIDP/50006/2020), which is financed by national funds from FCT/MCTES. FCT/MCTES is also acknowledged for supporting the National Portuguese NMR Network (ROTEIRO/0031/2013-PINFRA/22161/2016, cofinanced by FEDER through COMPETE 2020, POCI, PORL, and FCT through PIDDAC) and for the projects PTDC/QUI-COL/ 32351/2017, 2022.02538.PTDC, and the CEECIND/00466/ 2017 research contract (N.B.). J.N.M. acknowledges FCT for the PhD grant (2021.06296.BD). J.M. thanks the Spanish Agencia Estatal de Investigación (AEI) [PCI2019-103400 and PID2020-117143RB-I00], Xunta de Galicia (ED431C 2017/ 25 and ED431G 2019/03), and the ERDF. J.M. received an ERC-Stg (DYNAP, 677786), ERC-POC (TraffikGene, 838002), Xunta de Galicia (Oportunius Program), and HFSP-YIG (RGY0066/2017). Y.F.-C. and A.R. thank the AEI for the FPU fellowships (FPU21/04747) and (FPU18/ 03192), respectively. We acknowledge Dr. João Carlos Lima for fruitful scientific discussions.

References
1. Geoffrey M. Cooper, *The Cell: A Molecular Approach*, Oxford University Press, 8th Ed., 2019, 45-80.
2. M. J. Langton, *Nat. Rev. Chem.*, 2021, **5**, 46–61.
3. J. N. Martins, B. Raimundo, A. Rioboo, Y. Folgar-Cameán, J. Montenegro and N. Basílio, *J. Am. Chem. Soc.*, DOI:10.121/jacs.3c01829.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Sustainable multi-step catalytic processes in continuous-flow

Vitaliy Masliy[1*], Fábio M. S. Rodrigues[1], Rui M. B. Carrilho[1], László Kollár[2], Mariette M. Pereira[1]

[1]*Coimbra Chemistry Center, Department of Chemistry, University of Coimbra, Rua Larga, 3004-535 Coimbra, Portugal*
[2]*Department of Inorganic Chemistry and ELKH-PTE Research Group for Selective Chemical Syntheses, University of Pécs, Ifjúság útja 6, H-7624 Pécs, Hungary*
**vmasliy@qui.uc.pt*

Nowadays, flow chemistry is considered a promising approach for developing sustainable and efficient synthetic processes, allowing for greener and environmentally friendlier chemical transformations.[1] When compared with batch reactions, continuous-flow systems offer enhanced control over reaction parameters such as temperature, pressure and residence time,[2] which enables the use of milder conditions, improving the reaction's selectivity.[3] Additionally, continuous-flow systems may significantly reduce the consumption of reagents and solvents by only utilizing the necessary amounts, thereby minimizing waste generation and reducing the overall environmental impact.[4] Furthermore, the implementation of sequential reactions in continuous-flow eliminates the need for time-consuming purification steps between reactions, resulting in streamlined and sustainable synthetic processes, which allow for a better scale-up transposition.[1]
In this communication, we present our recent results on the implementation of multistep continuous-flow catalytic processes for synthesis of value-added products. The studies are focused on the development and optimization of several reactions, including carbonylation, hydroformylation, acetalization, olefin epoxidation and CO_2 cycloaddition to epoxides. The transposition of these reactions from traditional batch processes to continuous-flow systems, using different types of reactors, will be presented. Moreover, to avoid the interference of non-compatible catalysts, the implementation of sequential catalytic epoxidation/CO_2 addition and hydroformylation/acetalization processes, involving the coupling of different reactors in series (Figure 1), will be presented and discussed.

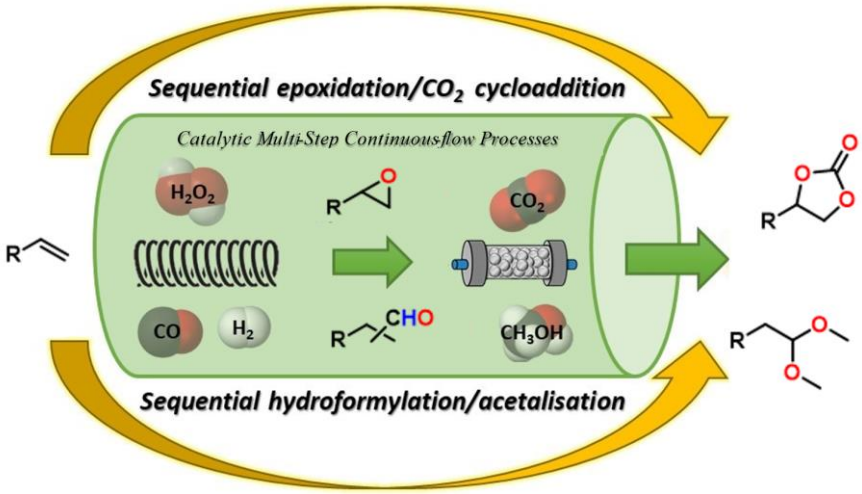


Figure 1: Multistep continuous-flow catalytic processes for synthesis of value-added compounds.

Acknowledgements
The authors thank to the Portuguese Agency for Scientific Research "Fundação para a Ciência e a Tecnologia" (FCT) and COMPETE2020-UE, for funding through projects UIDB/00313/2020 and UIDP/00313/2020 to Coimbra Chemistry Centre (CQC) and to the University of Coimbra/Santander Universidades/Institute of Interdisciplinary Research (iiiUC) for funding through Project PT0047.F.02.C (*CO2BioFilter* - Semente de Investigação Científica Interdisciplinar).

References
1. F. M. S. Rodrigues, V. Masliy, M. F. C. Silva, A. P. Felgueiras, R. M. B. Carrilho, M. M. Pereira, *Catalysis Today*, 2023, **418**, 114055.
2. D. Dallinger, C. O. Kappe, Current Opinion in Green and Sustainable Chemistry, 2017, **7**, 6–12.
3. J. R. Naber, C. O. Kappe, J. A. Pesti, *Organic Process Research & Development*, 2020, **24**, 1779–1780.
4. A. S. Burange, S. M. Osman, R. Luque, *iScience*, 2022, **25**, 103892.

Modeling of perylene-based MOFs

G. Valente*, J. Rocha, M. Souto

Department of Chemistry, CICECO – Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal
**goncalovalente@ua.pt*

Electrically conductive Metal-Organic Frameworks (MOFs) have emerged as promising materials for applications in (opto)electronics, electrocatalysis or energy storage in the past few years.[1] Besides their inherent porosity, MOFs may also incorporate tunable electrical and optical properties that strongly depend on the selected building blocks, making them very attractive for their implementation as integral components in electronic devices. One of the most common strategies for designing conductive MOFs is based on using electroactive organic ligands and their partial oxidation/reduction to increase the number of charge carriers.[2] Although perylene salts were reported as the first molecular conductors, they have been scarcely explored as building blocks for constructing conductive MOFs.

Herein, we report a detailed study on the electrical conductivity enhancement of a perylene-based MOF upon partial ligand oxidation by iodine doping using two-probe single-crystal devices (Fig 1a).[3] This conductivity is ascribed to the partial oxidation of the perylene ligands, as witnessed by EPR and emission spectroscopy and supported by theoretical calculations. The charge transport is described by means of a through-space hopping mechanism along the herringbone perylene packing, with the highest conductivities of the order of 10^{-5} S·cm^{-1}. In addition, we have presented a new synthetic route to prepare a novel family of isostructural MOFs based on perylene-tetracarboxylic ligands and transition metals (TM = Co, Ni, and Zn) exhibiting high crystallinity and stability. The photophysical properties of perylene-Zn were thoroughly studied, revealing the presence of J-aggregation-based and monomer-like emission bands (Fig. 1b). These bands were experimentally identified, and their behavior was further understood using quantum-chemical calculations Solid-state cyclic voltammetry experiments on perylene-TMs showed that the perylene redox properties are maintained within the CP framework.[4] For these reasons, we highlight the versatility of perylene building blocks for the design of electroactive MOFs exhibiting tunable physical properties.

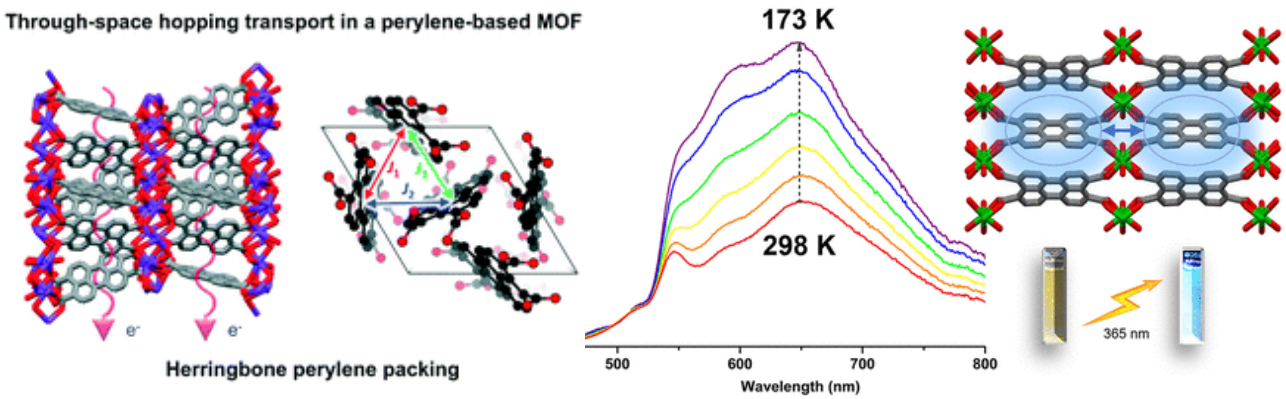


Figure 1: a) Crystal structure and electronic couplings for holes of perylene-based MOF. b) Emission spectra of a perylene-Zn suspension in ethanol (λ_{exc} = 285 nm) at different temperatures (173−298 K).

Acknowledgements
This work was developed within the scope of the project CICECO Aveiro Institute of Materials, Grants UIDB/ 50011 2020 and UIDP/50011 2020 financed by national funds through the FCT/MEC and when appropriate co financed by FEDER under the PT 2020 Partnership Agreement We thank FCT for funding the project PTDC/QUI ELT/ 2593 2021.

References

1. M. D. Allendorf, R. Dong, X. Feng, S. Kaskel, D. Matoga and V. Stavila, *Chem. Rev.* 2020, **120**, 8581.
2. M. Souto, K. Strutyński, M. Melle-Franco, J. Rocha, *Chem. Eur. J.* 2020, **26**, 10912.
3. G. Valente, M. Esteve-Rochina, A. Paracana, A. Rodríguez-Diéguez, D. Choquesillo-Lazarte, E. Ortí, J. Calbo, M. Ilkaeva, L. Mafra, M. A. Hernández-Rodríguez, J. Rocha, H. Alves, M. Souto, *Mol. Syst. Des. Eng.* 2022, **7**, 1065-1072.
4. G. Valente, M. Esteve-Rochina, S. P. C. Alves, J. M. G. Martinho, E. Ortí, J. Calbo, F. A. A. Paz, J. Rocha, M. Souto, *Inorganic Chemistry* 2023, **62**, 7834-7842.

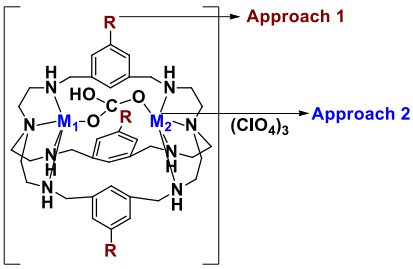
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Visible light conversion of CO_2 using cryptates with Earth abundant metals

Rafaela T. Marques[1,*], Sara Realista[1], Rui G. Santos[2], Paulo N. Martinho[1]

[1]*Centro de Química Estrutural - Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa.*
[2]*CERENA - Centre for Natural Resources and the Environment, Instituto Superior Técnico, Av. Rovisco Pais, Lisbon, Portugal.*
**rfmarques@fc.ul.pt*

CO_2 plays a crucial role in the carbon cycle, which keeps the Earth's temperature stable. The expansion of the human population and the energy demand, increased Earth's CO_2 concentration unbalancing the carbon cycle, affecting our planet's energy balance. This led to the urgency of finding efficient pathways of carbon utilisation and recycling to form valuable products.
Molecular activation is crucial in chemical and biological systems, where CO_2 is one important player. Thus, researchers and industries had a deep interest in creating catalysts that, by electro- and photoreduction, can convert CO_2 either into liquid fuel precursors (carbon monoxide and hydrogen)[1] or directly to liquid fuels (methanol and/or methane).[2]
The photoconversion of CO_2 can be made in homogeneous and heterogeneous media. The former has the advantage of modulating the catalytic active sites to improve selectivity. It requires three components: the catalyst (CAT, which in the active form, converts CO_2), the sacrificial donor (SD, donates electrons and is consumed) and the photosensitiser (PS, absorbs light and mediates the electronic transfer between the CAT and the SD).
Our research group reported Co(II)-cryptates, catalysts, with different substituents in the aromatic rings (-Br, -NO_2, -CCH) and observed that the capture and conversion of CO_2 were affected by them.[3]
We present the synthesis and characterisation of Co(II)/Co(II), Co(II)/Zn(II) and Fe(II)/Zn(II) cryptates previously synthesized and new ones with -Br as substituents in the aromatic rings. The photoreduction of CO_2 and the photocatalytic system and setup was also investigated.



Scheme 1: Dinuclear Co(II)/Co(II), Co(II)/Zn(II) or Fe(II)/Zn(II) cryptate with ClO_4^- as anion.

Acknowledgements
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e a Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). P.N.M. acknowledges FTC for financial support (CEECIND/00509/2017). S.R. acknowledges FTC for financial support (2020.02134.CEECIND).

References
1. W. Sheng, S. Kattel, S. Yao, B. Yan, Z. Liang, C. J. Hawxhurst, Q. Wu, J. G. Chen, *Energy Environ. Sci*. 2017, **10**, 1180–1185. https://doi.org/10.1039/C7EE00071E
2. K. P. Kuhl, T. Hatsukade, E. R. Cave, D. N. Abram, J. Kibsgaard, T. F. Jaramillo, *J. Am. Chem. Soc*. 2014, **136**, 14107–14113. https://doi.org/10.1021/ja505791r
3. S. Realista, J. C. Almeida, S. A. Milheiro, N. A. G. Bandeira, L. G. Alves, F. Madeira, M. J. Calhorda, P. Martinho, *Chem. Eur. J.* 2019, **25**, 11670–11679. https://doi.org/10.1002/chem.201901806

Carbon nitride coated cotton for photocatalytic elimination of pharmaceutical pollutants from simulated hospital wastewater

Maria A. Barros*, Maria J. Sampaio, Cláudia Silva, Joaquim L. Faria

LSRE-LCM - Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
**up201608044@fe.up.pt*

Hospital wastewater (HWW) constitutes a foremost contributor to the introduction of pharmaceutical compounds (PhCs) into the environment. Although wastewater treatment plants (WWTPs) have been demonstrated high efficiency for water treatment, some pollutants such as PhCs have been found in surface waters in concentrations that vary from ng/L to µg/L.[1] Even at low concentrations, PhCs can pose a threat to living beings, aquatic systems, plants, and soils.[1] Therefore, advanced oxidation processes have been investigated to mitigate the presence of these compounds from water environments, with heterogeneous photocatalysis standing out for its promising results. Graphite carbon nitride (GCN-T) has been widely used as photocatalyst because it is a metal-free and a non-toxic material, with less impact on the environment, it is easy to prepare and can be active under solar irradiation. However, from the point of view of the application, it must be immobilized on a support so that it can be easily reused without the need of separation steps.[2]
In this work, GCN-T was immobilized on cotton fabrics (CO/GCN-T) to evaluate the photocatalytic degradation of seven PhCs under visible light irradiation. Carbamazepine (CBZ), sulfamethoxazole (SMX), atenolol (ATE), venlafaxine (VNF), diclofenac (DCF), ethinylestradiol (EE2), and tramadol (TRA) were chosen as model compounds to simulate HWW. The photocatalytic results showed that CO/GCN-T has the ability to degrade more than 75% after 240 min of reaction when each PhCs was individually spiked in a water sample (Figure 1a). In mixture (Figure 1b), it was observed a slight difference on the photocatalytic removal, suggesting a competitive effect between the molecules to adsorb at the reactive sites of the photocatalyst. In addition, the photocatalytic degradation pathway was also investigated to understand this competitive behavior of PhCs during the reactions. Finally, the present study confirmed the photocatalytic efficiency and the stability of the immobilized GCN-T.

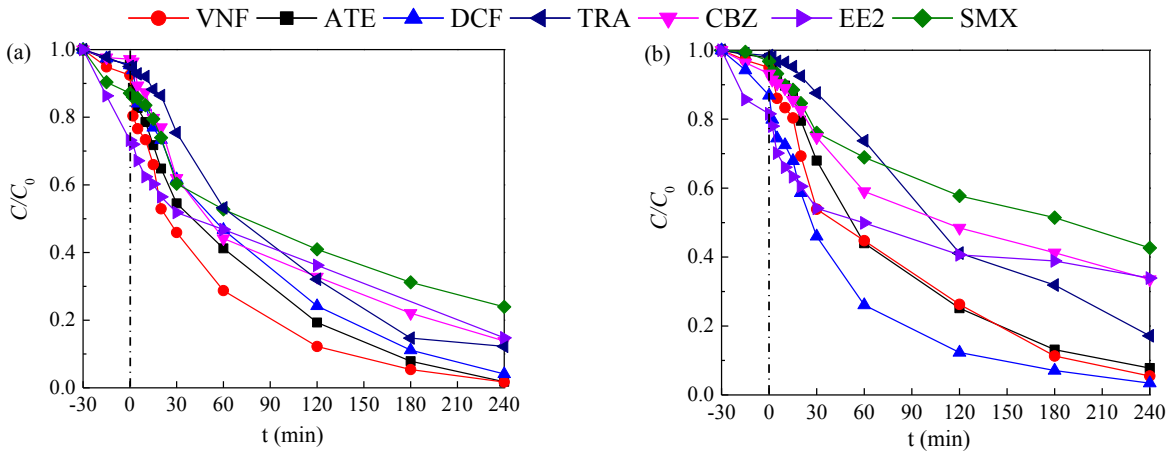


Figure 1: Photocatalytic degradation of VNF, ATE, DCF, TRA, CBZ, EE2 and SMX spiked in ultrapure water individually **(a)** and in mixture **(b)**; Experimental conditions: 80 mL aqueous solution spiked with each pharmaceutical at 0.90 µM, cotton coated with GCN-T (0.81 ± 0.03 % (w/w)), 1 h of irradiation with LED (λ_{max} = 420 nm, 160 W m^{-2}). n=3 (standard deviation).

Acknowledgements
This work was financially supported by LA/P/0045/2020 (ALiCE), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM), funded by national funds through FCT/MCTES (PIDDAC), and ClimActiC Project - NORTE-01-0145-FEDER-000071 (PORTUGAL2020). MAB acknowledges the research grant from FCT (ref. SFRH/BD/145014/2019).

References

1. D. A. Pino-Sandoval, L. Hinojosa-Reyes, J. L. Guzmán-Mar, J. C. Murillo-Sierra and A. Hernández-Ramírez, *Water Air Soil Pollut*, 2022, **14**, 233, DOI:10.1007/s11270-021-05484-7.
2. M. Vukšić, M. Kocijan, L. Ćurković, T. Radošević, D. Vengust and M. Podlogar, *Applied Sciences (Switzerland)*, 2022, **12**, 9704, DOI:10.3390/app12199704

FC19

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of novel polyhydroxylated *bis*-chalcones and their cyclodehydrogenation into *bis*-flavones

Rui Pereira[1,*], Artur M. S. Silva[2], Daniela Ribeiro[1,3], Vera L. M. Silva[2], Eduarda Fernandes[1]

[1]*LAQV-REQUIMTE, Laboratory of Applied Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal.*
[2]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[3]*Faculty of Agrarian Sciences and Environment, University of the Azores, 9700-042 Angra do Heroísmo, Açores, Portugal.*
**r97pereira@gmail.com*

Chalcones are a class of natural aromatic compounds that have been known for a long time for their broad and potent biological activities, like antioxidant, anti-inflammatory and anticancer.[1] Accordingly, new subcategories of compounds derived from chalcones recently gained attention, like dihydrochalcones and fused chalcones.[2] However, less attention has been given to another subcategory of chalcones, *bis*-chalcones. These molecules are characterized by the presence of two chalcone moieties in the same structure and some studies suggest that they possess improved bioactivities over their mono derivatives.[3] Their synthesis is much like chalcones but usually requires longer reaction times and harder purifications, especially for derivatives with free hydroxy groups. Since the most bioactive *bis*-chalcones known in literature possess hydroxy groups in their structure, their synthesis becomes challenging.[3]

Furthermore, chalcones are known precursors of many flavonoids, like flavanones, flavones, flavanols, among others. Most of these transformations are well documented, especially their cyclodehydrogenation into flavones, and it is well known that an increased number of free hydroxy groups hinders this process.[4] However, the cyclodehydrogenation of *bis*-chalcones into *bis*-flavones is pretty much underexplored.

In this context, the objectives of this work were to establish an efficient methodology for the synthesis of novel polyhydroxylated *bis*-chalcones with different substituents and successfully transform them into *bis*-flavones.

Herein, we report our most recent results on the synthesis of *bis*-chalcones and their subsequent transformation into *bis*-flavones. Several *bis*-chalcones containing different substituents (methoxy, halogens, prenyl) were synthetized by Claisen–Schmidt condensation of MOM/Me-protected *bis*-acetophenones with aromatic aldehydes in good yields (50-80%). Partial deprotection of the MOM groups was accomplished in MeOH/HCl at room temperature. Complete deprotection of the MOM groups was achieved in DCM/TFA at 0 ºC. Then, some partially deprotected *bis*-chalcones were successfully transformed into *bis*-flavones through cyclodehydrogenation with DDQ/dioxane or DMSO/I_2, depending on the remaining protective group.

In the future, we intend to apply the same synthetic methodology for the cyclization of *bis*-hydroxycinnamylideneacetophenones to yield *bis*-2-styrylchromones. All the synthetized compounds are being tested as potential anti-inflammatory agents.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.

Acknowledgements
Rui Pereira thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for his PhD grant UI/BD/151269/2021. Thanks, are also due to the Portuguese NMR Network. Vera L.M. Silva thanks funding through FCT under the Scientific Employment Stimulus – Institutional Call – reference CEECINST/00026/2018.

References

1. E. Nadia, H. Hajer, A. Ruba, D. Wassila, Z. Fatin, B. Rania, *ACS Omega*, 2022, **7**, 27769-27786.
2. A. Mallia, J. Sloop, *Mol.* 2023, ***28***, 3201.
3. R. Pereira, A.M.S. Silva, D. Ribeiro, V.L.M. Silva, E. Fernandes, *Eur. J. Med. Chem.* 2023, **252**, 115280.
4. I. Masesane, *Int. J. Chem. Stud.*, 2015, **3**, 53-59.

Chitosan electromechanical response: piezoelectric or electrostritive?

Dayana L.Guzmám Sierra[1], Qiancheng Zhang[2], Srikanth Kolagatla[2],Paula M. Vilarinho[1], Brian J. Rodriguez[2], Cláudia Nunes[1], Paula Ferreira[1,*]

[1]*Department of Materials and Ceramic Engineering, CICECO – Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*School of Physics and Conway Institute of Biomolecular and Biomedical Research, University College Dublin, Ireland*
pcferreira@ua.pt

The electromechanical response, i.e. the capacity of converting energy to mechanical energy (deformation or stress) and vice versa, is an exciting and rapidly growing field of research with numerous potential applications in electronics as sensor and actuators.[1] Nevertheless, it has been challenging to identify the origin of the electromechanical performance in natural polymers such as chitosan due to the lack of consent among the information found in literature for possible application in biomedicine. In this work a systematic characterisation of chitosan pristine films was performed using films prepared by solvent casting with two different acidic solutions. The effect of a neutralization step was also studied. The structural characterization obtained by X-Ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) was correlated with the electromechanical performance of the films assessed by piezoresponse force microscopy (PFM) including the analysis of the first and second harmonic generation,[2] which are assigned to piezoelectric and elestrostritive responses, respectively.
The response to the first (1w) and second harmonic (2w) was obtained and in all cases the second harmonic was higher than the first (2w>1w) (Figure 1).

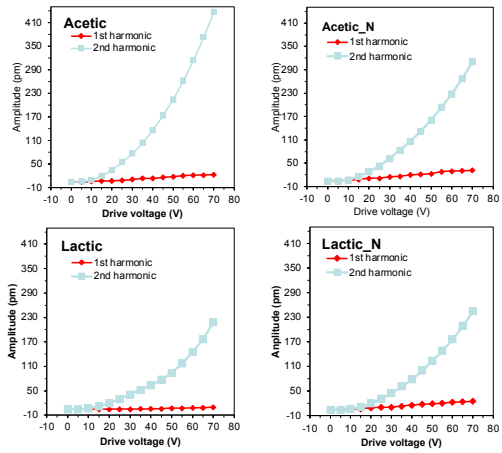


Figure 1: Chitosan films response to the first (1w) and second harmonic (2w).

The results allowed to conclude that the main contribution of the electromechanical performance of chitosan comes from non-piezoelectric effects, raising new questions on the approaching of the electrostrictive component in dielectrics as recently proposed.[3] The relation between the piezoelectric and electrostrictive components allowed us to conclude that the films fabricated with acetic acid have a higher output response than those prepared with lactic acid furthermore this response increases in the neutralized films after applying negative voltage bias, this could be due to the reduction of the amine groups after neutralization.

Acknowledgements
This work was developed under the scope of the projects CICECO (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC). CN thanks the national funds, through FCT, IP, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, changed by Law 57/2017. DLGS thanks to FCT PhD fellowship ref. UI/BD/151142/2021.

References
1. M. Jian, Y. Zhang, Z. Liu, *Natural Biopolymers for Flexible Sensing and Energy Devices*, Vol. 38, 2020.
2. B. J. Rodriguez, S. V. Kalinin, J. Shin, S. Jesse, V. Grichko, T. Thundat, A. P. Baddorf, A. Gruverman, *J. Struct. Biol.* 2006, **153**, 151.
3. J. Yu, P. Janolin, J. Yu, P. J. Defining, G. Electrostriction, A. Physics 2022, **131**.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis and evaluation of tetrapyrrolic macrocycles as potential antivirals

Zoe A. Arnaut[1,*], Christine Cruz-Oliveira[2], Miguel A. R. B. Castanho[2], Mariette M. Pereira[1]

[1]*CQC-IMS, Chemistry Department, University of Coimbra 3004-535 Coimbra, Portugal*
[2]*Instituto de Medicina Molecular, Faculdade de Medicina, Universidade de Lisboa, 1649-028 Lisbon, Portugal*
**zoearnaut@gmail.com*

Due to the COVID-19 pandemic, researchers have been focusing on antiviral drug development. Several molecules have been studied for their potential antiviral activity against SARS-CoV-2.[1] Tetrapyrrolic macrocycles, including porphyrins and chlorins, represent a noteworthy group of molecules with intriguing properties. These macromolecules can function as photosensitizers when exposed to light, while also demonstrating potential activity in the absence of light.[2] Research on structure/activity relationships of porphyrin-derived antivirals is still necessary. This study primarily revolves around the synthesis and application of porphyrin derivatives for the inactivation of SARS-CoV-2 in the dark.
In this work, novel approaches for the synthesis of *meso*-substituted porphyrins (Figure 1) will be presented and discussed. Porphyrin structural determinants for SARS-CoV-2 inactivation were explored by modulating porphyrin size, charge distribution and the presence of functional groups including sulphonic, hydroxy and carboxy groups. Porphyrin cytotoxicity was also evaluated in Caco-2 cells.
The tested porphyrin with the highest activity against SARS-CoV-2 was found to be the hydroxy-substituted porphyrin which did not present cytotoxicity in Caco-2 cells in the tested concentrations.

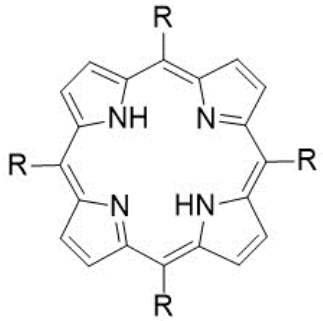
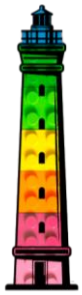


Figure 1: *meso*-substituted porphyrin structure.

Acknowledgements
The authors thank FCT (Fundação para a Ciência e Tecnologia), for funding through project PRR - Recovery and Resilience Plan and the European Union (EU) Next Generation Funds, for funding through Project Nº 6979 - PRODUTECH R3 [Recuperação-Resiliência-Reindustrialização] following NOTICE N.º 02/C05-i01/2022, Component 5 – Capitalization and Business Innovation - Mobilizing Agendas for Business Innovation. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 828774. Z. A. A. thanks FCT for the PhD grant (2021.09454.BD).

References
1. Chavda, V.P., Vuppu, S., Mishra, T. *et al Pharmacology, 2022,* 74, 1120–1148.
2. Sh Lebedeva N, A Gubarev Y, O Koifman M, I Koifman O. *Molecules* 2020, 23;25(19):4368.
3. Cruz-Oliveira C, Almeida AF, Freire JM, Caruso MB, Morando MA, Ferreira VNS, Assunção-Miranda I, Gomes AMO, Castanho MARB, Da Poian AT Antimicrobial Agents and Chemotherapy. 2017, 24;61(6):e00053-17.



Poster Communications

Green functional biomaterials for wound healing

M. Silva[1,2,*], M. Araújo[2], R. Viveiros[1]

[1]LAQV-REQUIMTE, Chemistry department, NOVA School of Science & Technology | NOVA SST, NOVA University of Lisbon, Campus de Caparica, Portugal; [2]i3S - Instituto de Investigação e Inovação em Saúde, University of Porto, Portugal
**msf.silva@campus.fct.unl.pt*

Abstract Wound care is one of the major concerns to public health and the global market is expected to expand from €17.7 billion in 2022 to €26.3 billion by 2029, at a CAGR of 6.2%.[1] Once damaged, the skin loses its protective role against external pathogens and the risk of acquiring an infection is dramatically increased. This leads to an impaired and retarded wound healing causing a negative impact on the quality of life.[2] Bacterial invasion may guide to degradation of extracellular matrix (ECM), high levels of inflammation and an increase of wound pH, being important targets to consider in the design of antimicrobial wound dressings. Biomaterials are highly attractive for the development of functional wound dressings due to their intrinsic biocompatibility and possibility of chemical modification, improving their ability to regulate the wound microenvironment and promote tissue regeneration.[3] Since the last years, there has been a significant interest in using alternative solvents/technologies, such as supercritical fluids, in particular supercritical CO_2 ($scCO_2$) to produce and process (bio)materials in several formats. CO_2 is non-toxic, non-flammable, inexpensive, accessible, chemically inert, readily removed without the use of additional energy. It is also a particularly appealing media for chemical reactions and impregnations due to its low energy critical point (31 ºC and 73 bar), making it a green alternative to replace the use of hazardous organic solvents.[4] Natural-derived and synthetic polymers have been widely applied in wound healing (WH),[5] mimicking the characteristics of the ECM.[6,7] Herein, green, ready-to-use and affordable biomaterial-based coatings for WH were developed on cellulose membranes through a grafting from strategy using acrylic- and acrylate-based monomers, selected from their biocompatible and antibacterial properties.[8,9] Further, thymol, a naturally monoterpenoid phenol with antibacterial, antioxidant and anti-inflammatory properties was impregnated in the developed biomaterial using $scCO_2$.[10] The materials were characterized for their physico-chemical, morphological and mechanical properties and the thymol release profile was investigated, returning very promising results.

Acknowledgements
The authors would like to acknowledge the financial support from projects PTDC/EQU-EQU/32473/2017 and NORTE-01-0247-FEDER-069697 through Fundação para a Ciência e a Tecnologia, Ministério da Ciência, Tecnologia e Ensino Superior (FCT/MCTES), and Agência Nacional de Inovação (ANI), Portugal, respectively. R.V. would like to thank FCT/MCTES for her Individual Scientific Employment Stimulus (CEECIND, reference 2020.00377.CEECIND). The Associate Laboratory for Green Chemistry for Green Chemistry - Clean Technologies and Processes - LAQV is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020) and co-financed by the ERDF under the PT2020 Partnership Agreement (POCI-01–0145-FEDER – 007265).

References

1. https://www.fortunebusinessinsights.com/wound-care-market-103268.
2. E.R. Ghomi, S. Khalili, S.N. Khorasani, R.E. Neisiany, S. Ramakrishna, J. Appl. Polym. Sci., 2019, 136, 47738:1–12.
3. R. Lungu, A. Anisiei, I. Rosca, A.-I. Sandu, D. Ailincai, L. Marin, React. Funct. Polym., 2021, 167, 105028: 1–10.
4. A.I. Furtado, R. Viveiros, T. Casimiro, Method. Mol. Biol., 2021, 2359, 19–42.
5. A.O. Ijaola, D.O. Akamo, F. Damiri, C.J. Akisin, E.A. Bamidele, E.G. Ajiboye, M. Berrada,V.O. Onyenokwe, S.-Y. Yang, E. Asmatulu, J. Biomater. Sci. Polym. Ed., 2022, 33, 1998–2050.
6. M.F. Abazari, S. Gholizadeh, S.Z. Karizi, N.H. Birgani, D. Abazari, S. Paknia, H. Derakhshankhah, Z. Allahyari, S.M. Amini, M. Hamidi, C. Delattre, Appl. Sci., 2021, 11, 7769: 1–23.
7. M. Araújo, J. Silveira, A. Sousa, M. Bessa-Gonçalves, S.G. Santos, C.C. Barrias, Biomater. Sci., 2021, 9, 6510:1–18.
8. I.A. Duceac, L. Verestiuc, C.D. Dimitriu, V. Maier, S. Coseri, Polymers, 2020, 12, 1473:1–20.
9. A.K. Mittal, R. Bhardwaj, R. Arora, A. Singh, M. Mukherjee, S.K. Rajput, ACS Omega, 2020, 5, 24239– 24246.
10. M. Araújo, R. Viveiros, A. Philippart, M. Miola, S. Doumett, G. Baldi, J. Perez, A.R. Boccaccini, A. AguiarRicardo, E. Verné, Mater. Sci. Eng. C., 2017, 77, 342–351.

P2

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Ecotoxicological impacts associated with fluorescent lamp waste leachates on the marine macroalgae *Ulva lactuca*

Ana Francisca Santos[1,*], Daniel Barros[1], Thainara Viana[1], Daniela Tavares[1], Rosa Freitas[2], Eduarda Pereira[1], Bruno Henriques[1]

[1]LAQV-REQUIMTE, Departamento de Química, Universidade de Aveiro, 3810-193 Aveiro, Portugal
[2]CESAM, Departamento de Biologia, Universidade de Aveiro, 3810-193 Aveiro, Portugal
**francisca.santos@ua.pt*

In the last years, there has been a major growth in the light-emitting diode (LEDs) market, which directly impacted the production of fluorescent lamps (FL). Despite this transition and the legislation for the elimination of this type of lamps, FL are still manufactured and used mainly by developing countries, resulting in huge volumes of FL waste improperly disposed of each year [1]. The presence of mercury (Hg), a contaminant that can persist in the environment and bioaccumulate in the biological chain, is one of the main associated concerns [2,3]. However, rare earth elements (REE), mainly yttrium (Y) and europium (Eu), are also present in lamp phosphors[2], although they are often overlooked in toxicity studies. Currently, there are no ecotoxicological studies regarding the impacts of FL waste or their leachates which raises great concern about the disposal of FL, whose leachates can reach the aquatic ecosystem.

Therefore, the present work evaluated the ecotoxicological effects induced by real FL waste leachates on the macroalga *Ulva lactuca*, a well-known species frequently used in pollution biomonitoring studies. For this, the organism was exposed to different dilutions of a FL waste leachate for 3 days and several parameters such as lethality, relative growth rate, chlorophyll content, as well as biochemical biomarkers related to cell damage and oxidative stress were analysed. Results showed that Hg, Y and Eu concentrations in exposed macroalgae depend positively on the initial concentration of the element in the solution. The enrichment of the macroalgae followed the order of preference: Hg > Y > Eu. Most of Hg (73 – 98%) present in the solution was incorporated by the macroalgae, while Y and Eu remained mostly at the surface of the tissue. All the exposure conditions tested led to a significant decrease in chlorophyll content compared to the blank. This decrease was more evident when the leachate was more concentrated, with a 63% decrease at the end of the 3 days compared to the chlorophyll initial values. Growth capabilities were also impacted negatively in all dilutions tested compared to the control. The exposure to FL waste leachate resulted in a biochemical response in *U.lactuca*, evidenced by the activation of the antioxidant enzyme SOD when the concentrations of the elements were higher ([Y] > 4,0 mg/L), and GPx when the leachate was more diluted, as well as the biotransformation enzymes GSTs, at intermediate concentrations. These antioxidant and biotransformation enzymes play a crucial role in detoxifying reactive oxygen species (ROS) through their breakdown, making them less toxic and more easily eliminated. However, despite their activation, in the majority of the dilutions tested, cellular damage was observed, evidenced by the increase in LPO levels. Overall, the results highlight the importance of carrying out ecotoxicological tests with real waste, and the need for proper management of e-waste, to guarantee environmental and human safety.

Acknowledgements
This work was supported by the project Nº46998_N9ve-REE, co-funded by Portugal 2020) program (PT2020), PO Centro and European Regional Development Fund. Thainara thanks the Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior for her PhD grant ref. 2022. 13015.BD, while Bruno Henriques acknowledges FCT for the research contract (Ref. CEECIND/03511/2018).

References

1. L. N. Viana, A. P. S. Soares, D. L. Guimarães, W. J. S. Rojano and T. D. Saint'Pierre, *J. Environ. Chem. Eng.*, 2022, **10**, 108915.
2. N. Dhawan and H. Tanvar, *Sustain. Mater. Technol.*, 2022, **32**, e00401.
3. G. S. Simate and S. Ndlovu, *J. Environ. Chem. Eng.*, 2014, **2**, 1785–1803.

Kinetic characterisation of the CO_2 reduction by the periplasmic *Desulfovibrio desulfuricans* formate dehydrogenase

Navendu Paul, Luis Pereira, Isabel Moura, José J. G. Moura, Luisa B. Maia*

LAQV, REQUIMTE, NOVA School of Science and Technology | FCT NOVA, Portugal
**luisa.maia@fct.unl.pt*

Formate dehydrogenases (FDH) are enzymes that catalyse the reversible two-electron oxidation of formate to CO_2 (eq. 1).[1,2] The class of metal-dependent FDHs comprises only prokaryotic enzymes that hold different redox-active centres and whose active site harbours one molybdenum or one tungsten atom that mediates the formate oxidation/CO_2 reduction. Due to their ability to reduce CO_2, FDH have been the centre of intense research to develop innovative, "greener" and more efficient devices to convert the problematic CO_2 into added-value compounds.[2,3]

$$CO_2 + 2e^- + H^+ \rightleftharpoons HCOO^- \quad (1)$$

In this communication, the kinetic properties of the periplasmic FDH from the sulfate reducing bacterium *Desulfovibrio desulfuricans* (Dd FDH) will be described. The Dd FDH was found to be one of the most efficient carbon dioxide reducers so far described in the literature, with a k_{cat} of 47s^{-1} and a K_mCO_2 of 16μM.[4]

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020) and PTDC/BTA-BTA/0935/2020, which are financed by national funds from FCT/MCTES. LBM thanks to FCT/MCTES, for the CEEC-Individual Program Contract.

References

1. L. Maia *et al.*, Molybdenum and tungsten-containing enzymes: an overview, Royal Society of Chemistry (2017), pag 1-80
   (read it here: http://docentes.fct.unl.pt/lblm/files/mo_w_enzymes-rsc_book-chap_1.pdf)
2. L. Maia *et al.*, *Inorg. Chim. Acta*, 2017, **455**, 350-363.
   (read it here: https://docentes.fct.unl.pt/lblm/files/ica-2017-455-350.pdf)
3. L. Maia *et al.*, Carbon Dioxide Utilisation -The Formate Route, Springer, 2021, pag 29-81.
   (read it here: https://docentes.fct.unl.pt/lblm/files/co2_utilisation-formatedehydrogenases-maia.pdf)
4. L. Maia *et al.*, *J. Am. Chem. Soc.*, 2016, **138**, 8834-8846,
   (read it here: http://docentes.fct.unl.pt/lblm/files/jacs-2016-138-8834.pdf)

P4

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Exploiting bacterial formate dehydrogenases to reduce CO_2: Preparation of periplasmic fractions to purify the enzymes

Luis Pereira, Navendu Paul, Ana R. Lourenço, Isabel Moura, José J. G. Moura, Luisa B. Maia*

LAQV, REQUIMTE, NOVA School of Science and Technology | FCT NOVA, Portugal
**luisa.maia@fct.unl.pt*

The atmospheric levels of CO_2 are causing huge and unpredictable impacts on Earth's climate due to its significant greenhouse effect. To stop the catastrophic consequences caused by climate change, CO_2 emissions must be greatly reduced. Additionally, it is necessary to develop new and more effective ways to convert this compound into added-value products.[1,2] In this context, the conversion of CO_2 into formate (eq. 1) offers significant benefits for carbon recycling, since formate can be easily stored, transported and converted into various products highly interesting for the energy and chemical industry. To achieve the CO_2 conversion into formate, enzymes offer significant advantages, namely the selectivity and specificity of substrate and product, as well as the ability to run reactions at room temperature and pressure, in water, at neutral pH.

$$CO_2 + 2e^- + H^+ \rightleftharpoons HCOO^- \quad (1)$$

Our main goal is to exploit formate dehydrogenase (FDH)[3] enzymes to develop photochemical and electrochemical devices for the conversion of CO_2 into added-value compounds. Presently, we are interested in studying the periplasmic FDH from the *Desulfovibrio desulfuricans* bacterium.[4] To this end, it is necessary to first prepare a *D. desulfuricans* periplasmic fraction free of cytoplasmic protein contamination. In this communication, different strategies to prepare the periplasmic fraction will be compared.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (UIDB/50006/2020 and UIDP/50006/2020) and PTDC/BTA-BTA/0935/2020, which are financed by national funds from FCT/MCTES. LBM thanks to FCT/MCTES, for the CEEC-Individual Program Contract.

References

1. L. Maia *et al.*, Carbon Dioxide Utilisation -The Formate Route, Springer, 2021, pag 29-81.
   (read it here: https://docentes.fct.unl.pt/lblm/files/co2_utilisation-formatedehydrogenases-maia.pdf)
2. L. Maia *et al.*, *Inorg. Chim. Acta*, 2017, **455**, 350-363.
   (read it here: https://docentes.fct.unl.pt/lblm/files/ica-2017-455-350.pdf)
3. L. Maia *et al.*, Molybdenum and tungsten-containing enzymes: an overview, Royal Society of Chemistry (2017), pag 1-80.
   (read it here: http://docentes.fct.unl.pt/lblm/files/mo_w_enzymes-rsc_book-chap_1.pdf)
4. L. Maia *et al.*, *J. Am. Chem. Soc.*, 2016, **138**, 8834-8846.
   (read it here: http://docentes.fct.unl.pt/lblm/files/jacs-2016-138-8834.pdf)

A Novel Approach to Discover ABC Transporter Modulators

D. J. V. A. dos Santos[1,3,5,*], R. J. Ferreira[2], M. J. U. Ferreira[3], J.-P. Gillet[4], M. N. D. S. Cordeiro[5], C. A. Bonito[5]

[1]CBIOS— Research Center for Biosciences and Health Technologies, Universidade Lusófona de Humanidades e Tecnologias, Lisbon, Portugal; [2]Red Glead Discovery AB, Medicon Village, Lund, Sweden; [3]Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Portugal; [4]Laboratory of Molecular Cancer Biology, URPhyM, NARILIS, Faculty of Medicine, University of Namur, Belgium; [5]LAQV@REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Portugal
**daniel.dos.santos@ulusofona.pt*

The estimated number of new cancer cases is expected to grow 33% by 2030, with an estimated increase of 35% in the total number of deaths. Although having a multifactorial origin, multidrug resistance (MDR) can be achieved through efflux pump-mediated resistance in which the ATP-binding cassette transporters superfamily (ABC transporters) like P-glycoprotein (Pgp/ABCB1), Multidrug Resistance Protein 1 (MRP1/ABCC1), and Breast Cancer Resistance Protein (BCRP/ABCG2) were found to be markers of overall poor chemotherapy response and prognosis. To date, three distinct generations of P-gp modulators were developed, but all failed to demonstrate efficacy and safety in the clinical environment. Furthermore, the development of more selective and effective modulators, using structure-based approaches, was also hampered by the polyspecificity of the drug-binding pockets (DBPs). Therefore, novel strategies for efflux modulation are extremely important to reverse MDR in cancer cells. In this communication, we will present and discuss our research on computational approaches used in the study of ABC transporters involved in multidrug resistance in cancer like Pgp and BCRP. We will focus our attention on the efflux mechanism[1,2] and on a novel approach aiming at designing modulators that bypass drug-binding at the DBPs of ABC transporters.[3]

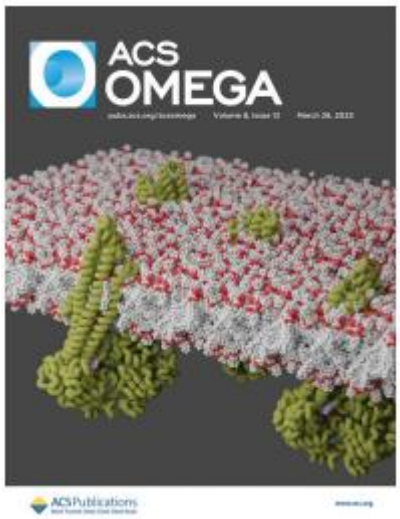


Figure 1: ABC transporters (P-glycoprotein) in a lipid bilayer

Acknowledgements
Fundação para a Ciência e a Tecnologia (FCT) is acknowledged for financial support through several projects (PTDC/MED-QUI/30591/2017, UIDB/DTP/04138/2020, CPCA/A0/7304/2020 and 2021.09821.CPCA). This work also received financial support by national funds, and was co-financed by the European Union (FEDER) over PT2020 Agreement (UIDB/QUI/50006/2020 and POCI/01/0145/FEDER/007265). C. A. Bonito acknowledges FCT for the PhD grant SFRH/BD/130750/2017. Project ILIND Seed Funding CoSysCan: Combining Synergistic Approaches to Fight Cancer (COFAC/ILIND/ CBIOS/1/2021) is also acknowledged for funding.

References

1. C. A. Bonito, R. J. Ferreira, M.-J. U. Ferreira, J.-P. Gillet, M. N. D. S. Cordeiro, D. J. V. A. dos Santos, Scientific Reports 2020, 10, 9823-9835. DOI: 10.1038/s41598-020-66587-5.
2. C. A. Bonito, R. J. Ferreira, M.-J. U. Ferreira, J.-P. Gillet, M. N. D. S. Cordeiro, D. J. V. A. dos Santos, Journal of Biomolecular Structure and Dynamics 2023, 1-10. DOI: 10.1080/07391102.2023.2181633.
3. C. A. Bonito, R. J. Ferreira, M.-J. U. Ferreira, J.-P. Gillet, M. N. D. S. Cordeiro, D. J. V. A. dos Santos, ACS Omega, 2023. DOI: 10.1021/acsomega.2c08273

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A coarse-grain molecular dynamic simulation framework to tackle oil extraction from silica-based surfaces

Germán Pérez-Sánchez[1,*], Filipa M. Costa[1], Gonçalo M. C. Silva[1], Manuel M. Piñeiro[2], João A. P. Coutinho[1]

[1] *CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 – Aveiro, Portugal.*
[2] *CINBIO, Department of Applied Physics, University of Vigo, 36310, Spain.*
**gperez@ua.pt*

The depletion of crude natural oil reservoirs yielded the industry to find alternative pathways to recover the oil that remains enclosed in reservoir's walls. One of the most effective are the so-called Enhanced Oil Recovery (EOR) processes which entails different techniques; thermal, chemical or gas injection.[1] In chemical EOR, aqueous solutions of surfactants[2] are injected into the reservoir to reduce the water-oil interfacial tension[3] promoting the detachment of oil from surfaces. However, numerous parameters are involved in chemical EOR such as surfactant concentration, phase behaviour, temperature, and pressure conditions among others, that impact the performance of EOR, making their characterisation a tough task for researchers. The development of reliable computer model approaches able to resemble chemical EOR processes can provide a significant insight at the molecule scale. Atomistic scale molecular dynamics simulations have been applied to describe different oil/water and oil/water/surfactant interfaces,[4] however, time and size scale limitations prevented the analysis of the surfactant phase.

Recently, we developed a coarse-grained molecular dynamics (CG-MD) model based in the recently released MARTINI 3 to study the impact of the surfactant phase behaviour in the recovery of oil from silica-based surfaces, resembling chemical EOR processes.[5] Therefore, CG-MD computer simulations were performed for four Poly(oxyethylene) alkyl ethers (CiEj) nonionic surfactants (C_8E_6, C_8E_{12}, $C_{12}E_6$, $C_{16}E_{12}$), encompassing a wide range hydrophilic/lipophilic balances (HLB), besides the cationic cetyl trimethyl ammonium bromide C_{16}TAB surfactant to analyse the impact of Coulombic interactions in the oil detachment process. Thus, the impact of surfactant nature whilst the concentration in the detachment of dodecane and eicosane from silica-based surfaces was analysed from a CG-MD perspective that increased the size and time scale of previous literature attempts by several orders of magnitude. Four concentrations ranged from 8%wt. to 60%wt. were attempted for each surfactant where visual inspections of the simulation snapshots and the evolution of the solvent accessible surface areas (SASA) were used to characterise their performance on retrieving dodecane or eicosane from the silica surface. In contrast with previous atomistic simulations, diluted nonionic solutions have been shown more effective in contrast with the cationic C_{16}TAB solutions. Interestingly, in absence of the silica surface, the C_{16}TAB was the most efficient on retrieving dodecane or eicosane from the aqueous solution. Overall surfactants, only the C_8E_6 completely recovered dodecane from the silica surface but for diluted solutions. Different HLB of C_iE_j only yielded partial or no detachment of oil. In addition, SASA profiles for oil moieties and the hydrophilic groups of the surfactants determined the promptness of the formation of water channels throughout the dodecane or eicosane layers attached to the silica surface.

The results obtained in this study demonstrated the capabilities of MARTINI 3 and CG-MD simulations to tackle multi-component systems used in the industry and the importance of addressing the phase behaviour in EOR processes. CG-MD simulations can face the high pressures and temperatures conditions that are found in natural oil reservoirs surpassing the limitations of experimental attempts carry out in the laboratory whilst aiding the design of novel approaches for EOR process.

Acknowledgements
We This work was developed within the scope of the project CICECO - Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). G. Pérez-Sánchez acknowledges the national funds (OE), through FCT – Fundação para a Ciência e a Tecnologia, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29th, changed by Law 57/2017, of July 19th. Simulations were performed at the OBLIVION Supercomputer managed by the HPC Centre of the University of ´Evora and acquired under the "Enabling Green E-science for the SKA Research Infrastructure (ENGAGE SKA)", reference POCI-01-0145-FEDER- 022217, funded by COMPETE 2020 and Foundation for Science and Technology (FCT), Portugal. The simulations were funded by the FCT program "Concurso de Projetos de Computação Avançada - 2ª Edição" with the project reference CPCA/A1/394985/2021.

References

1. O. Massarweh and A.S. Abushaikha, *Energy Rep.*, 2020, **6**, 3150-3178.
2. G. Lemahieu, J.F. Ontiveros, N. Terra Telles Souza, V. Molinier and J.-M. Aubry, *Fuel*, 2021, **289**, 119928.
3. P. Becher, *J. Dispers. Sci. Technol.*, 1990, **11**, 431-432.
4. Q. Liu, S. Yuan, H. Yan and X. Zhao, *J. Phys. Chem. B.*, 2012, **116**, 2867-2875.
5. G. Pérez-Sánchez, F. M. Costa, G. M. C. Silva, M. M. Piñeiro and J. A. P. Coutinho, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 2023, **131583**, 670.

Core–shell polycationic polyurea pharmadendrimers are a potential alternative to fight planktonic and biofilm infections caused by foodborne pathogens

Laura Pereira[1,*], Dalila Mil-Homens[1], Ana P. Quendera[2], José M. Andrade[2], Marta M. Alves[3], Vasco D. B. Bonifácio[1,4], Sandra N. Pinto[1]

[1]iBB-Institute for Bioengineering and Biosciences and i4HB-Institute for Health and Bioeconomy, , Instituto Superior Técnico, Universidade de Lisboa - Lisboa (Portugal);
[2]Instituto de Tecnologia Química Biologica António Xavier, Universidade Nova de Lisboa - Lisboa (Portugal);
[3]Centro de Química Estrutural (CQE), Instituto Superior Técnico (IST), Universidade de Lisboa - Lisboa (Portugal);
[4]Bioengineering Department, Instituto Superior Técnico, Portugal.
**lauraa13.gp@gmail.com*

With the continued spread of antimicrobial resistance, new alternatives to conventional antimicrobial agents are urgently needed. Particular relevant, is the fact that most of the bacterial infections observed in hospitals settings are caused bacteria in its biofilm form. A biofilm is a community of microorganisms where cells stick to each other and to a surface. Also, biofilm related infections are extremely difficult to eradicate since microbial cells in biofilms exhibit increased resistance levels to antibiotics and other antimicrobial agents. *Listeria monocytogenes*, the primary cause of listeriosis, is one of the most serious illnesses associated with bacterial biofilm formation. It can be discovered in raw foods and refrigerated products that are ingested without being heated beforehand, the presence of this bacteria poses a greater risk to the consumer having the highest mortality rate when compared to other foodborne pathogens. In this context, for the first time we investigate the efficacy of polycationic polyurea pharmadendrimers (PURE-OEI) designed by us[1] against *Listeria monocytogenes* in its planktonic and biofilm forms. In addition to traditional microbiological assays, we used here confocal microscopy and scanning electron microscopy (SEM) techniques to better understand the mechanism of action of dendrimers and to examine possible morphological alterations of bacteria within the in vitro biofilm models. The results indicate that PURE-OEI is highly effective in the treatment of *L. monocytogenes* infections. We also discovered that polycationic core-shell dendrimers affect cell density and biofilm adherence, which could lead to a possible application against *L. monocytogenes* biofilm development. PURE-OEI was observed to have a disruptive function at the bacterial membrane level using SEM. Interestingly, we observed that administering biocompatible doses of PURE-OEI sped up the wound closure process in an *in vitro L. monocytogenes* wound infection model. Our findings may pave the way for the development of techniques for preventing *L. monocytogenes* primary infection (for example, smart packaging using PURE-OEI) as well as a prospective therapeutic therapy that includes the development of novel smart dressings.

Funding
Fundação para a Ciência e a Tecnologia (FC&T, Portugal) supported this work through projects EXPL/BTM-MAT/0910/2021 and 2022.03627.PTDC. This work is also financed by national funds from FC&T in the scope of the projects UIDB/04565/2020 and UIDP/04565/2020 from the Research Unit iBB-Institute for Bioengineering, UIDB/00100/2020 from Centro de Química Estrutural, and Biosciences and the project LA/P/0140/2020 from the Associate Laboratory i4HB-Institute for Health and Bioeconomy and LA/P/0056/2020 from the Institute of Molecular Sciences (IMS).

References

1. Pinto SN, Mil-Homens D, Pires RF, Alves MM, Serafim G, Martinho N, Melo M, Fialho AM, Bonifácio VDB. *Biomater Sci.*, 2022, **10**, 5197-5207.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Proximate composition and free sugar and fatty acid profiles of Asian hornet larvae: An alternative food source?

Alexis Pereira[1,2], Maria Inês Dias[1,2], Carla Pereira[1,2], M. Alice Pinto[1,2], Lillian Barros[1,2], José Pinela[1,2,*]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [2]Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
**jpinela@ipb.pt*

Asian hornet (*Vespa velutina nigrithorax*) is an invasive species native to Southeast Asia that unintentionally found its way into Europe in 2004.[1,2] It was first reported in France and rapidly spread across the country and later into other European nations, including Portugal in 2011.[2] Asian hornet larvae are believed to be rich in nutrients, but further research is required to determine their potential as an alternative food source. Although entomophagy is recognized as a sustainable dietary practice for replacing animal protein and promoting food security, it has not received the deserved attention in many Western countries.[3] Therefore, this study aimed to characterize the proximate composition and individual profiles of free sugars and fatty acids in Asian hornet larvae from nests collected in Northern Portugal. The Asian hornet population from each nest was immobilized with cold carbon dioxide. Thereafter, the nests were dissected to remove the larvae, which were analyzed for moisture, ash, protein, crude fat, and dietary fiber contents following official food analysis procedures.[4] The carbohydrate content was estimated by difference, and the energy value was calculated according to current regulations.[5] HPLC-RI and GC-FID techniques were employed to characterize the individual profiles of free sugars and fatty acids, respectively.[6] The study revealed that proteins and carbohydrates were the most abundant macronutrients, followed by crude fat and dietary fiber. A 100 g portion of dehydrated larvae provided 446 kcal of energy. Furthermore, seven free sugars and twenty-five fatty acids were identified in the studied samples. Overall, these findings contribute to a more detailed characterization of the nutritional value of this invasive species' larvae. In future works, it will be important to perform other chemical analyses and promote the consumer's perception and attitude toward the inclusion of insects into sustainable contemporary diets.

Acknowledgements
This work is funded by the research Project POSEUR-03-2215-FC000164 through the Operational Program Sustainability and Efficiency in the Use of Resources (POSEUR-15-2021-02) and Cohesion Fund; A. Pereira is grateful for his research grant to this project. The authors also thank the Foundation for Science and Technology (FCT, Portugal) for the financial support through national funds FCT/MCTES to CIMO (UIDB/00690/2020 and UIDP/00690/2020) and SusTEC (LA/P/0007/2020). National funding by FCT, through the institutional scientific employment program-contract with M.I. Dias, C. Pereira, and L. Barros, and through the individual scientific employment program-contract with J. Pinela (CEECIND/01011/2018).

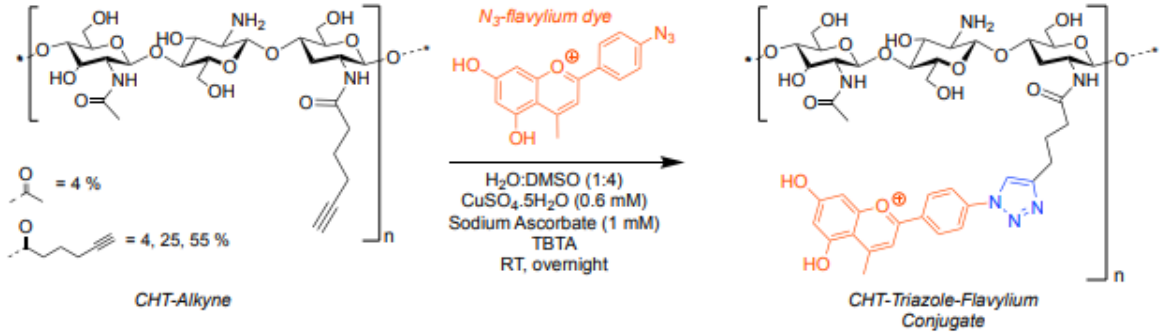
References
1. O. Haira, M. L. Alonso, R. M. Alonso, Insects, 2023, 14, 59.
2. K. Monceau, O. Bonnard, D. Thiéry, J. Pest Sci., 2014, 87, 1-16.
3. V. B. Meyer-Rochow, R. T. Gahukar, S. Ghosh, C. Jung, Foods, 2021, 10, 1036.
4. AOAC International, Official Methods of Analysis of AOAC International, G.W. Latimer, 20th Ed., Gaithersburg, 2016
5. European Parliament, Council of the European Union, Regulation (EU). Off. J. Eur. Union, 2011, 27, 18-63.
6. J. Pinela, L. Barros, A. M. Carvalho, I. C. F. R. Ferreira, Food Chem. Toxicol., 2012, 50, 829–834.

Chitosan-flavylium conjugates towards construction of pH-responsive multilayer membranes for food spoilage detection

Mariana Cunha[1,*], Victor de Freitas[1], João M. M. Rodrigues[2], Luís Cruz[1]

[1]Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre, 687, 4169-007, Porto, Portugal;
[2]Departamento de Química, CICECO – Instituto de Materiais de Aveiro, Universidade de Aveiro, 3810-193 Aveiro, Portugal
*up201805022@fc.up.pt

Nowadays, consumers are more concerned about food safety and quality, while being consciously committed to food waste issues. To that end, the development of smart packaging systems to provide real-time visual information of the freshness state of food products has been investigated. (Bio)films, incorporating pH-sensitive dyes embedded in biopolymers, have been extensively studied as pH-freshness indicators for this purpose. It is necessary to point out that pH is correlated with food freshness, as the spoiling process promotes the development of organic acids and volatile amine-based compounds that lower or raise the pH of perishable foods such as dairy products, meat, and fish, among others (in the case of milk, the formation of lactic acid and other organic acids will cause the lowering of pH).[1,2] The major purpose of this work is to create biodegradable and sustainable multilayer films for detecting food deterioration, using flavylium-based pH-sensitive dyes and marine-origin biopolymers [modified Chitosan (CHT) and Alginate (ALG)]. To this propose, an azide-containing flavylium was rationally synthesized to enable further functionalization onto Chitosan-Alkyne (CHT-alkyne) derivatives by copper-catalyzed azide-alkyne cycloaddition (CuAAC), often known as "Click Chemistry". Both dye and conjugate were thoroughly characterized using several methods, including FTIR-ATR, NMR (1H, NOESY), and zeta-potential. The CHT-Triazole-Flavylium conjugate, in combination with ALG, were used as building block using Layer-by-Layer (LbL) assembly methodology.[3] The build-up process was firstly monitored by quartz crystal microbalance (QCM-D), and then highly ordered pH-responsive multilayered membranes were fabricated. The developed membranes were subsequently exposed to milk samples throughout time. This technology will provide precise control of thickness, highly ordered composition, and architecture, raising as an alternative to the conventional casting method for film formation.



Scheme 1: Click chemistry reaction between N3-flavylium dye and CHT-alkyne.

Acknowledgements
We thank Dr. Zélia Azevedo for the MS analysis and Dr. Mariana Andrade for the NMR analysis. This work was supported by the Associate Laboratory for Sustainable Chemistry, Clean Processes and Technologies LAQV. L.C. acknowledges the FCT research contract (DL 57/2016/CP1334/CT0008).

Funding
This work was supported by the Associate Laboratory for Sustainable Chemistry, Clean Processes and Technologies LAQV and financed by national funds from UIDB/50006/2020 and by the project PTDC/OCE-ETA/31250/2017 funded by FCT and FEDER.

References

1. A. S. Pires, V. Gomes, D. Neves, N. Mateus, V. De Freitas and L. Cruz, ACS Appl Polym Mater, 2022, 4, 4961– 4971. https://doi.org/10.1021/acsapm.2c00514
2. L. P. G. Monteiro, J. Borges, J. M. M. Rodrigues and J. F. Mano, Mar Drugs, 2023, 21,92. https://doi.org/10.3390/md21020092
3. L. Cruz, N. Basílio, N. Mateus, V. De Freitas and F. Pina, Chem Rev, 2022, 122, 1416–1481. https://doi.org/10.1021/acs.chemrev.1c0039

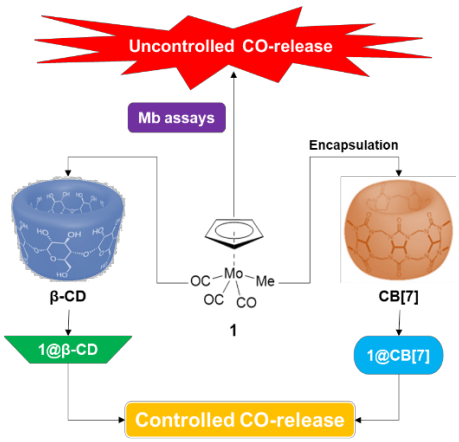
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Effect of the macrocyclic host on carbon monoxide release from inclusion compounds with $CpMo(CO)_3Me$

Rodrigo P. Monteiro[1,*], Isabel B. Calhau[1], Ana C. Gomes[1], André D. Lopes[2], José P. Da Silva[2], Isabel S. Gonçalves[1], Martyn Pillinger[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal; [2]CCMar and Department of Chemistry and Pharmacy, FCT, University of the Algarve, Gambelas Campus, 8005-139, Faro, Portugal
**rod.monteiro@ua.pt*

Carbon monoxide (CO) is usually associated with its negative side due to its responsibility for intoxication cases.[1] What is less well known is that CO is endogenously produced in the human body from the oxidation of heme catalysed by heme-oxygenase, which is known for its cytoprotective and restorative processes. Consequently, there is the positive side of CO as a therapeutic agent. In this context, CO-releasing molecules (CORMs) have emerged as potential prodrugs to deliver CO to cells and tissues.[2] Among these molecules, the most common ones have transition metals in their constitution, including molybdenum (Mo).
Mo-based CORMs, such as $[NEt_4][Mo(CO)_5Br]$, can be used as antimicrobial and bactericidal agents.[3] However, these compounds have some limitations, for instance, poor water solubility and low stability. Supramolecular chemistry provides solutions to overcome these drawbacks, where macrocyclic hosts such as cucurbiturils (CBs) and cyclodextrins (CDs) have frequently been used as hosts in the synthesis of inclusion compounds with drug molecules. The encapsulation of CORMs in these hosts could potentially result in improved pharmacokinetic properties, and lead to a more controlled CO-release rate, to prevent hypoxia.
In the present work, the cyclopentadienyl molybdenum tricarbonyl complex $CpMo(CO)_3Me$ and its 1:1 inclusion complexes with β-CD and CB[7] were prepared and characterized. The free complex $CpMo(CO)_3Me$ and the inclusion compounds were studied in relation to their CO-release capacity through the myoglobin (Mb) assay, where absorption spectroscopy (in the Q-band region) is used to monitor the conversion of deoxy-Mb into carbonmonoxy-Mb. These studies were performed in the presence of PBS buffer (pH 7.4) and DMSO as co-solvent, at 37 ºC. Both inclusion compounds displayed slower CO-release rates in relation to the free complex $CpMo(CO)_3Me$, which may be desirable for optimal CO-based therapies.



Scheme 1: CO-release studies for free complex $CpMo(CO)_3Me$ (**1**) and its 1:1 inclusion complexes with β-CD and CB[7].

Acknowledgements
We acknowledge funding provided within the project CICECO – Aveiro Institute of Materials (UIBD/50011/2020, UIDP/50011/2020 and LA/P/0006/2020), financed by national funds through the FCT (Fundação para a Ciência e a Tecnologia)/MCTES (Ministério da Ciência, Tecnologia e Ensino Superior) (PIDDAC). R.P.M. (ref. 2020.04758.BD) and I.B.C. (ref. 2021.05953.BD) thank the FCT for PhD grants. A.C.G. thanks the FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus (ref. CEECIND/02128/2017).

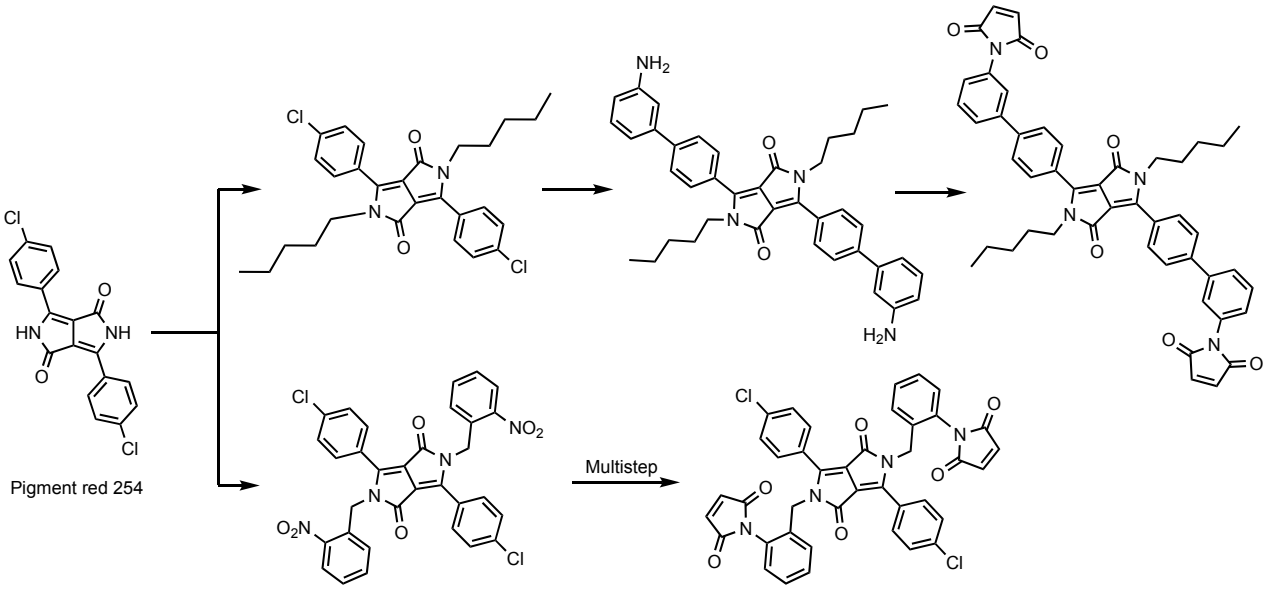
References
1. J. Varon, P. E. Marik, R. E. Fromm Jr and A. Gueler, *J. Emerg. Med.*, 1999, **17**, 87-93.
2. K. Ling, F. Men, W.-C. Wang, Y.-Q. Zhou, H.-W. Zhang and D.-W. Ye, *J. Med. Chem.*, 2018, **61**, 2611-2635.
3. L. S. Nobre, J. D. Seixas, C. C. Romão and L. M. Saraiva, *Antimicrob. Agents Chemother*, 2007, **51**, 4303-4307.

Synthesis of new diketopyrrolopyrrole derivatives

Gonçalo F. Oliveira*, Vítor A. S. Almodôvar, Augusto C. Tomé

LAQV-Requimte, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal
**goncalofoliveira@ua.pt*

Diketopyrrolopyrroles are a family of highly fluorescent synthetic organic dyes and pigments. They possess excellent physical and photophysical properties, suggesting a possible use as fluorophores.[1,2] Their properties can be tuned by modification at the N-H groups or by extending the aromatic system.[1,2] Fluorophores commonly used have some drawbacks like low Stokes shifts and are prone to photodegradation.[3,4]
In this work we report the synthesis of DPP derivatives that can be used as precursors to probes for thiols. The functionalization was attempted in the group used for alkylation of the N-H group and with the addition of an aromatic ring using Suzuki–Miyaura cross-coupling reaction.[5]
Pigment red 254, a commercially available pigment, was used as starting material and it was functionalized with (3-aminophenyl)boronic acid and 2-nitrobenzyl bromide, as illustrated in scheme 1. The conversion of the resulting DPP dyes to maleimide derivatives is in progress.



Scheme 1: Attempted strategies for the synthesis of DPP derivatives

Acknowledgments:
Thanks are due to the University of Aveiro and Fundação para a Ciência e a Tecnologia (FCT) for the financial support to the LAQV-REQUIMTE. Thanks are also due to the Portuguese NMR and Mass Networks Partnership Agreement.

Funding:
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through projects UIDB/50006/2020 and UIDP/50006/2020. Vítor A. S. Almodovar thanks FCT/MCTES for his PhD grant ref. SFRH/BD/135598/2018.

References

1. M. Grzybowski and D. T. Gryko, *Adv Opt Mater*, 2015, **3**, 280–320.
2. S. A. L. Shaikh, S. S. Birajdar, S. D. Ambore, A. L. Puyad, P. Vijayanand, S. V. Bhosale and S. V. Bhosale, *Results Chem*, 2022, 4.
3. M. Kaur and D. H. Choi, *Chem Soc Rev*, 2015, 44, 58–77.
4. B. Hötzer, I. L. Medintz and N. Hildebrandt, *Small*, 2012, **8**, 2297–2326.
5. V. A. S. Almodôvar and A. C. Tomé, *Molecules*, 2021, **26**, 4758.

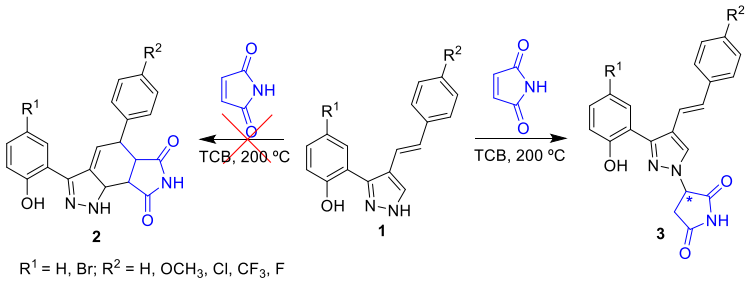
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of (*E*)-3-[3-(2-hydroxyphenyl)-4-styryl-1*H*-pyrazol-1-yl]pyrrolidine-2,5-diones as potential PARP1 inhibitors

Inês M. Bastos[1], Mariana Vassal[2], Igor Marques[3], Vítor Félix,[3] Artur M. S. Silva[1], Sandra Rebelo[2], Vera L. M. Silva[1,*]

LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]Institute of Biomedicine—iBiMED, Department of Medical Sciences, University of Aveiro, 3810-193 Aveiro, Portugal
[3]Department of Chemistry, CICECO – Aveiro Institute of Materials, University of Aveiro, 3810-193, Aveiro, Portugal.
**verasilva@ua.pt*

Pyrazoles and indazoles have been raising great interest due to their numerous medicinal properties, namely, anti-inflammatory, neuroprotectant and anticancer activities.[1] Recent studies highlighted the important role of this type of nitrogen-based heterocyclic compounds in cancer therapies.[1]
PARP1 is a protein that plays essential roles in cellular regulation, namely in DNA damage repair and cell survival. Interestingly, in some cancer types this protein is overactivated leading to carcinogenesis.[2] For this reason, PARP1 has emerged as a good candidate for anticancer therapy. Some putative/potential PARP1 inhibitors contain pyrazole or indazole moieties in their structures.[2,3]
In this context, the objectives of the present work were the synthesis and structural characterization of novel pyrazoles and indazoles as potential inhibitors of PARP1. Aiming to synthesize indazoles, a Diels-Alder cycloaddition reaction of (*E*)-3(5)-(2-hydroxyphenyl)-4-styryl-1*H*-pyrazoles **1** with maleimide was carried out. However, the expected cycloadduct **2**, precursor of the indazole, was not obtained; instead the (*E*)-3-[3-(2-hydroxyphenyl)-4-styryl-1*H*-pyrazol-1-yl]pyrrolidine-2,5-diones **3** were isolated as the main reaction product (Scheme 1). In fact, vinylpyrazole derivatives are very reluctant to participate as dienes in cycloaddition reactions involving the pyrazole ring, owing to the loss of its aromaticity in the reaction.[4] Yet, compounds **3** are very interesting since they present key structural characteristics for the inhibition of PARP1, such as the amide group, aromatic rings, and groups capable of forming hydrogen bonds. Moreover, these compounds present physicochemical properties similar to Olaparib, a well-known inhibitor of this protein, presenting similar topological polar surface area (tPSA) (Olaparib: 82; **3**, $R^1 = R^2 = H$: 82) and similar solubility in water (logS) (Olaparib: -5.1; **3**: -4.9 to -5.9). All the synthesised compounds **3** were characterized by nuclear magnetic resonance spectroscopy.
In a near future, molecular modelling, and *in vitro* studies, including PARP1 enzymatic assays, will be carried out to evaluate the inhibitory activity of these compounds. Further, the cell viability of the more promising compounds will be evaluated using HeLa cells and human dermal fibroblasts.



Scheme 1: Synthesis of (*E*)-3-[3-(2-hydroxyphenyl)-4-styryl-1*H*-pyrazol-1-yl]pyrrolidine-2,5-diones.

Acknowledgements
Thanks are due to the University of Aveiro and FCT (Fundação para a Ciência e a Tecnologia), the European Union, QREN, FEDER, and COMPETE for funding the LAQV-REQUIMTE (UIDB/50006/2020+ UIDP/50006/2020) and to the Portuguese NMR Network (PT NMR) partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). Vera L.M. Silva thanks funding through FCT under the Scientific Employment Stimulus – Institutional Call – reference CEECINST/00026/2018.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project units UIDB/50006/2020 and UIDP/50006/2020 (LAQV-Requimte), and the Institute of Biomedicine (iBiMED)—UIDP/04501/2020 and UIDB/04501/2020— and the FCT/MCTES, the COMPETE 2020 Program, the QREN and the European Union (Fundo Europeu de Desenvolvimento Regional).

References

1. N. Santos, A. Carreira, V. L. M. Silva and S. Santos Braga, *Molecules* 2020, **25**, 1364.
2. M. Kumar, R. Jaiswal, P. Yadava and R. Singh, *BioFactors*. 2020, **46**, 894- 905.
3. Z. Wu, Y. Bai, J. Jin, T. Jiangg, H. Shen, Q. Ju, Q. Zhu and Y. Xu, *Eur. J. Med. Chem*, 2021, **217**, 113357.
4. V. L.M. Silva, A. M.S. Silva, D. C.G.A. Pinto and J. A.S. Cavaleiro, *Synlett,* 2006, **9**, 1369-1373.

Synthesis of arylated DT-TTF derivatives with tuneable molecular orbital energy levels and formation of 2D networks on surface

Catarina Ribeiro[1,*], Gonçalo Valente[1], Miguel Espinosa[1], Rafaela A. L. Silva[2], Dulce Belo[2], Sara Gil-Guerrero[2], Nicolás Arisnabarreta[3], Kunal S. Mali[3], Steven De Feyter[3], Manuel Melle-Franco[1], Manuel Souto[1]

[1]Department of Chemistry, CICECO-Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal; [2]Centro de Ciências e Tecnologias Nucleares, Instituto Superior Técnico, Universidade de Lisboa, E.N. 10, Bobadela LRS, Portugal; [3]KU Leuven, Department of Chemistry, Division of Molecular Imaging and Photonics, Celestijnenlaan 200F, Leuven, Belgium.
**Catarina.gribeiro@ua.pt*

Tetrathiafulvalene (TTF) and its derivatives are electron-donor and redox-active molecules that received a lot of attention in the field of molecular electronics.[1] The synthesis of arylated TTF derivatives allowed the formation of TTF-based extended frameworks such as metal-organic frameworks (MOFs), and covalent organic frameworks (COFs).[2] Because of its high field-effect charge carrier mobility, dithiophene-tetrathiafulvalene (DT-TTF) derivative, attracted a lot of attention as an active material for organic field-effect transistors (OFETs).[3,4] However, the direct functionalization of DT-TTF building blocks has not yet been described. Herein, we describe the direct C-H arylation of DT-TTF (1) to synthesize derivatives **2**-**5** bearing different electron-donor or electron-withdrawing functional groups in order to modify its electronic properties (Fig. 1).[5] Finally, the formation of DT-TTF-tetrabenzoic acid (**5**) 2D self-assembled networks was also studied using scanning tunneling microscopy (STM).

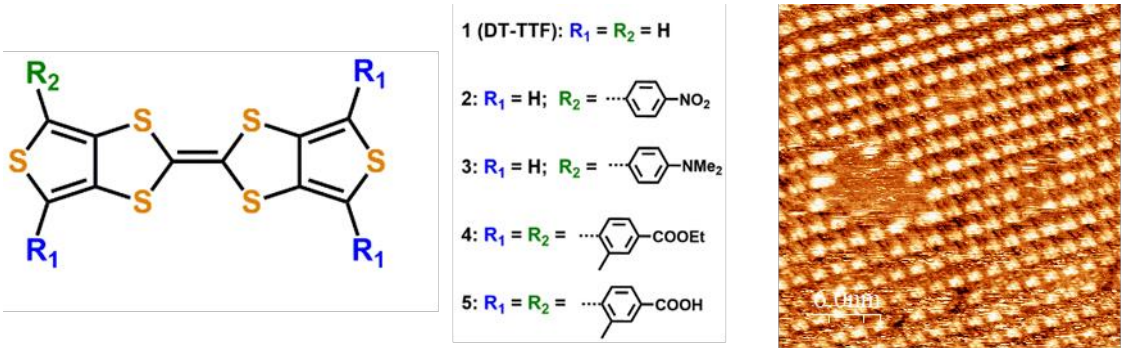


Figure 1: a) Molecular structures of arylated DT-TTF derivatives (**1**-**5**) and b) STM image of physisorbed monolayer of **5** on HOPG.

Acknowledgements
This work has received funding from the European Research Council (ERC) under the European Union's Horizon Europe Framework Programme (ERC-2021-Starting Grant, grant agreement no. 101039748-ELECTROCOFS). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, Grants UIDB/50011/2020 and UIDP/50011/2020, financed by national funds through the FCT/MEC and when appropriate co-financed by FEDER under the PT2020 Partnership Agreement. We thank FCT for funding the project PTDC/QUI-ELT/2593/2021.

References
1. N. Martín, *Chem. Commun.*, 2013, **49**, 7025–7.
2. M. Souto, K. Strutyński, M. Melle-Franco and J. Rocha, *Chem. Eur. J.*, 2020, **26**, 10912–10935.
3. M. Mas-Torrent, M. Durkut, P. Hadley, X. Ribas and C. Rovira, *J. Am. Chem. Soc.*, 2004, **126**, 984–985.
4. R. Pfattner, S. T. Bromley, C. Rovira and M. Mas-Torrent, *Adv. Funct. Mater.*, 2016, **26**, 2256–2275.
5. C. Ribeiro, G. Valente, et al., *Chem. Eur. J.* 2023, DOI: 10.1002/chem.202300572 (front cover).

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Redox-active tetrathiafulvalene-based covalent organic frameworks as cathodes for lithium batteries

Pedro Ferreira[1,*], Gonçalo Valente[1], Raquel Dantas[1], Karol Strutynski[1], Manuel Melle-Franco[1], David Rodríguez San-Miguel[2], Felix Zamora[2], Roman Guntermann[3], Thomas Bein[3], Manuel Souto[1]

[1]Department of Chemistry, CICECO – Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal; [2]Departamento de Química Inorgánica, Universidad Autónoma de Madrid, 28049 Madrid, Spain; [3]Department of Chemistry and Center for NanoScience (CeNS), University of Munich (LMU), Butenandtstraße 5-13, 81377 Munich, Germany
**pmcferreira@ua.pt*

Covalent organic frameworks (COFs) are an emerging class of crystalline porous materials constructed from organic building blocks linked by covalent bonds. Given their great chemical and structural versatility, COFs have received a lot of interest towards applications in gas sorption and separation, catalysis, sensing, among others.[1] Recently, 2D COFs have received particular interest for electronics,[2] optoelectronics,[3] and energy related applications,[4] due to the possibility of 2D π-conjugation. The porosity of the COFs, combined with the electrical conductivity derived from the 2D π-conjugation can lead to exciting new electronic related applications, not easily achieved with either 1D polymers or inorganic 2D materials.[5]
Tetrathiafulvalene (TTF) and its derivates are organic molecules with excellent electron-donor and redox properties, making them the ideal candidates as building blocks for the preparation of redox-active COFs for electronic and energy-related applications.[2] Herein we present a new family of TTF-based COF with different building blocks, in order to study the influence of the spacer between the TTF moieties on the electrical conductivity. The neutral and doped TTF-based COFs were characterized by multiple spectroscopic techniques in order to fully understand the charge transport mechanisms occurring in these materials. Finally, some TTF-COFs were also explored as organic cathodes for lithium batteries.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). This work has also received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant 101039748). P. F. and G. V. would also like to thank FCT for the PhD grants UI/BD/151049/2021 and 2020.08520.BD, respectively.

References

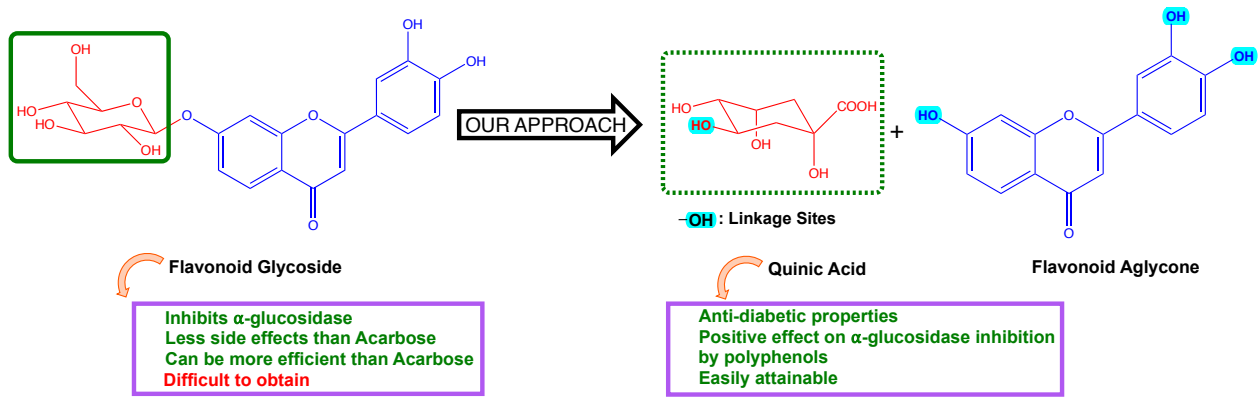
1. K. Geng, T. He, R. Liu, S. Dalapati, K. T. Tan, Z. Li, S. Tao, Y. Gong, Q. Jiang and D. Jiang, *Chem. Rev.* 2020, *120*, 8814.
2. M. Souto, K. Strutyński, M. Melle-Franco and J. Rocha, *Chem. Eur. J.* 2020, *26*, 10912.
3. M. Souto, D. F. Perepichka, J. Mater. Chem. C. 2021, 9, 10668.
4. J. Rotter, R. Guntermann, M. Auth, A. Mähringer, A. Sperlich, V. Dyakonov, D. Medina and Thomas Bein, *Chem. Sci.* 2020, *11*, 12843.
5. H. Ding, Y. Li, H. Hu, Y. Sun, J. Wang, C. Wang, C. Wang, G. Zhang, B. Wang, W. Xu and D. Zhang, Chem. Eur. J., 2014, *20*, 14614 – 14618.

Synthesis of quinic acid derivatives for α-glucosidase inhibition

Iago C. Vogel*, Diana C. G. A. Pinto, Nuno R. Candeias

LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
iagocvogel@ua.pt

One of the anti-diabetic strategies for diabetes type 2 is the inhibition of α-glucosidase, being acarbose the most popular inhibitor[1]. Because of its side effects, the discovery of new and potent molecules with less undesirable effects is a timely challenge.
Flavonoid glycosides seem to offer great inhibition potential with less adverse reactions[2]. However, its attainment through natural extraction, chemical synthesis or even biotechnological approaches, can be impractical, due to environmental concerns, poor yields and high costs[3]. Given the fact that flavonoids can be viably synthesized[4], the problem resides in its glycosylation. One solution to this problem can be the functionalization with a derivative of quinic acid, that can be easily obtained from natural sources, such as coffee beans, fruits and several plants[5], besides having antidiabetic properties[6] and positive effect on α-glucosidase inhibition by some polyphenols[7].
The objective of this work is to develop a viable alternative to the attainment of α-glucosidase inhibitors, based on the functionalization of flavonoids with a quinic acid derivative.



Scheme 1: Functionalization of flavonoids with quinic acid as a possible alternative to flavonoid glycosides

Acknowledgements
This work received support and funding from PT national funds (FCT/MCTES) through the projects UIDB/50006/2020, UIDP/50006/2020, CEE-CINST/2018 and PTDC/QUI-QOR/1131/2020.

References
1. N. Kaur, V. Kumar, S. K. Nayak, P. Wadhwa, P. Kaur and S. K. Sahu, Chem Biol Drug Des, 2021, **98**, 539–560.
2. R. Tundis, M. R. Loizzo and F. Menichini, Mini Rev Med Chem, 2010, **10**, 315–331.
3. J. O. Chaves, M. C. de Souza, L. C. da Silva, D. Lachos-Perez, P. C. Torres-Mayanga, A. P. da F. Machado, T. Forster-Carneiro, M. Vázquez-Espinosa, A. V. González-de-Peredo, G. F. Barbero and M. A. Rostagno, Front Chem, 2020, **8**, 864.
4. A. M. Pereira, H. Cidade and M. E. Tiritan, Molecules 2023, Vol. 28, Page 426, 2023, **28**, 426.
5. T. Benali, S. Bakrim, R. Ghchime, N. Benkhaira, N. El Omari, A. Balahbib, D. Taha, G. Zengin, M. M. Hasan, S. Bibi and A. Bouyahya, https://doi.org/10.1080/02648725.2022.2122303, , DOI:10.1080/02648725.2022.2122303.
6. E. Heikkilä, A. Hermant, J. Thevenet, F. Bermont, S. S. Kulkarni, J. Ratajczak, J. Santo-Domingo, E. H. Dioum, C. Canto, D. Barron, A. Wiederkehr and U. De Marchi, Br J Pharmacol, 2019, **176**, 3250–3263.
7. H. Gao, Y. N. Huang, B. Gao, P. Y. Xu, C. Inagaki and J. Kawabata, Food Chem, 2008, **106**, 1195–1201.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Lytic polysaccharide monooxygenase direct electrochemical behavior - role of the active center ligands

C. M. Cordas[1,*], R. Duarte[1], G. N. Valério[1,2], Å. K. Røhr[2], V. G. H. Eijsink[2], J. J. G. Moura[1]

[1]LAQV, REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal; [2]Faculty of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences (NMBU), PO Box 5003, 1432 Ås, Norway
**c.cordas@fct.unl.pt*

Lytic polysaccharide monooxygenases (LPMO) are redox enzymes acting in conjunction with carbohydrate-active enzymes (CAZ), classified in different families according to their auxiliary activities (AA). LPMOs have been intensively studied due to its high interest for industry for their role in lignocellulose biomass (LB) processing[1]. The enzymes possess an exposed and highly conserved active redox center containing a single ion copper and two histidine residues (in the so-called "histidine-brace") together with a third histidine (the N-terminal residue) in equatorial positions. Less conserved residues are present, such as phenylalanine and a distal alanine in the AA10 bacterial family[2]. The mechanism, still under discussion, starts with the reduction of the Cu(II) to Cu(I) and involves hydrogen peroxide (and/or molecular oxygen), that seems essential for initiating the catalytic reaction, but is also formed during the catalytic cycle[3]. A better understanding of the mechanism and the redox features of LPMOs are crucial for using these enzymes more efficiently. In the current work, the direct electrochemical behavior of a LMPO, the immobilized *Sc*LPMO10C, and the influence of different residues in the copper center (A142G, F219Y and F219A) redox properties were evaluated.

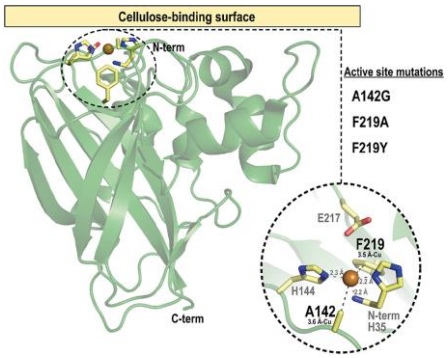


Figure 1: Structure of ScLPMO10C (PDB 4OY7), showing the residues and the copper ion of the redox center. The studied mutations are listed in the figure[2].

Acknowledgements
This work was supported by the OXYMOD project funded by the Research Council of Norway with grant number 269408. Also, this work was supported by the Associate Laboratory for Green Chemistry - LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020) and (UIDP/50006/2020), Portugal. CNC acknowledges FCT (Fundação para a Ciência e Tecnologia) for funding through program DL 57/2016 – Norma transitória

References
1. Xiao Guo, Yajing An, Fufeng Liu, Fuping Lu and Bo Wang, *Bioresource Technology*, 2022, **362,** 362.
2. Cristina M. Cordas, Gabriel N. Valério, Anton Stepnov, Eirik Kommedal, Åsmund R. Kjendseth, Zarah Forsberg, Vincent G.H. Eijsink, José J.G. Moura, *Journal Inorg. Biochemistry* 2023, **238**, 112056.
3. Vincent G. H. Eijsink, Dejan Petrovic, Zarah Forsberg, Sophanit Mekasha, Åsmund K. Røhr, Anikó Várnai, Bastien Bissaro and Gustav Vaaje-Kolstad, *Biotechnol Biofuels*, 2019, **12**, 58.

The impact of increased soil salinity on the production of secondary metabolites by *Olea europaea* L.

Natacha C. P. Rodrigues[1,2,*], Maria J. Ferreira[1,2], M. Ângela Cunha[2], M. Amparo F. Faustino[1], I. Natalia Sierra-Garcia[2], Diana C. G. A. Pinto[1]

[1]*LAQV-REQUIMTE & Department of Chemistry, University of Aveiro, Campus of Santiago 3810-193, Aveiro, Portugal*
[2]*CESAM & Department of Biology, University of Aveiro, Campus of Santiago 3810-193, Aveiro, Portugal*
**ncprodrigues@ua.pt*

Olive tree (*Olea europaea* L.) is renowned for its rich composition in bioactive compounds, particularly secondary metabolites, which are known to possess various health benefits, including antioxidant, anti-inflammatory and cardioprotective effects.[1] However, the Mediterranean region, where the olive tree has a significant economic and cultural impact, faces an emergent soil salinization issue,[2] which can compromise the biosynthesis and accumulation of these secondary metabolites. Therefore, it is crucial to study the effects of salt stress on olive trees' secondary metabolites to understand the changes in their nutritional and medicinal value.

In the present study, leaves of the Galega Vulgar cultivar obtained from plants representing different development stages and cultivation conditions (adult trees from an olive grove, young trees grown in greenhouse conditions (control treatment), young trees grown in greenhouse and irrigated with 150 mM of NaCl solutions). The phenolic profile of the ethanolic extract of leaves of each group was analyzed using UHPLC-DAD-ESI/MS.

As an example, 47 phenolic compounds were identified in leaf extracts of field-grown Galega Vulgar trees, that were grouped into seven classes: flavonoids (18), secoiridoids (16), phenolic alcohols (3), sterols (3), terpenoids (2), cinnamic acid derivatives (4) and sugars (1) (Figure 1). Both secoiridoids and flavonoids were the predominant classes of identified compounds, being secoiridoids class the most abundant. All details will be presented and discussed in this communication.

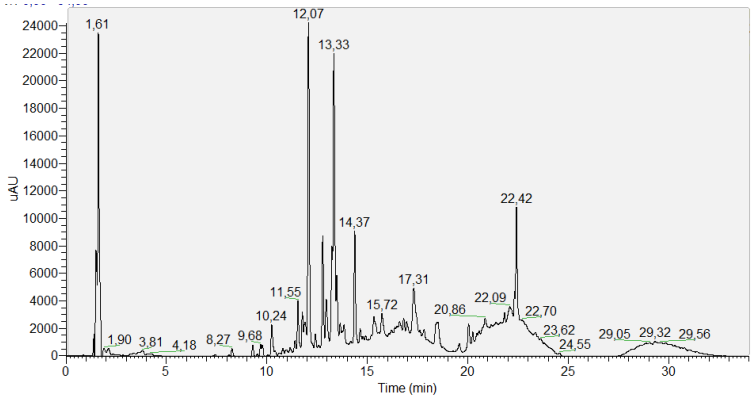


Figure 1: Chromatogram obtained by UHPLC-DAD-ESI/MS of the phenolic profile of olive leaf ethanolic extracts of Galega Vulgar cultivar, recorded at 280 nm.

Acknowledgements
Thanks are due to the University of Aveiro and FCT (Fundação para a Ciência e a Tecnologia), the European Union, QREN, FEDER, and COMPETE for funding the LAQV-REQUIMTE (UIDB/50006/2020+ UIDP/50006/2020) and CESAM (UIDP/50017/2020 + UIDB/50017/2020). FCT is also acknowledge for the support through the project Halius (PTDC/BIA-MIC/3157/2020).

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects units UIDB/50006/2020 and UIDP/50006/2020 (LAQV-Requimte), UID/AMB/50017/2019 and UIDB/50017/2020 + UIDP/50017/2020 (CESAM) and the FCT project Halius (PTDC/BIA-MIC/3157/2020).

References

1. S. Z. Hussain, in Fruits Grown in Highland Regions of the Himalayas, Springer, Switzerland, 2021, ch. 9, pp. 117–129.
2. I. Zipori, R. Erel, U. Yermiyahu, A. Ben-Gal and A. Dag, Agriculture, 2020, **10**, DOI: 10.3390/agriculture10010011

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Reactivity studies of 1,5-diarylpentadienones with hydroxylamine: Synthesis of diarylpyridines and styrylisoxazolines

Lara Almeida[1], Ricardo F. Mendes[2], Filipe A. Almeida Paz[2], Artur M. S. Silva[1], Diana C. G. A. Pinto,[1] Vera L. M. Silva[1,*]

[1]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]CICECO−Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, *3810-193 Aveiro, Portugal*
**verasilva@ua.pt*

(2*E*,4*E*)-1,5-Diarylpenta-2,4-dien-1-ones **1** and (1*E*,4*E*)-1,5-diarylpenta-1,4-dien-3-ones **2** are two classes of compounds very important as precursors of a variety of nitrogen-based heterocyclic compounds with relevant biological activity, such as pyridines, pyrazoles, indoles, isoxazoles, among others.[1,2]

Isoxazoles are a class of compounds with a vast range of biological activities which have been studied for their potential analgesic, anti-inflammatory, anticancer, antimicrobial, anticonvulsant, antidepressant, and anti-Alzheimer activities, among others.[3] This variety of activities is associated with the flexibility of the isoxazole ring to integrate different structures, as these compounds can be synthesized through various synthetic routes using a diversity of starting materials.[4]

This work aimed to synthesize novel styrylisoxazoles by reacting (2*E*,4*E*)-1,5-diarylpenta-2,4-dien-1-ones **1** with hydroxylamine hydrochloride, in ethanol, under microwave irradiation. However, the expected isoxazoles were not isolated in these conditions; instead, 2,6-diarylpyridines **3** were obtained as the major reaction product, as confirmed by nuclear magnetic resonance spectroscopy (NMR) and Single-Crystal X-ray diffraction analysis**.** This was a fascinating result since pyridines are important heterocycles widely found in natural products, functional materials, agrochemicals, and organocatalysis. Consequently, developing novel methods for synthesizing pyridines, especially unsymmetrical pyridines, is of major interest.

Regarding the aforementioned results, it was decided to study the reaction of 1,5-diarylpenta-1,4-dien-3-ones **2** with hydroxylamine in similar conditions, using ethanol as a solvent in microwave heating, as an alternative route for the synthesis of styrylisoxazoles. Under these conditions, the main product formed in the reaction was the corresponding oxime that can be further cyclized to give the expected styrylisoxazoline **4**.

In this communication, will be discussed the reactivity of these two important scaffolds **1** and **2** with hydroxylamine hydrochloride, as well as the electronic and steric effect of the different substituents on the reactivity. All the obtained compounds were characterized by NMR.

In the near future, *in vitro* studies will be performed to assess the activity of compounds **3** and **4** (figure 1) as acetylcholinesterase and butyrylcholinesterase inhibitors, using Ellman's method, to evaluate their potential as anticholinergic drugs.

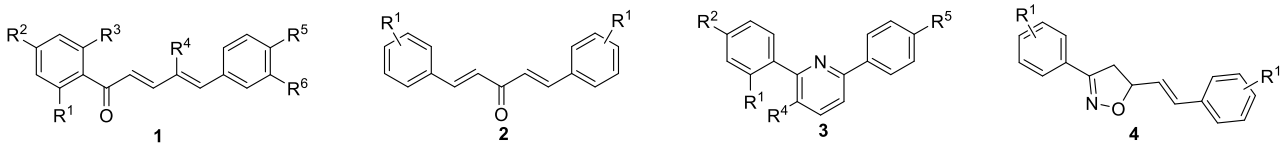


Figure 1: Structures of (2*E*,4*E*)-1,5-diarylpenta-2,4-dien-1-ones **1**, (1*E*,4*E*)-1,5-diarylpenta-1,4-dien-3-ones **2**, diarylpyridines **3** and styrylisoxazolines **4**.

Acknowledgements

Thanks are due to the University of Aveiro and FCT (Fundação para a Ciência e a Tecnologia), the European Union, QREN, FEDER, and COMPETE for funding the LAQV-REQUIMTE (UIDB/50006/2020+ UIDP/50006/2020) and to the Portuguese NMR Network (PT NMR) partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). Vera L.M. Silva thanks funding through FCT under the Scientific Employment Stimulus – Institutional Call – reference CEECINST/00026/2018. RFM gratefully acknowledges FCT for a Junior Research Position (CEECIND/00553/2017).

Funding

This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project units UIDB/50006/2020 and UIDP/50006/2020 (LAQV-Requimte). This work was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC).

References

1. P. Varandas, D. Rocha, F. Paz, E. Silva and A. Silva, *Synthesis*, 2018, **50**, 1965–1972.
2. Q. Li, J. Zhang, L. Z. Chen, J. Q. Wang, H. P. Zhou, W. J. Tang, W. Xue and X. H. Liu, *J Enzyme Inhib Med Chem*, 2018, **33**, 130–138.
3. N. Agrawal and P. Mishra, *Med Chem Res*, 2018, **27**, 1309–1344.
4. O. B. Bondarenko and N. V. Zyk, *Chem Heterocycl Comp*, 2020, **56**, 694–707.

Synthesis of steroid-quinoline hybrids with donor-acceptor architectures

Lúcia Melo*, Artur M. S. Silva, Hélio M. T. Albuquerque

LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
** luciacruzmelo@ua.pt*

Alzheimer's disease (AD), which is the most common form of neurodegenerative dementia, leads to memory loss as well as other cognitive functions impairments.[1] There are currently no disease modifying therapies available, and those that are accessible for general population had quite limited efficacy.[2] Therefore, the search for effective alternative disease-modifying alternative therapies as well as efficient early-stage AD diagnostic techniques is highly desirable.[2] In the last few years, steroids have become interesting compounds that target not only the aggregation of amyloid-β (Aβ), but also other protein aggregation processes.[3] In 2022, our research group disclosed a new set of steroid-quinoline hybrids (Figure 1) capable to disrupt and reverse protein aggregation processes, including the Aβ fibrillation both *in vitro* and in cell models.[3] As these compounds were capable to interact with Aβ peptide, the installation of near-infrared fluorescent (NIRF) units in their scaffold would be quite looked-for in order to develop theranostic tools capable to deliver therapeutic and diagnostic responses simultaneously. Herein, the design, synthesis and NMR structural characterization of steroid-quinoline compounds with donor-acceptor (D-A) architectures will be disclosed (Figure 1).

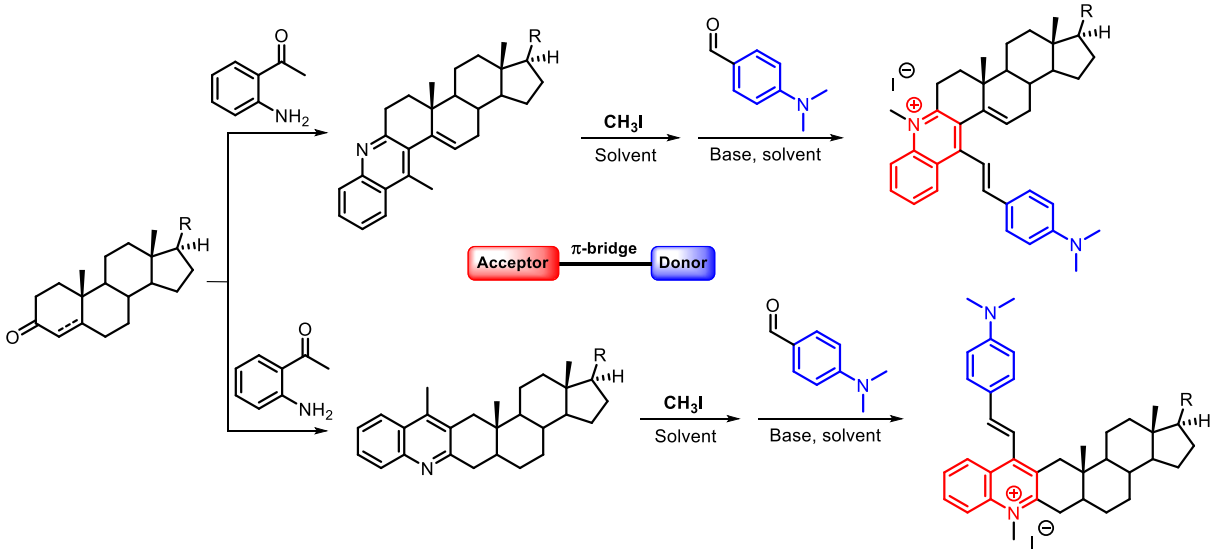


Figure 1: Synthesis of steroid-quinoline compounds with donor-acceptor architectures.

Acknowledgements
This work received financial support from PT national funds (OE) through FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) within the projects: LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), and MuTaTher-AD—"Multi-target theranostics for Alzheimer's disease" (2022.06064.PTDC).

References

1. Y. Li, C. Chen, D. Xu, C.-Y. Poon, S.-L. Ho, R. Zheng, Q. Liu, G. Song, H.-W. Li and M. S. Wong, *ACS Omega*, 2018, 3, 6812–6819.
2. J. Yang, F. Zeng, Y. Ge, K. Peng, X. Li, Y. Li and Y. Xu, *Bioconjugate Chem.*, 2019, 31, 2–15.
3. H. M. T. Albuquerque, R. Nunes Da Silva, M. Pereira, A. Maia, S. Guieu, A. R. Soares, C. M. M. Santos, S. I. Vieira and A. M. S. Silva, *ACS Med. Chem. Lett.*, 2022, 13, 443–448.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Tuning the sign and magnitude of pK_a shift in cucurbit[7]uril host-guest complexes by molecular engineering

A. Trevisan[1,*], A. S. Ferreira[1], P. Marrec[2], A. J. Parola[1], N. Basílio[1]

[1]*Laboratório Associado para a Química Verde (LAQV), Rede de Química e Tecnologia (REQUIMTE), Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal*
[2]*LCR Hallcrest Ltd., Riverside Buildings, Connah's Quays Road, Connah's Quays CH5 4DS, United Kingdom*
**a.trevisan@fct.unl.pt*

Cucurbit[*n*]uril homologues (CB*n*) are highly symmetric structures with negatively charged carbonyl rims and a hydrophobic cavity:[1] They became popular macrocyclic receptors in supramolecular chemistry owing to their ability to recognize complementary guest molecules with high affinity in aqueous environments. CB*n* selectively bind positively charged guest molecules, including ionizable ammonium cations which frequently display much higher affinity than their neutral counterparts. This selectivity for the protonated species is translated into an increase in the basicity of encapsulated guest (i.e., into complexation-induced positive pK_a shifts). In other words, CB*n* stabilize the protonated form of guest molecules and then increase the pK_a value of the conjugate acids of amines (positive pK_a shifts).[2,3,4]
However, despite being very rare, negative pK_a shifts can be observed for specific guests. Following a previous work from our group[5] reporting slightly negative pK_a shifts for flavylium and chalcone dyes featuring *N*-diethylamino substituents (ΔpK_a = − 0.2), herein we report a systematic study on the complexation of *N*-dialkylaminochalcones with CB7. The results show that the pK_a shifts of these host-guest complexes can be rationally tuned by the nature of the *N*-dialkylamino groups and as well by target substitutions on the skeleton of the dye, allowing design of a CB7 1:1 host-guest complex with a ΔpK_a = − 0.6 (Figure 1).

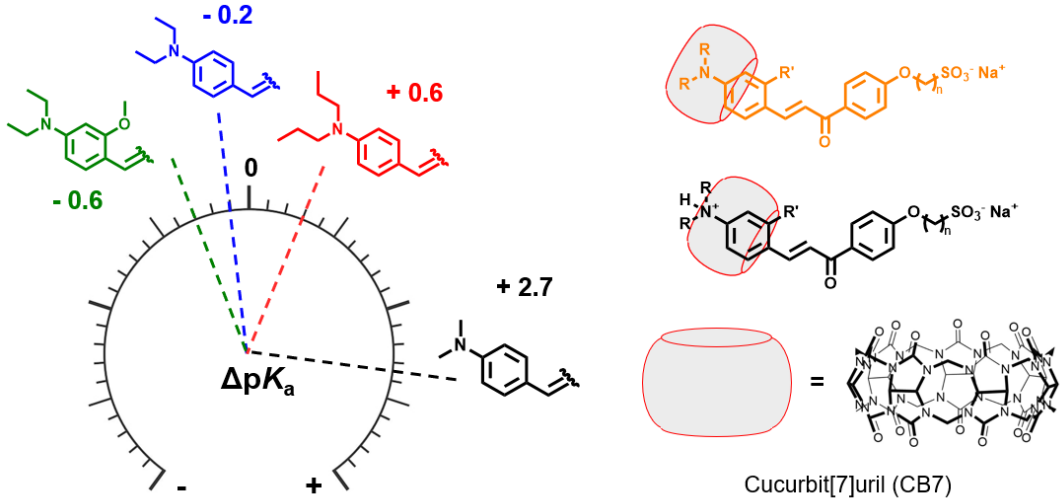


Figure 1: Schematic representation of the complexations of *N*-dialkylaminochalcones with CB7 and their corresponding pK_a shifts observed by our group.

Acknowledgements
This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement N° 814299 - CHARISMA.
This work was supported by the Associate Laboratory for Green Chemistry LAQV, which is financed by national funds from FCT/MCTES. FCT/MCTES is also acknowledged for the CEECIND/00466/2017 research contract (N.B.).

References
1. K. I. Assaf and W. M. Nau, *Chem. Soc. Rev.*, 2015, **44**, 394–418.
2. I. Ghosh and W. M. Nau, *Adv. Drug Deliv. Rev.*, 2012, **64**, 764–783.
3. N. Barooah, M. Sundararajan, J. Mohanty and A. C. Bhasikuttan, *J. Phys. Chem. B*, 2014, **118**, 7136–7146.
4. N. Saleh, A. R. B. Suwaid, A. Alhalabi, A. Z. A. Abuibaid, O. V. Maltsev, L. Hintermann and P. Naumov, *J. Phys. Chem. B*, 2016, **120**, 7671–7680.
5. N. Basílio, S. Gago, A. J. Parola and F. Pina, *ACS Omega*, 2017, **2**, 70–75.

Advances in platinum(II)-based chlorins: Scale-up, chemical modulation and photodynamic activity

Alfredo Bartolomeu[1,*], Américo J. S. Alves[1], Gabriela Correia-Barros[2], Susana M. M. Lopes[1], Mafalda Laranjo[2], Marta Pineiro[1], M. Filomena Botelho[2], Teresa M. V. D. Pinho e Melo[1]

[1]University of Coimbra, Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS) and Department of Chemistry, Portugal; [2]University of Coimbra, Coimbra Institute for Clinical and Biomedical Research (iCBR) area of Environment Genetics and Oncobiology (CIMAGO), Institute of Biophysics, Faculty of Medicine, Coimbra, Portugal, University of Coimbra, Center for Innovative Biomedicine and Biotechnology (CIBB), Coimbra, Portugal and Clinical Academic Centre of Coimbra (CACC), Coimbra, Portugal
**abartolomeu1@gmail.com*

Photodynamic therapy (PDT) is a promising therapeutic approach that combines the use of light, photosensitizing agents and molecular oxygen to selectively target and destroy cancer cells or other diseased tissues. Platinum(II) 4,5,6,7-tetrahydropyrazolo[1,5-*a*]pyridine-fused chlorins are a type of porphyrin-based photosensitizer that possess unique structural and chemical properties. These molecules exhibit a strong absorbance in the red region of the electromagnetic spectrum and good ROS production yields. Furthermore, their versatility extends beyond their excellent photodynamic activity, as they can also be used for tumor imaging and as oxygen sensors, making them remarkable theranostic agents for cancer.[1,2]

In this communication we describe scale-up studies aiming at the gram-scale preparation of sulfone **1**, the precursor of dipolar specie **2**, which allowed the subsequent gram-scale synthesis of chlorin diester **2**, via [8π+2π] cycloaddition reaction. The successful scale-up synthesis of both sulfone **1** and chlorin diester **2** represents significant progress towards the sustainable production of our lead compound ($R^1 = R^2 = CH_2OH$). In the pursuit of novel and more potent derivatives, chlorin monoester (R^1 = H and $R^2 = CO_2Me$) was also synthesized. Further transformations involved the reduction of chlorin ester derivatives to the corresponding alcohols, followed by an oxidation step in the presence of Dess-Martin periodinane. As a result, a novel class of platinum(II) chlorins, containing aldehyde moieties, was successfully obtained in excellent overall yields. The inclusion of an aldehyde moiety within the chlorin structure serves also as a versatile starting point for further synthetic transformations. The novel chlorins were assayed for their *in vitro* photodynamic activity, providing relevant structure-activity relationships. Further details of this study will be disclosed.

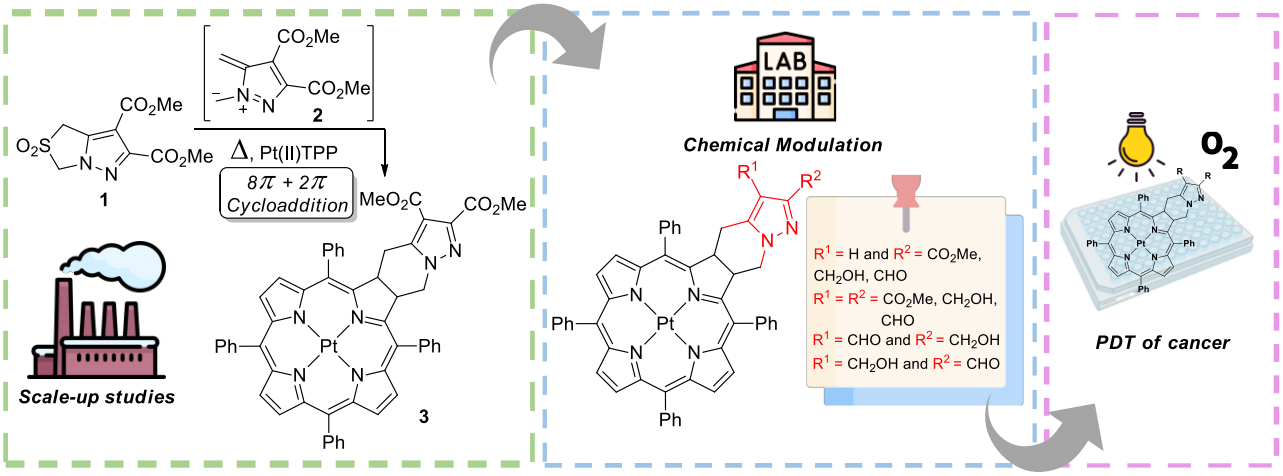


Figure 1: Novel platinum(II) ring-fused chlorins for PDT of cancer.

Acknowledgements
We thank Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS) supported by the Portuguese Agency for Scientific Research, FCT through projects UIBD/00313/2020 and UIDP/00313/2020 (National Funds) and the IMS special complementary funds provided by FCT. This work was also supported by the FEDER, through CENTRO2020, in the scope of the Proof-of-Concept Project THERABULLET, under Grant CENTRO-01-0145-FEDER-180078 and by Project PTDC/QUI-QOR/0103/2021, funded by national funds (PIDDAC) via FCT. Alfredo Bartolomeu thanks Fundação Calouste Gulbenkian for his PhD Grant (2020 edition). We also acknowledge the UC-NMR facility for producing the NMR data (www.nmrccc.uc.pt) and PorphyChem SAS for the support in the scale-up studies.

References
1. N. A. M. Pereira, M. Laranjo, *et al.*, *ACS Med. Chem. Lett.*, 2017, **8**, 310-315.
2. M. Laranjo, M. C. Aguiar, N. A. M. Pereira, *et al.*, *Eur. J. Med. Chem.*, 2020, **200**, 112468.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Stable Al(III) complexes of a water-soluble Schiff base: overcoming hydrolysis for improved water stability

Hajer Bouznif[1,2,*], Licínia L. G. Justino[2], Maria I. L. Soares[2], Telma Costa[2], M. Luísa Ramos[2], Teresa M. V. D. Pinho e Melo[2], Nabil Zouari[1], Rui Fausto[2,3]

[1]*Laboratory Physico-Chemistry of the Solid State, Department of Chemistry, Faculty of Sciences of Sfax, B. P. 1171, Sfax 3000, University of Sfax, Tunisia;* [2]*CQC-IMS, Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal;* [3]*Faculty of Sciences and Letters, Department of Physics, Istanbul Kultur University, Ataköy Campus, Bakirköy 34156, Istanbul, Turkey*
**bouznifhajer13@gmail.com*

Aluminum, the most abundant metal in the Earth's crust and a biological non-essential element, is widely used in industry and daily life in applications such as water treatment systems, food additives, cosmetics, packaging materials, and pharmaceutical drugs.[1,2]
Although the *N*,*N*′-ethylenebis(salicylimine) (salen) chelating double Schiff base ligand and its derivatives are probably amongst the most extensively investigated ligands (*e.g.*, they have been used to build interesting functional metal-organic frameworks (MOFs)), there is an increasing demand to use metal-salen complexes in aqueous systems due to the current upswing in aqueous organometallic catalysis. However, this is frequently hampered by the complexes' insolubility in water. A possible solution to this problem is the attachment of ionic or highly polar substituents (such as sulfonate, carboxylate, ammonium, or phosphonium) to the salen ligands.[3,4] Even so, the imine-type ligands' hydrolytic instability continues to be a significant barrier to their application in aqueous conditions, since it has been conclusively proven that prolonged use of metal-salen complexes in aqueous reaction mixtures causes their breakdown via hydrolysis.[4,5] Moreover, it was soon found that the literature data was oddly inconsistent, and that some Schiff bases undergo hydrolysis faster than anticipated. The effect of water turned out to be unexpected.[5]
Therefore, we optimized the synthetic conditions and obtained a water-soluble Schiff base *N*,*N'*-bis(3-methoxyl-5-sulfonatosalicylidene)-1,2-ethylenediamine disodium salt (abbreviated as MSS), prepared by condensing 3-methoxyl-salicylaldehyde-5-sulfonate sodium and 1,2-ethylenediamine. Special attention was given to the investigation of the phenol-imine (O-H···N) // keto-amine (O···H-N) equilibrium of MSS in solutions of different solvents. The Schiff base ligand MSS was then employed to synthesize novel Al(III) complexes in non-aqueous media. All the studied compounds were investigated by carrying out elemental analysis, and NMR, UV/vis and ATR-FTIR spectroscopies, complemented with density functional theory (DFT) and time-dependent DFT calculations.

Acknowledgements
The Coimbra Chemistry Centre-Institute of Molecular Sciences (CQC-IMS) is supported by FCT through projects UIDB/00313/2020, UIDP/00313/2020 and LA/P/0056/2020. The authors also thank the Laboratory for Advanced Computing at University of Coimbra for providing computing resources that have contributed to the research results reported (https://www.uc.pt/lca) and the UC-NMR facility which is supported in part by FEDER through the COMPETE Program and by National Funds from FCT through grants REEQ/481/QUI/2006, RECI/QEQ-QFI/0168/2012, CENTRO-07-CT62-FEDER-002012, and Rede Nacional de Ressonância Magnética Nuclear (RNRMN).

References

1. B. Naskar, R. Modak, Y. Sikdar, D. K. Maiti, A. Bauzá, A. Frontera, A. Katarkar, K. Chaudhuri and S. Goswami, *J. Sens. Actuators B*, 2017, **239**, 1194.
2. K. Boonkitpatarakul, J. Wang, N. Niamnont, B. Liu, L. Mcdonald, Y. Pang and M. Sukwattanasinitt, *J. Am. Chem. Soc. Sens.,* 2016, **1**, 144.
3. I. Correia, J. C. Pessoa, M. T. Duarte, M. F. M. da Piedade, T. Jackush, T. Kiss, M. M. C. A. Castro, C. F. G. C. Geraldes and F. Avecilla, *Eur. J. Inorg. Chem.*, 2005, **4**, 732.
4. N. Shahnaz, A. Puzari, B. Paul and P. Das, *Catal. J. Commun.*, 2016, **86**, 55.
5. K. Bakalorz, Ł. Przypis, M. M. Tomczyk, M. Książek, R. Grzesik and N. Kuźnik, J., *Molecules,* 2020, **25**, 1257.

Development of hybrid-based layered molybdenum disulfide for SERS applications

Beatriz Sousa*, Sara Fateixa, Tito Trindade

Department of Chemistry and CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal
*beatrizpintosousa@ua.pt

Two-dimensional (2D) semiconductor materials, such as molybdenum disulfide (MoS_2), have attracted significant attention due to their properties, including layered crystalline structure, band gap energy dependent on the number of layers and a large specific surface area prone to chemical functionalization, making them excellent platforms for optical sensing applications.[1,2] The combination of layered materials with metal nanoparticles (MNPs) allows the fabrication of new materials that can be active in surface-enhanced Raman scattering (SERS), thus with the potential to detect a variety of biomolecules by such spectroscopic method.[3,4]

Herein, we report our research on developing materials containing MNP deposited on MoS_2 sheets prepared by the hydrothermal method. Several experimental parameters were investigated to optimize the SERS performance of Au/MoS_2 hybrid substrates to detect RhB, including the metal deposition method (spin coating and dip coating) and the nature of the support (Si wafers or Au wafers). The higher Raman signal for RhB was observed for the MoS_2 deposited on Au wafers. Preliminary results on the immobilization of lactate dehydrogenase (LDH) to optimize the detection of lactate, a biomarker used for sport performance monitoring, using MoS_2/Au wafer as SERS substrate will also be addressed.

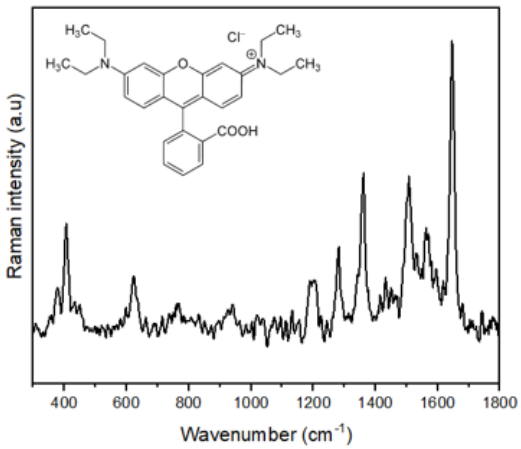


Figure 1: SERS spectrum of RhB molecules adsorbed on MoS_2/Au wafers; Inset: RhB structure.

Acknowledgements
This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC) and when appropriate cofinanced by FEDER under the PT2020 Partnership Agreement. S. F. thanks FCT for her research contract (REF-069-88-ARH-2018), which is funded by national funds (OE), through FCT-Fundação para a Ciência e aTecnologia, I.P.

References
1. Y. Liu, Z. Qin, J. Deng, J. Zhou, X. Jia, G. Wang, F. Luo, *Chemosensors* **2022**, 10, 455.
2. M. Chen, D. Liu, X. Du, K. H. Lo, S. Wang, B. Zhou, H. Pan, *Trends in Analytical Chemistry* **2020**, 130.
3. K. Lv, H. Si, J. Liu, T. Zhu, Y. Xia, S. Chen, Y. Zhao, C. Yang, *Journal of Alloys and Compounds* **2020**, 846.
4. S. Fateixa, H. I. S. Nogueira, T. Trindade, Phys. Chem. Chem. Phys. **2015**, 17, 21046.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Endoperoxide–pyrazole hybrids: synthesis, structure and antiparasitic properties

Inês C. C. Costa[1,2,*], Patrícia S. M. Amado[1,2], José A. Paixão[3], Ricardo F. Mendes[4], Ana Candido[5], Denise Duarte[5], Sofia Cortes[5], Fátima Nogueira[5], Maria L. S. Cristiano[1,2]

[1]Center of Marine Sciences, CCMAR, Gambelas Campus, University of Algarve, UAlg, 8005-139 Faro, Portugal, [2]Department of Chemistry and Pharmacy, Faculty of Sciences and Technology, FCT, Gambelas Campus, University of Algarve, UAlg, 8005-139 Faro, Portugal, [3]CFisUC, Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal, [4]CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal, [5]Global Health and Tropical Medicine-GHTM, Instituto de Higiene e Medicina Tropical-IHMT, Universidade Nova de Lisboa-NOVA, 1349-008 Lisboa, Portugal,
**a52917@ualg.pt*

Leishmaniases are parasitic diseases that mostly affect poor populations of countries with precarious healthcare infrastructure.[1] The standard antileishmanial chemotherapy relies on repurposed drugs, however the applicability of these drugs is limited by serious drawbacks, including high cost, need for long-term treatments, severe toxicity and painful mode of administration, in addition to loss of efficacy due to emerging resistance.[2] Within the drug repurposing concept, endoperoxides, a class of antimalarials, emerge as a useful alternative to fight leishmaniases.[3,4] The "molecular hybridization" strategy has also attracted the interest of medicinal chemists, who envisage the combination of various pharmacophores into one hybrid structure. It is expected that novel hybrid molecules present benefits such as better efficacy, improved safety, cost-effectiveness, and less vulnerability to resistance selection than the parent drugs. Endoperoxides can be linked to other biologically active moieties, and the pyrazole motif could be of interest since pyrazoles revealed potential as antiparasitic[5] agents. Pyrazoles exhibit prototropic tautomerism, due to the possibility of 1,2-H shifts between the two vicinal nitrogen atoms, enabling the formation of distinctive pyrazole-based structures with diverse reactivities, properties and biological activities.[6,7]

We report the synthesis and structure elucidation of trioxolane–pyrazole (OZ1, OZ2) and tetraoxane–pyrazole (T1, T2) hybrids, obtained from amide coupling of 3(5)-aminopyrazole with endoperoxide building blocks, and of their respective salts. Applying the synthetic approach depicted in Figure 1, conjugates OZ2 and T2 were obtained with better yields than OZ1 and T1. These results can be explained by the structural evidence gathered from a previous study on the prototropic tautomerism in 3(5)-aminopyrazoles, where tautomer 3-aminopyrazole proved more stable than its 5-aminopyrazole tautomer, the most reactive in the synthesis. All compounds were evaluated *in vitro* for their antileishmanial activity against *L. tropica* and *L. infantum promastigotes,* and for cytotoxicity against THP-1 cells. Biological evaluations in promastigotes showed that compound **OZ1•HCl** was the most active against both strains, and against *L. infantum* amastigotes (IC_{50} values (87 µM)).[8] Interestingly, **OZ1•HCl** showed excellent *in vitro* activity against the 3D7-GFP and IPC5202 strains of *P. falciparum,* with IC_{50} values of 2.19 nM and 12.30 nM, respectively.

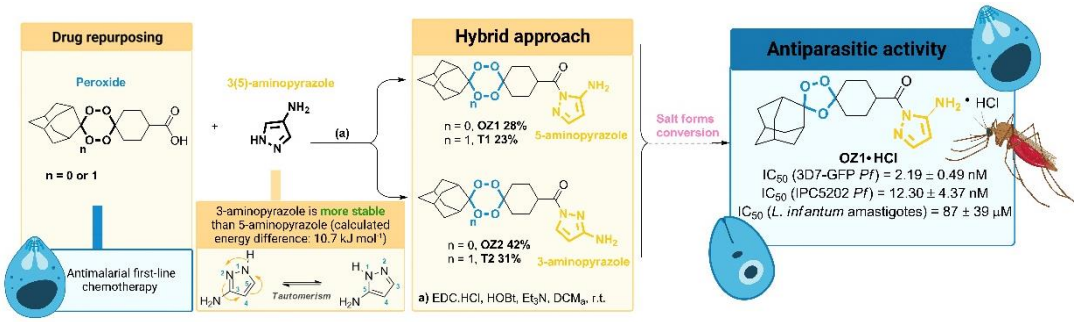


Figure 1: Representative structures of 1,2,4,5-tetraoxane-3-aminopirazole hybrids reported in this study.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for Grant SFRH/BD/08242/2020 (ICCC) and projects UID/MULTI/04326/2021 (CCMAR), UIDB/04564/2021 (CFisUC); CRESC Algarve 2020 and COMPETE 2020, for project EMBRC.PT ALG-01-0145-FEDER-022121.

References

1. Tiuman, T. S. et al. Int. J. Infect. Dis. **15**, e525–e532 (2011).
2. Chakravarty, J. et al. Expert Opin. Pharmacother. **20**, 1251–1265 (2019).
3. Cabral, L. I. L. et al. Mol. **5**, 465 (2020).
4. Cortes, S. et al. Antimicrob. Agents Chemother. **59**, 5032–5035 (2015).
5. Camargo, J. do N. A. et al. Front. Pharmacol. **11**, (2020).
6. Secrieru, A.; Lopes, S.; Cristiano, M. L. S. Mol. **26**, 4299 (2021).
7. Secrieru, A. et al. Mol. **25**, 42 (2020).
8. Amado, P. S. M. et al. Mol. **27** (17), 5401 (2022).

Edible flowers rich in anthocyanins: biochemistry and biotechnology towards an emerging, healthier, and sustainable diet

Margarida Teixeira*, Nuno Mateus, Victor de Freitas, Hélder Oliveira

REQUIMTE/LAQV, Chemistry and Biochemistry Department, Faculty of Sciences, University of Porto, Portugal
**up202103465@edu.fc.up.pt*

There has been a noticeable global shift in dietary patterns driven by increased awareness and understanding of the impact of food choices on overall health and well-being. As a result, there is a growing demand for functional foods that go beyond basic nutrition and offer additional health benefits. Edible flowers (EFs), known for their medicinal properties since ancient times, are now making a comeback in contemporary cuisine.[1]
In addition to their aesthetic appeal, EFs also provide nutritional advantages. They generally have a favorable nutritional composition and contribute to a low-calorie intake.[2] EFs are rich in natural phytochemicals, some of which with a high level of anthocyanins that give flowers their red, purple, and blue colors. Numerous EFs contain polyglycosylated and polyacylated anthocyanins, which are renowned for their intricate molecular structures. Moreover, due to their structural characteristics, these compounds have been implied in several health benefits. Several well-researched EF species have demonstrated both preventive and treatment potential against various prevalent diseases. Consequently, EFs should be considered a valuable addition to our everyday diet, going beyond their traditional role as mere garnishes in gourmet cuisine.[3]
Health benefits highly depend on the metabolism and bioavailability, as well as bioaccessibility, of the EFs anthocyanins, as they are the key factors for these compounds to exert their physiological effects.[4]
Hence, acquiring a deeper comprehension of the alterations in bioaccessibility and bioavailability after the ingestion of EFs can illuminate the intricate mechanisms entwined with their health-promoting attributes. Such insights hold the potential to advocate for the incorporation of EFs abundant in anthocyanins within our daily dietary regimens, thereby accentuating the inherent nutritional worth of this source of sustenance.
The aim of this work was to explore the anthocyanin content in some EFs (*Viola tricolor*, *Cosmos bipinnatus, Centaurea cyanus* and *Clitoria ternatea*), as well as their bioaccessibility through a range of different approaches. All the species presented polyglycosylated anthocyanins with different degrees of complexity and substitution patterns. The stability assays were performed by varying factors such as temperature, pH, and time. The results showed that depending on the species, different factors have a specific impact, prompting for the effects of different cooking techniques on the content of such bioactives. Considering the effects of food matrices, including proteins and starch, the presence of both affected the anthocyanin content of the EFs in distinct ways for all the pH values tested. Finally, simulated digestions were performed according to INFOGEST and revealed that overall, a pronounced decrease in the anthocyanin content was observed after the intestinal phase. Furthermore, the cytotoxicity of the extracts was evaluated to determine the ideal conditions to perform *in vitro* transepithelial absorption studies using gastrointestinal cell models.
These preliminary results suggest that the structural differences in the anthocyanins present in different EFs, may have a great impact on their stability and behavior towards the cooking and gastrointestinal processes prior to their absorption as bioactive compounds.

Acknowledgments
The authors acknowledge the national funds provided to the development of this work, by Fundação para a Ciência e Tecnologia (FCT) under the scope of the project “AnthoE.Flos” (2022.01014.PTDC).

References

1. Rivas-García, L.; Navarro-Hortal, M. D.; Romero-Márquez, J. M.; Forbes-Hernández, T. Y.; Varela-López, A.; Llopis, J.; Sánchez-González, C.; Quiles, J. L., Edible flowers as a health promoter: An evidence-based review. *Trends in Food Science & Technology* **2021,** *117*, 46-59.
2. Kumari, P.; Ujala; Bhargava, B., Phytochemicals from edible flowers: Opening a new arena for healthy lifestyle. *Journal of Functional Foods* **2021,** *78*.
3. He, J.; Ye, S.; Correia, P.; Fernandes, I.; Zhang, R.; Wu, M.; Freitas, V.; Mateus, N.; Oliveira, H., Dietary polyglycosylated anthocyanins, the smart option? A comprehensive review on their health benefits and technological applications. *Compr Rev Food Sci Food Saf* **2022,** *21* (4), 3096-3128.
4. Cosme, P.; Rodríguez, A. B.; Espino, J.; Garrido, M., Plant Phenolics: Bioavailability as a Key Determinant of Their Potential Health-Promoting Applications. *Antioxidants* **2020,** *9* (12), 1263.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of alginate-based bioinks with curcumin loaded cellulose particles for 3D-bioprinting of drug-releasing living structures

João P. F. Carvalho[1,*], Maria C. Teixeira[1], Nicole S. Lameirinhas[1], Filipe S. Matos[1], Jorge L. Luís[1,2], Liliana Pires[1,2], Helena Oliveira[3], José M. Oliveira[1,2], Armando J. D. Silvestre[1], Carla Vilela[1], Carmen S. R. Freire[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]EMaRT Group - Emerging: Materials, Research, Technology, School of Design, Management and Production Technologies Northern Aveiro, University of Aveiro, 3720-511 Oliveira de Azeméis, Portugal
[3]Department of Biology & CESAM, University of Aveiro, 3810-193 Aveiro, Portugal
**joao.pedro.carvalho@ua.pt*

3D printing has impacted many scientific domains by allowing the layer-by-layer construction of complex structures in a versatile and controlled way. In the biological field, the possibility of creating an artificial living structure through 3D bioprinting is fascinating, but also very challenging. In 3D bioprinting, the so-called bioinks must have the appropriate rheological properties to be extruded and to originate stable structures, but they should also be biocompatible and protect encapsulated cells from the forces applied during the printing process.[1] Therefore, different types of bioinks have been developed. Biopolymeric hydrogels are of particular relevance in this area because they mimic the native cellular microenvironment, while also being biocompatible and biodegradable.[2] However, these hydrogels often reveal inadequate mechanical properties, stability or printability, and so they must be combined with other polymers or with different (nano)structures to circumvent such limitations.[3]

In this work, spherical particles based on cellulose derivatives (cellulose acetate and cellulose nitrate), with diameters of 740 ± 147 nm, were used to enhance the rheological and mechanical properties of alginate hydrogels and their printability, and to grant alginate hydrogels with the ability to release active molecules (e.g., drugs or bioactive compounds). In this case, curcumin was chosen as a low water soluble model-drug and encapsulated in the cellulose-based spherical particles. When combined with HaCaT keratinocyte cells, the resulting composite hydrogels became versatile bioinks with enhanced rheological features (namely shear viscosity and stress) and improved 3D printability (Pr = 0.9), which can be used to fabricate drug-releasing tissue constructs for wound healing and skin regeneration. These constructs were able to release curcumin, with a 70% cumulative release achieved in phosphate buffered saline (PBS, pH 7.4) at 37 ºC after 24 h. Moreover, the resulting fully crosslinked composite hydrogels kept their previous mechanical and viscoelastic properties regardless of the addition of particles, and showed lower degradation rates than that of pristine alginate in culture medium after 3 days.

The curcumin-loaded cellulose-based particles and the composite hydrogel formulations also showed no significant cytotoxicity against HaCaT cells, as assessed for up to 72 h using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay. In fact, the 3D bioprinting of the composite bioinks loaded with HaCaT cells (1.2×10^6 cells mL^{-1}) originated living structures that preserved high cell viability (nearly 90%) for up to 7 days, confirming the potential of these formulations for the creation of tissue analogues with drug-releasing abilities that could constitute a new approach for tissue regeneration (viz. wound healing) applications.

Acknowledgements
This work was developed within the scope of the projects CICECO—Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) and CESAM (UIDP/50017/2020 & UIDB/50017/2020 & LA/P/0094/2020), financed by national funds through the FCT/MEC (PIDDAC), and financially supported by the project I&D "NANOBIOINKS-Engineering bio-based nanofibers for the development of high-performance nanostructured bioinks for 3-D bioprinting, CENTRO-01-0145-FEDER-031289" funded by the Operational Program of the Center Region, in its FEDER/FNR component, and by national funds (OE), through FCT/MCTES. FCT is acknowledged for the doctoral grants to J.P.F.C (2020.09018.BD) and N.S.L. (SFRH/BD/140229/2018) and the research contracts under Scientific Employment Stimulus to C.S.R.F. (CEECIND/00464/2017), C.V. (CEECIND/00263/2018 and 2021.01571.CEECIND) and H.O. (CEECIND/04050/2017).

References
1. S. Bom, R. Ribeiro, H. M. Ribeiro, C. Santos and J. Marto, *Int. J. Pharm.*, 2022, **615**, 121506.
2. M. C. Teixeira, N. S. Lameirinhas, J. P. F. Carvalho, A. J. D. Silvestre, C. Vilela and C. S. R. Freire, *Int. J. Mol. Sci.*, 2022, **23**, 6564.
3. Y. Cai, S. Y. Chang, S. W. Gan, S. Ma, W. F. Lu and C.-C. Yen, *Acta Biomater.*, 2022, **151**, 45–69.

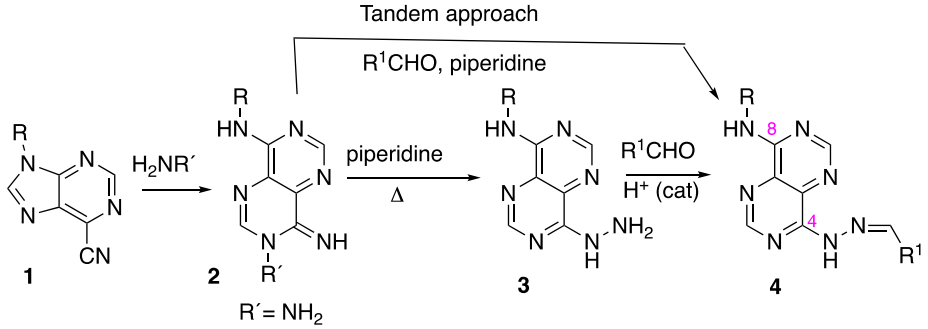
Synthesis of 4-hydrazone-pyrimido[5,4-*d*]pyrimidine derivatives via a cascade reaction

A. Rocha, A. Lopes*, S. Teixeira, M. A. Carvalho

Departamento de Química, Centro de Química da Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal
**pg33722@alunos.uminho.pt*

Pyrimido[5,4-*d*]pyrimidine is a heterocycle with important biological activity. Dipyridamole is used in clinic as a coronary vasodilator, with antithrombotic and stroke-preventing effects. It is also recognised as an inhibitor of platelet activation and aggregation[1-3]. Besides inhibits lipid peroxidation and is a hydroxyl radical/ superoxide scavenger[4]. Literature refers to pyrimido[5,4-*d*]pyrimidine compounds with anticancer activity[5-7], antituberculosis activity[8], and also as GPR119 agonists for type II diabetes treatment[9], modulators of nucleoside transporters with the potential to act in cardiovascular, and inflammatory-infectious diseases[10-12]. Recently our research group identified pyrimido[5,4-*d*]pyrimidines with antituberculosis activity and as a new promising class of agents to combat sleeping sickness and leishmania, compounds **4**[8,13]. The activity depends on the substituents around the central nucleus, and efficient methods to generate the target molecules are needed. The initial method to generate the compounds involves a multi-sequential approach starting on 6-cyanopurines (Scheme 1). This approach has an intermediate, compound **3**, whose synthesis constitutes a challenge.

In this work, we will present a general method to obtain compounds **3** efficiently, which enables synthesizing high diversity of compounds **5**. It will also be presented a new approach involving a cascade reaction that allows obtaining compounds **5** without the isolation of **3** in a proficient way.



Scheme 1: Approaches for the synthesis of 4,8-disubstituted-pyrimido[5,4-*d*]pyrimidines **4**

Acknowledgements
This work was supported by Fundação para a Ciência e Tecnologia with funds in the framework of the Strategic Funding of CQUM (UID/QUI/00686/2020), (UID/QUI/ 00686/2018) and Rede Nacional de RMN (PINFRA/22161/ 2016).

References

1. Y. B. J. Aldenhoff, L. H. Koole, J. Biomed. Mater. Res. 1995, **29**, 917–928.
2. L. Jones, S. Griffin, S. Palmer, C. Main, V. Orton, M. Sculpher, C. Sudlow, R. Henderson, N. Hawkins, R. Riemsma, Health Technol. Assess. (Rockv). 2004, **8**, 1–198.
3. S. Chakrabarti, J. E. Freedman, Vascul. Pharmacol. 2008, **48**, 143–149.
4. L. Iuliano, D. Pratico, A. Ghiselli, M. S. Bonavita, F. Violi, Lipids 1992, **27**, 349–353.
5. A. Virgilio, D. Spano, V. Esposito, V. Di Dato, G. Citarella, N. Marino, V. Maffia, D. De Martino, P. De Antonellis, A. Galeone, M. Zollo, Eur. J. Med. Chem. 2012, **57**, 41–50.
6. G. W. Rewcastle, A. J. Bridges, D. W. Fry, J. R. Rubin, W. A. Denny, J. Med. Chem. 1997, **40**, 1820–1826.
7. I. Dakhlaoui, S. Vahdati, E. Maalej, F. Chabchoub, M. Wiese, J. Marco-Contelles, L. Ismaili, Bioorg. Chem. 2021, **116**, 105326.
8. A. H. Bacelar, M. A. Carvalho, M. F. Proença, Eur. J. Med. Chem. 2010, **45**, 3234–3239.
9. Y. Fang, J. Xu, Z. Li, Z. Yang, L. Xiong, Y. Jin, Q. Wang, S. Xie, W. Zhu, S. Chang, Bioorg. Med. Chem. 2018, **26**, 4080–4087.
10. K. Saravanan, H. C. Barlow, M. Barton, A. H. Calvert, B. T. Golding, D. R. Newell, J. S. Northen, N. J. Curtin, H. D. Thomas, R. J. Griffin, J. Med. Chem. 2011, **54**, 1847–1859.
11. W. Lin, J. K. Buolamwini, Bioconjug. Chem. 2011, **22**, 1221–1227.
12. N. J. Curtin, H. C. Barlow, K. J. Bowman, a H. Calvert, R. Davison, B. T. Golding, B. Huang, P. J. Loughlin, D. R. Newell, P. G. Smith, R. J. Griffin, J. Med. Chem. 2004, **47**, 4905–4922.
13. A. Lopes, N. Santarém, A. Cordeiro-da-Silva, M. A. Carvalho, ACS Med. Chem. Lett. 2022, **13** (9), 1427-1433.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A data-driven approach to unveil the reactivity of MXene-based catalysts for the water gas shift reaction

K. Iben Nassar[1,*], J. D. Gouveia[1], T. L. P. Galvão[2], J. R. B. Gomes[1]

[1]*CICECO-Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Portugal*
[2]*CICECO-Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, University of Aveiro, Portugal*
**kais.nassar@ua.pt*

MXenes, two-dimensional few-layered transition-metal nitrides and carbides, with general formula $M_{n+1}X_nT_x$ (M is an early transition metal, n = 1-4, X is C and/or N and T_x is the surface termination), possess substantial surface areas and distinctive physicochemical features, which make them interesting for applications in areas as waste water treatment, energy storage, gas sensing or catalysis.[1]
In the past few years, we have developed several computational studies based on the density functional theory (DFT) to understand the mechanisms of several different reactions on the surface of MXenes, bare or with surface terminations, namely, N_2 reduction to ammonia, CO_2 activation or the water gas shift (WGS) reaction.[2] Given the potential of MXenes for catalysis and the numerous structures possible for MXenes due to metal alloying,[3] and mixture of surface terminations,[4] the ForTheShift project was envisioned with the goal of developing machine learning models for the predictive analysis and understanding of the main molecular features influencing the WGS reaction (Scheme 1). Thus, a data set is being generated from descriptors available in the literature, e.g. band-gap energy, formation energy, bond distance, reaction and activation energies of chemical reactions on MXene surfaces, and from on-going calculations based on the DFT using realistic MXene catalyst models and transition state theory.

Scheme 1: ForTheShift project in a nutshell.

Acknowledgements
This work was developed within the scope of the projects CICECO-Aveiro Institute of Materials, Refs. UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020, and ForTheShift, Ref. 2022.02949.PTDC, financed by national funds through the FCT/MCTES (PIDDAC). Additional computational resources were granted through the Advanced Computing Project, Ref. 2021.09799.CPCA. TLPG and JDG thank the Portuguese Foundation for Science and Technology (FCT) for the grants in the scope of the Individual Call to Scientific Employment Stimulus – 5th Edition, Refs. 2022.08205.CEECIND and 2022.00719.CEECIND, respectively.

References

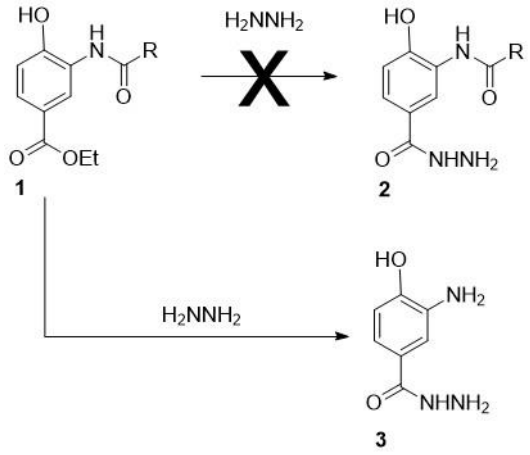
1. B. Anasori and Y. Gogotsi, *Graphene 2D Mater.*, 2022, **7**, 75–79.
2. a) J. D. Gouveia, Á. Morales-García, F. Viñes, J. R. B. Gomes and F. Illas, *ACS Catal.*, 2020, **10**, 5049–5056; b) R. Morales-Salvador, J. D. Gouveia, Á. Morales-García, F. Viñes, J. R. B. Gomes and F. Illas, *ACS Catal.*, 2021, **11**, 11248–11255; c) J. D. Gouveia, Á. Morales-García, F. Viñes, F. Illas and J. R. B. Gomes, *Appl. Catal. B: Environ.*, 2020, **260**, 118191.
3. T. L. Tan, H. M. Jin, M. B. Sullivan, B. Anasori and Y. Gogotsi, *ACS Nano*, 2017, **11**, 4407–4418.
4. R. Ibragimova, P. Erhart, P. Rinke and H.-P. Komsa, *J. Phys. Chem. Lett.*, 2021, **12**, 2377–2384.

Drawbacks in the synthesis of substituted aryl hydrazides

S. Teixeira[1,2,*], E. M. S. Castanheira[2], M. A. Carvalho[1]

[1]*Centre of Chemistry (CQ), University of Minho, Gualtar, 4710-057 Braga, Portugal*
[2]*Centre of Physics of Minho and Porto Universities (CF-UM-UP), Gualtar, University of Minho, 4710-057 Braga, Portugal*
**id9191@alunos.uminho.pt*

In medicinal chemistry, hydrazides are often used to synthetize compounds with various biological activities, such as antimalarial[1], anti-inflammatory[2], antifungal[3], antimicrobial[4], antiviral[5], antitumor[6], and antituberculosis[7] activities. However, there are only a few hydrazides commercially available and some of them are expensive.
In the literature, hydrazides can be obtained from acyl derivatives (acyl esters, anhydrides or halides) and hydrazine.[8] Recently, in our research group, new specific hydrazides were successfully synthesized from in-house functionalized esters in the presence of hydrazine.
In the attempt to synthesize 4-hydroxy-3-amidearyl hydrazide derivatives **2**, the corresponding aryl esters **1** were reacted with hydrazine, in the reaction conditions used previously. Surprisingly, cleavage of the amide group occurred, and generated compound **3** (Scheme 1). Therefore, reaction conditions were carefully analyzed, and an alternative route was considered to obtain compounds **2** using different methodologies. All the results will be presented and discussed.



Scheme 1: Cleavage of amide group by hydrazine

Acknowledgements
This work was supported by Fundação para a Ciência e a Tecnologia (FCT-Portugal) in the framework of CQUM (UIDB/00686/2020), and by funds from FEDER/FCT through the project PTDC/MED-ONC/31354/2017. S. Teixeira acknowledges FCT and FSE (Fundo Social Europeu) through "Programa Operacional Regional Norte" for funding the PhD grant 2020.04975.BD.

References
1. H. Ramírez, E. Fernandez, J. Rodrigues, S. Mayora, G. Martínez, C. Celis, J. B. De Sanctis, M. Mijares and J. Charris, Arch. Pharm. (Weinheim)., 2021, **354**, 2100002.
2. M. Saylam, F. Aydın Köse, A. Pabuccuoglu, D. Barut Celepci, M. Aygün and V. Pabuccuoglu, Eur. J. Med. Chem., 2023, **248**, 115083.
3. X. Wang, Z. C. Dai, Y. F. Chen, L. L. Cao, W. Yan, S. K. Li, J. X. Wang, Z. G. Zhang and Y. H. Ye, Eur. J. Med. Chem., 2017, **126**, 171–182.
4. S. G. Küçükgüzel, A. Mazi, F. Sahin, S. Öztürk and J. Stables, Eur. J. Med. Chem., 2003, **38**, 1005–1013.
5. A. F. Kassem, R. Z. Batran, E. M. H. Abbas, S. A. Elseginy, M. N. F. Shaheen and E. M. Elmahdy, Eur. J. Med. Chem., 2019, **168**, 447–460.
6. M. A. Sabry, M. A. Ghaly, A. R. Maarouf and H. I. El-Subbagh, Eur. J. Med. Chem., 2022, **241**, 114661.
7. A. H. Bacelar, M. A. Carvalho and M. F. Proença, Eur. J. Med. Chem., 2010, **45**, 3234–3239.
8. P. Majumdar, A. Pati, M. Patra, R. K. Behera and A. K. Behera, Chem. Rev., 2014, **114**, 2942–2977.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Hydrolysis of a Mo(VI) complex of 5-(2-pyridyl-1-oxide)tetrazole into a MoO_3-based hybrid catalyst for the epoxidation of bio-olefins

Martinique S. Nunes[1,*], Diana M. Gomes[1], Ana C. Gomes[1], Patrícia Neves[1], Ricardo F. Mendes[1], Filipe A. Almeida Paz[1], André D. Lopes[2,3], Martyn Pillinger[1], Anabela A. Valente[1], Isabel S. Gonçalves[1]

[1]CICECO—Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]Center of Marine Sciences, CCMAR, University of Algarve (UAlg), Gambelas Campus, 8005-139 Faro, Portugal; [3]Department of Chemistry and Pharmacy, Faculty of Sciences and Technology, FCT, University of Algarve (UAlg), Gambelas Campus, 8005-139 Faro, Portugal
**nunes.m@ua.pt*

Numerous products, *e.g.*, flavors, fragrances, resins, are derived from the epoxidation of olefins. Sourcing from biomass-related raw materials, like agricultural crops, waste from the forestry and citrus industries, and waste cooking oil, would veer production toward greater sustainability. Homogeneous or heterogeneous catalysts have contributed effectively for the production of epoxide products from biobased olefins. Here, an organic–inorganic polymeric hybrid, $[MoO_3(Hpto)]\cdot H_2O$ (**1**), where Hpto = 5-(2-pyridyl-1-oxide)tetrazole, was prepared by a hydrolysis–condensation reaction of the complex $[MoO_2Cl_2(Hpto)]\cdot THF$.[1] Complementary spectroscopic characterization techniques detected a common six-membered chelate ring from the bidentate N,O-coordination of Hpto to Mo^{VI} centers in both **1** and $[MoO_2Cl_2(Hpto)]\cdot THF$. The two compounds were examined as olefin epoxidation catalysts, being very active and selective toward the formation of epoxide products. The mononuclear complex acts as a homogeneous catalyst, unlike hybrid **1**, which is one of the few examples among molybdenum oxide/organic catalysts that acts as a solid catalyst. Hybrid **1** effectively catalyzed the reaction of biobased olefins with *tert*-butyl hydroperoxide, namely fatty acid methyl esters (methyl oleate, methyl linoleate, methyl linolenate, and methyl ricinoleate) and the terpene limonene, affording largely the corresponding epoxide products with yields in the range of 85–100 % after 24 h at 70 °C (Figure 1). To the best of our knowledge, **1** is the first molybdenum catalyst reported for methyl linolenate epoxidation, and the first of the family $[MoO_3(L)_x]$ studied for methyl ricinoleate epoxidation.

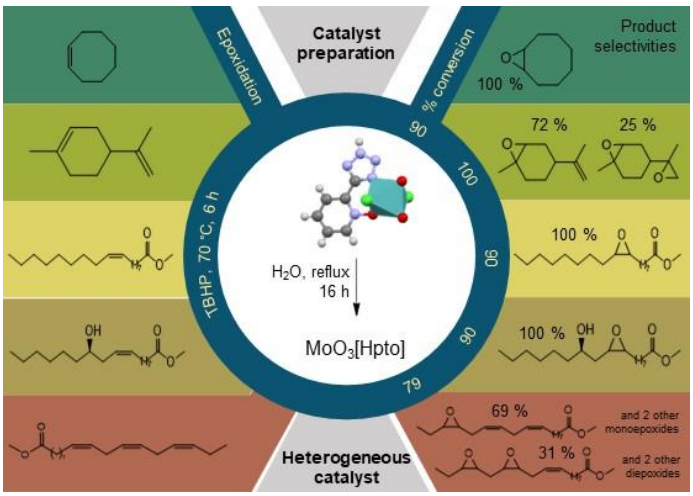


Figure 1: Synthesis and effectiveness of heterogeneous catalyst $MoO_3[(Hpto)]$ for the epoxidation of bio-based olefins.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC) and the COMPETE 2020 Operational Thematic Program for Competitiveness and Internationalization (Project POCI-01-0145-FEDER-030075), co-financed by national funds through the FCT/MCTES and the European Union through the ERDF under the Portugal 2020 Partnership Agreement. M.S.N. (grant ref. 2021.06403.BD) and D.M.G. (grant ref. 2021.04756.BD) acknowledge the FCT for PhD grants (State Budget, European Social Fund (ESF) within the framework of PORTUGAL2020, namely through the Centro 2020 Regional Operational Programme). R.F.M. and A.C.G. thank the FCT for a Junior Researcher Position (CEEC-IND/00553/2017) and an Assistant Researcher Position (CEECIND/02128/2017), respectively.

References

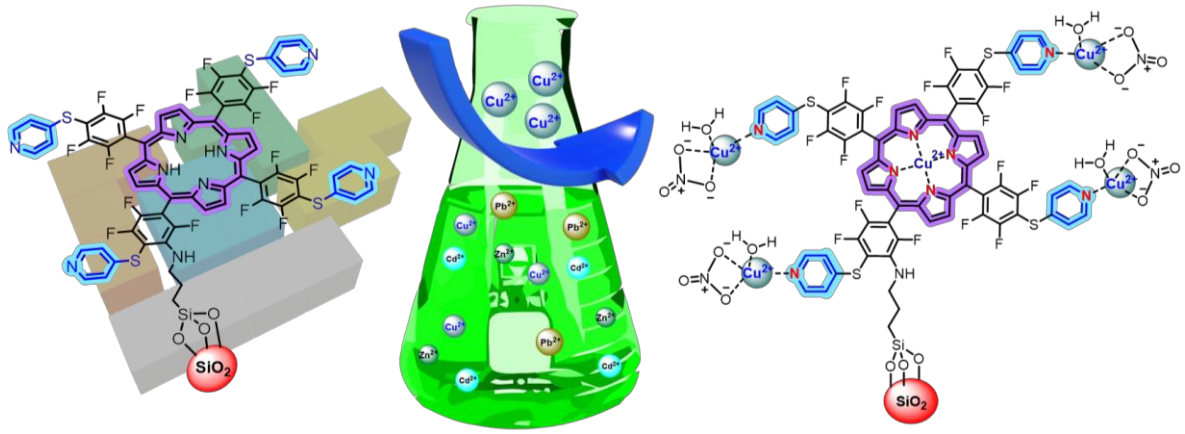
1. M. S. Nunes, D. M. Gomes, A. C. Gomes, P. Neves, R. F. Mendes, F. A. Almeida Paz, A. D. Lopes, M. Pillinger, A. A. Valente and I. S. Gonçalves, *Catalysts*, 2023, **13**, 565.

Porphyrin-silica gel hybrids as effective and selective metal ions adsorbents from industrial wastewater

Chahrazad El Abiad[1,2], Smaail Radi[1], Mohamed El Massaoudi[1,2], Morad Lamsayah[1], Flávio Figueira[3], M. Amparo F. Faustino[4], Nuno M. M. Moura[4], M. Graça P. M. S. Neves[4,*]

[1]*Mohammed First University, Faculty of Sciences, LCAE, 60 000 Oujda, Morocco.*
[2]*Higher School of Education and Training of Oujda, PO Box: 1458, Oujda 62000, Morocco*
[3]*CICECO, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal.*
[4]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal.*
*gneves@ua.pt

Nowadays, the presence of a high number of contaminants of emerging concern in wastewater (e.g. personal care products, hormones, industrial chemicals) where are included hazardous metal ions prompted the scientific community to develop advanced treatment processes to remove them in wastewater plants.[1] It is well-known that prolonged exposure to metals ions, like Cu^{2+}, Pb^{2+}, Cd^{2+}, and Zn^{2+} are associated to different diseases (e.g. liver and kidney damage, reduction in haemoglobin formation, lung cancer, memory or concentration problems), being their removal from natural waters and wastewater by different approaches like osmosis, coagulation, ion exchange, chemical precipitation or adsorption particularly relevant. Among them, a special attention is being given to approaches based on material adsorption capabilities due to their high efficiency, simplicity, low cost, and low environmental impact. Mesoporous materials based on silica gel are particularly promising adsorbents due to their high specific surface area, large pore size, low cost, feasibility, high thermal and mechanical stability, and low toxicity.[2] In this context, the combination of mesoporous silica with highly efficient metal ion ligands like porphyrins can give rise to new composites with excellent adsorption capabilities and enhanced metal ion specificity.[3,4]
In this work, we describe the synthesis and characterization of new inorganic-organic hybrid materials obtained by the functionalization of silica gel with porphyrin ligands substituted with three and four mercaptopyridyl units. The adsorption ability of the new hybrids with extra chelating units besides the porphyrin inner core towards Cu^{2+}, Pb^{2+}, Cd^{2+} and Zn^{2+} ions in aqueous solutions will be also discussed.[5]



Funding and Acknowledgements
The authors acknowledge the University of Aveiro, FCT/MCTES, and the Portuguese NMR Network for the financial support to LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) and CICECO – Aveiro Institute of Materials (UIDB/50011/2020 & UIDP/50011/2020), and the project RP2PS(EXPL/QUI/QOR/0586/2021), through national funds and, when applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement. NMM Moura and F Figueira thanks also FCT for their funding through program DL 57/2016. The authors extend their appreciation to the PPR2-MESRSFC-CNRST-P10 project (Morocco) for the financial support.

References
1. L. Rizzo, Environ. Sci. Water Res. Technol. 8 (2022) 2145.
2. M.G.P.M. S. Neves and co-workers, *J. Mater. Chem. A*, 6 (2018) 13096-13109.
3. M.G.P.M.S. Neves and co-workers, *J. Hazard. Mater*. 370 (2019) 80-90.
4. M. G. P.M.S. Neves and co-workers, Molecules 24 (2019) 669.
5. M. G. P. M. S. Neves and co-workers, *J. Env. Chem. Eng.* 11 (2023) 110097.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Oxidative desulfurization with Fe_3O_4−MoO_3 catalyst

C. D. Nunes*, P. Moreira

Centro de Química Estrutural - Institute of Molecular Sciences, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Portugal.
**cmnunes@fc.ul.pt*

Harvesting clean energy from fuel feedstocks is of utmost importance in the field of environmental sciences, to achieve this purpose more selective and robust catalysts for the oxidative desulfurization are required to raise the quality of petroleum and meet the environmental standards of lower or minimal emissions.[1] The high cost and energy dependency prompted researchers to find different catalytic methods to remove sulfur from fuel. Oxidative desulfurization (ODS) is a promising method due to the use of an oxidant (H_2O_2, tert-butyl hydroperoxide, molecular O_2, etc…), low temperature and pressure.[2] Conventional catalysts appear to exhibit lower activity compared to nanocatalysts in these processes. Metal nanoparticles (MNPs) have become popular in the petrochemical industry because of their excellent catalytic properties. They are an alternative in the design of new materials for catalysis, due to the high surface area, possibility to be dispersed in common solvents, and act as catalysts or (semi) heterogeneous catalyst supports. Current chemical processes are now established but environmental concerns are focused on the development of cheap catalysts leading to highly selective materials, although selectivity is still a major issue. Understanding better the upgrading processes, substitution of critical or scarce metals by first-row transition metals to achieve a lower consumption of natural resources and developing viable alternatives will contribute to achieve the Strategic Goals set by the EU for 2030. Recent interest in nanoparticles (NPs) has increased due to their unique physicochemical properties and potential applications.[3,4] In this work the functionalization of Fe_3O_4 NPs was explored to bind catalytic MoO_3 active species, using a mild technique (< 100 °C) under controlled conditions, Figure 1.

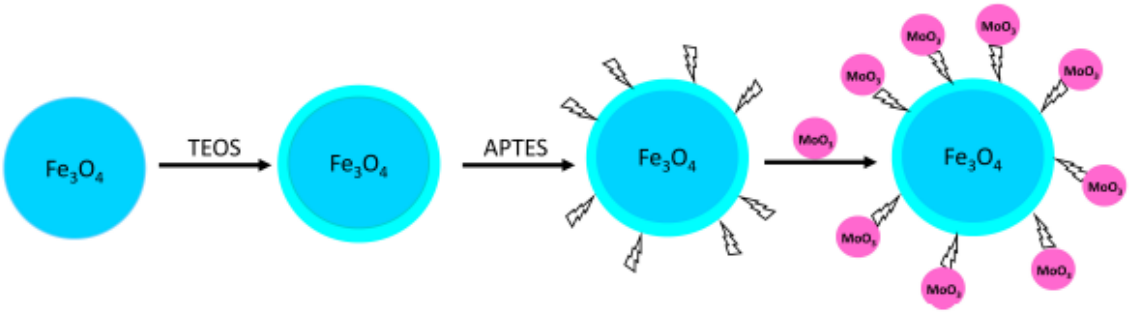


Figure 1: Functionalization of Fe_3O_4 with MoO_3.

The obtained Fe_3O_4−MoO_3 nanomaterial, Figure 1, was tuned toward its capacity to be a catalytically active catalyst for the oxidative desulfurization process of sulfides using tert-butyl hydroperoxide or H_2O_2 as oxidants. Promising results were achieved, and it was found that the catalytic oxidation reaction conducts to the respective sulfoxide, being afterwards converted into the sulfone. High yields were obtained for the sulfoxides and sulfones in all the studied reactions, with different conditions and in a short period of time. Catalyst recycling was also possible being possible to obtain systematically high yield of sulfone throughout 10 catalytic cycles. Taking advantage of the Fe_3O_4 properties, it was possible to separate the catalyst from the reaction medium by a magnet, accounting for an easy protocol for the workup of the reaction. After the removal of catalyst from the reaction medium was possible to identify the sulfone crystals.

Acknowledgements
This work was supported by the Portuguese Fundação para a Ciência e Tecnologia (FCT) for Centro de Química Estrutural through projects UIDB/00100/2020 and UIDP/00100/2020, Institute of Molecular Sciences through project LA/P/0056/2020 and project number 2022.03236.PTDC.

References

1. J. Garcia-Martinez, *Ang. Chem. Int. Ed.*, 2021, **60**, 4956–4960.
2. A. Rajendran, T.-C. Cui, H.-X. Fan, Z.-F. Yang, J. Feng and W.-Y. Li, *J. Mater. Chem. A*, 2020, **8**, 2246−2285.
3. Z. Li, S. Ji, Y. Liu, X. Cao, S. Tian, Y. Chen, Z. Niu and Y. Li, *Chem. Rev.*, 2020, **120**, 623−682.
4. L. Liu and A. Corma, *Chem. Rev.*, 2018, **118**, 4981−5079.

Extractive bioconversion of polydopamine by laccase in aqueous biphasic systems

Flávia F. Magalhães*, Ana Filipa Pereira, Ana Paula M. Tavares, Mara G. Freire

CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Aveiro, Portugal
**flaviamagalhaes@ua.pt*

Laccase is a multicopper oxidase, an environmentally friendly biocatalyst which has attracted worldwide attention due to its wide range of applications in biotechnology, including the synthesis of polymers.[1] Among them, polydopamine (PDA) is an added-value biopolymer produced from dopamine polymerization. PDA can be used in the modification and functionalization of surfaces with biomedical applications.[2] In contrast to the conventional method for dopamine polymerization, which is chemical-based, time-consuming and produces PDA films with poor stability, the production of PDA using laccase improves the efficiency of the process, fulfilling some green chemistry principles.[3] However, on an industrial scale, it is relevant to develop novel methods to allow the biocatalyst recovery and reuse. In this field, aqueous biphasic systems (ABS), which are liquid-liquid systems composed of water, appear as a promising alternative since they provide a mild and biocompatible environment for biocatalysts.[4]

This work aims the optimization of several parameters for the enzymatic production of PDA, including temperature, medium pH and different initial dopamine concentrations. It was demonstrated that the enzymatic polymerization of dopamine is a more efficient process when compared with the non-enzymatic method, since, for the same reaction time, the polymerization rate was significantly superior and allowed the use of lower concentrations of dopamine for film formation.[5] At the optimized conditions, an integrated and sustainable platform to efficiently produce PDA using laccase and simultaneously separate this target product and the enzyme through the use of designed ABS was developed.[5] Several ABS composed of polymers, salts and ionic liquids were investigated, with the most promising ABS allowing their use as an integrated platform for PDA production and recovery, and laccase reuse.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). Ana P. M. Tavares acknowledges FCT for the research contract CEECIND/2020/01867. Flávia Magalhães acknowledges the SPQ/FCT PhD grant SFRH/BD/150669/2020.

References

1. R. Debnath and T. Saha, An insight into the production strategies and applications of the ligninolytic enzyme laccase from bacteria and fungi, *Biocatal. Agric. Biotechnol.*, 2020, **26**, 101645.
2. Y. H. Ding, M. Floren and W. Tan, Mussel-inspired polydopamine for bio-surface functionalization, *Biosurface and Biotribology*, 2016, **2**, 121–136.
3. O. Y. Milyaeva, A. G. Bykov, R. A. Campbell, G. Loglio, R. Miller and B. A. Noskov, The dynamic properties of PDA-laccase films at the air-water interface, *Colloids Surfaces A Physicochem. Eng. Asp.*, 2020, **599**, 124930.
4. M. G. Freire, A. F. M. Cláudio, J. M. M. Araújo, J. A. P. Coutinho, I. M. Marrucho, J. N. Canongia Lopes and L. P. N. Rebelo, Aqueous biphasic systems: A boost brought about by using ionic liquids, *Chem. Soc. Rev.*, 2012, **41**, 4966–4995.
5. F. F. Magalhães, A. F. Pereira, M. G. Freire and A. P. M. Tavares, New liquid supports in the development of integrated platforms for the reuse of oxidative enzymes and polydopamine production, *Front. Bioeng. Biotechnol.*, , DOI:10.3389/fbioe.2022.1037322.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Heterologous production and characterization of nitrous oxide reductase from *Pseudomonas stutzeri*

Ricardo N. S. Oliveira[1,2,*], Vítor Mordido[1,2], Marta S. P. Carepo[2], Lin Zhang[3], Oliver Einsle[3], Sofia R. Pauleta[1], Isabel Moura[2]

[1]Microbial Stress Lab, UCIBIO, Dept. Chemistry, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal and Associate Laboratory i4HB - Institute for Health and Bioeconomy, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal; [2]LAQV, REQUIMTE, Dept. Chemistry, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal; [3]Institut für Biochemie, Albert-Ludwigs-Universität Freiburg, Albertstrasse 21, 79104, Freiburg im Breisgau, Germany
**rl.oliveira@campus.fct.unl.pt*

While much is known about carbon dioxide and how it causes climate change and global warming, the way nitrous oxide contributes to these problems still needs to be thoroughly studied, as well as mechanisms to mitigate the impact of this gas.
Denitrification is one of the pathways of the nitrogen cycle, performed by several bacteria[1]. The ability of an organism to carry out the denitrification represents a metabolic advantage, since it allows them to produce energy in the absence of oxygen[2].
Nitrous oxide reductase catalyzes the last step of this pathway. Its study is of interest since it can be part of the solution for the impact of N_2O in global warming, using biological knowledge applied to biotechnology. The nitrous oxide reductase (N_2OR) possesses two copper centers, the electron transfer CuA (binuclear) and the catalytic CuZ (tetranuclear)[3]. While CuA is a copper center present in other proteins, CuZ is exclusive of N_2OR and has unique spectroscopic features. CuZ can be found in different forms, namely CuZ and CuZ*, which differ in the sulfur content, being 4Cu2S or 4Cu1S[3], respectively. These two forms also differ in the spectroscopic and kinetic properties[4,5].
N_2OR from *Pseudomonas stutzeri* was successfully produced in *Escherichia coli* and its production, as well as its purification are being optimized. The enzyme is isolated in a mixed-oxidation state as a dimer in solution. Protein and copper content were determined by the Lowry and Cu(I)-biquinoline methodologies, respectively, showing that ~0.6 mg of protein is obtained per g of cells, with a low copper content (<6 Cu/monomer).
UV-visible spectra were acquired in the three oxidation states (as-isolated, corresponding to a mixed-oxidation state, oxidized, and dithionite reduced). Depending on the CuZ/CuZ* ratio, the oxidized spectrum presents bands with maximums around 550 nm, 650 nm, and 800 nm. The reduced spectrum (obtained after incubation with sodium dithionite for several hours) has a maximum at 650 nm. Specific activity will be used to estimate the percentage of CuZ and CuZ* present in the sample[6].
The kinetic characterization will be performed, under anaerobic conditions (inside an anaerobic chamber), with reduced methyl-viologen as an artificial electron donor. The activation mechanism will be studied by following the reduction of CuZ center to the fully reduced and determining the specific activity.

Acknowledgements
This work was supported by Fundação para a Ciência e Tecnologia by national funds: 2022.01152.PTDC (to IM), RNSO and VM thank this project for the BI scholarships; UIDP/04378/2020 and UIDB/04378/2020 of the Research Unit on Applied Molecular Biosciences - UCIBIO and the project LA/P/0140/2020 of the Associate Laboratory Institute for Health and Bioeconomy - i4HB, and UIDB/50006/2020, UIDP/50006/2020 and LA/P/0008/2020 to Associate Laboratory for Green Chemistry-LAQV.

References
1. W. G. Zumft, Microbiol Mol Biol Rev, 1997, 61, 533–616.
2. J. M. Bollag and N. M. Henninger, Soil Biol Biochem, 1978, 10, 377–381.
3. S. R. Pauleta, M. S. P. Carepo and I. Moura, in Transition Metals and Sulfur – A Strong Relationship for Life, De Gruyter, 2020, vol. 20, pp. 139–164.
4. L. Zhang, A. Wüst, B. Prasser, C. Müller and O. Einsle, Proc Natl Acad Sci U S A, 2019, 116, 12822–12827.
5. S. R. Pauleta, M. S. P. Carepo and I. Moura, Coord Chem Rev, 2019, 387, 436–449.
6. C. Carreira, M. M. C. dos Santos, S. R. Pauleta and I. Moura, Bioelectrochemistry, 2020, 133, 107483.

Conversion of plastics into optical sensors: approach and applications

Ana M. G. Silva,[1,*] Carla Queirós,[1] Fábio Martins,[1] Ken Lukau,[2] Maria Inês Soares,[2] Sofia Moreira,[2] Pedro Mendes[3]

[1]LAQV-REQUIMTE, DQB, Faculdade de Ciências, Universidade do Porto, 4169-007 Porto, Portugal; [2]Escola Secundária da Maia, Av. Luís de Camões, 4470-194 Maia, Portugal; [3]Colégio Internato dos Carvalhos, R. Moeiro s/n, 4415-133 Pedroso, Portugal.
**ana.silva@fc.up.pt*

According to recent studies, more than 8 billion tons of plastics are produced and about 80% of these plastics are discarded and accumulated in landfills or aquatic ecosystems, representing a serious environmental and biological threat.[1] Moreover, approximately 50% of this waste is made up of polyethylene terephthalate (PET), which in many cases due to a high level of contamination and degradation is not recyclable. On the other hand, the sea salt contamination of this plastic waste is often considered critical, as it causes serious damage to equipment and instrumentation used by the recycling industries.

To overcome this major environmental threat, it is urgent to develop new and improved sustainable recycling methods, in order to, give a new life to these materials, creating added value and innovation in these wasted plastics so that they can enter into a circular economy.[2]

The main objective of this project is to explore new approaches that can sustainably deal with non-recyclable PET waste collected in coastal regions of Portugal, in order to reuse the recycled monomers to prepare new materials for sensing purposes. With this in mind, we intend to give a new life to PET plastic coming from marine environments, by creating a set of fluorescent sensors, using the monomeric terephthalate obtained after hydrolysis/aminolysis of PET, prioritizing the use of sustainable reagents and eco-friendly methodologies (Figure 1). In this work, both hydrolysis and aminolysis of PET waste were performed with energy efficiency optimization in mind, by using conventional heating, microwave irradiation and ohmic heating. The terephthalate thus obtained is then used for the preparation of new materials, with sensing and adsorptive properties. For that, two strategies are being considered: (i) the derivatization with selective receptors and (ii) the synthesis of MOF nanostructures (such as UiO-66) doped with fluorescent dyes, namely rhodamines, with sensing capabilities.[3] When in contact with contaminated water, these materials allow signaling the presence of environmental contaminants - by color change and/or fluorescence - namely metal ions such as Pb(II) and Fe(III), as well as adsorbing part of them.

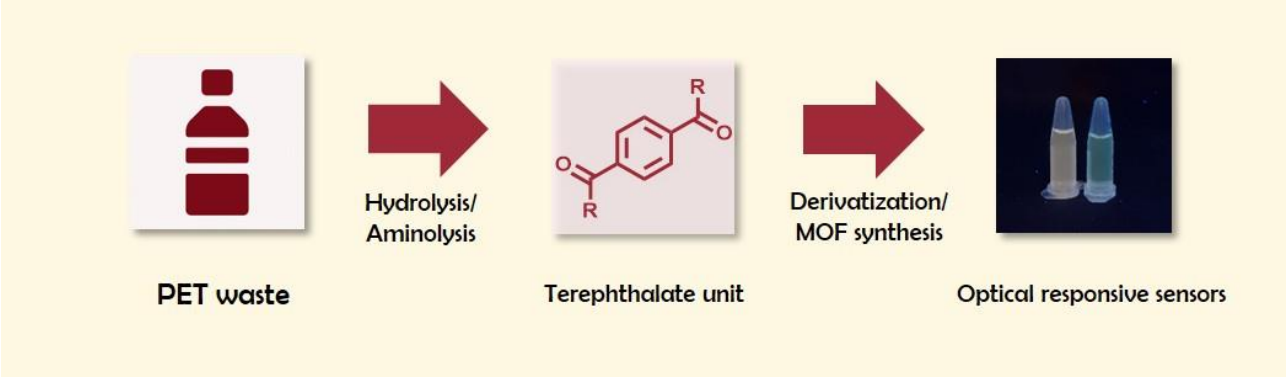


Figure 1: Approach developed for the synthesis of optical responsive sensors from PET waste

Acknowledgements
This work received financial support from the project EXPL/QUI-OUT/1554/2021. We also thank National Funds (FCT/MCTES), under the Partnership Agreement PT2020 through projects NORTE-07-0162-FEDER-000048, UIDB/50006/2020 and UIDP/50006/2020. F. Martins acknowledges FCT and ESF (European Social Fund) for his PhD grant (UI/BD/154485/2022). A. M. G. Silva thanks FCT for funding through program DL57/2016—Norma transitória. This project also counts with the partnership of Câmara Municipal de Ílhavo, through the Environmental Engineer, Luís Rabaça, and the Municipality Schools.

References

1. K. Ghosal and C. Nayak, *Mater. Adv.*, 2022, **3**, 1974-1992.
2. E. Barnard, J. J. R. Arias and W. Thielemans, *Green Chem.*, 2021, **23**, 3765-3789.
3. B. Ruan, J. Yang, Y.-J. Zhang, N. Ma, D. Shi, T. Jiang and F.-C. Tsai, *Talanta*, 2020, **218**, 121207-121216.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Catalytic epoxidation of biobased olefins over modified mesostructured and hierarchical silicates

D. M. Gomes[1,*], P. Neves[1], M. M. Antunes[1], A. J. S. Fernandes[2], M. Pillinger[1], A. A. Valente[1]

[1]CICECO—Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]i3N, Department of Physics, University of Aveiro, 3810–193 Aveiro, Portugal
**dianamgomes@ua.pt*

Olefin epoxidation is an important transformation for the chemical valorization of olefins, which may derive from renewable sources or domestic/industrial waste, contributing to a sustainable biobased/circular economy. The use of efficient heterogeneous catalysts in olefin epoxidation processes is important to achieve high productivity. Molybdenum-containing mesostructured and hierarchical micro-mesoporous catalysts of the type TUD-1 and BEA zeotype (hBEA), respectively, were prepared via top-down strategies, specifically, incipient wetness impregnation (IWI) and solid-state impregnation (SSI), followed by calcination. The materials possessed epoxidation activity for the conversion of relatively bulky C8 olefins (*cis*-cyclooctene, 1-octene, *trans*-2-octene) and biobased olefins (methyl oleate, *DL*-limonene) to the corresponding epoxides, using *tert*-butyl hydroperoxide (TBHP) as oxidant, at 70 ºC (Figure 1).[1] The corresponding epoxides are interesting for complementing non-renewable chemicals, such as petroleum derived phthalate esters used as plasticizers for PVC resins (impact negatively on human health) and bisphenol A, phosgene and isocyanates (hazardous) in the production of polycarbonates and polyurethanes. The influences of the (i) type of metal precursor ($MoO_2(acac)_2$ where acac = acetylacetonate, $(NH_4)_2MoO_4$ and $(NH_4)_6Mo_7O_{24}$), (ii) type of post-synthesis impregnation method (SSI versus IWI), (iii) type of support (TUD-1 versus BEA) and (iv) top-down versus bottom-up synthesis methodologies were studied to achieve superior catalytic performances. The epoxidation activity was highest for a catalyst prepared via IWI of $MoO_2(acac)_2$ on pre-treated siliceous TUD-1, followed by calcination. For example, methyl oleate was converted in 89% (24 h) to the corresponding epoxide with 100% selectivity; on the other hand, *DL*-limonene was converted to the corresponding mono- and diepoxides in 69% and 8% yield, respectively, at 81% conversion (4 h). Catalytic and solid-state characterization studies were conducted to shed light on material stability.

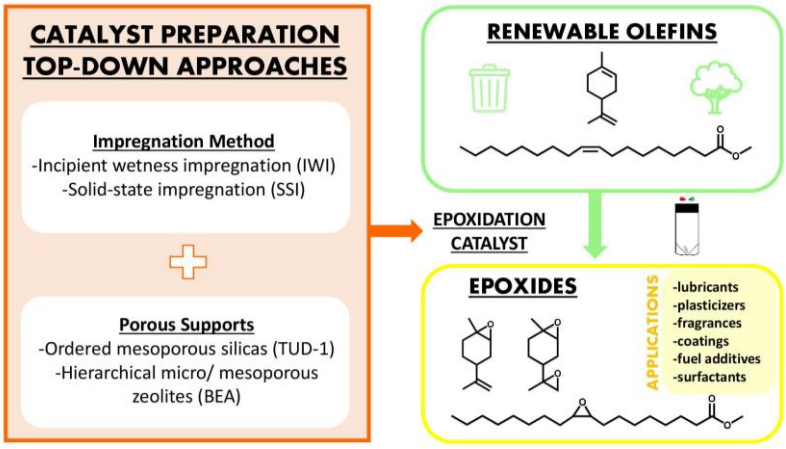


Figure 1: Silicate catalysts possessing mesoporosity prepared via top-down strategies for biobased olefins epoxidation.

Acknowledgements
This work was carried out with the support of CICECO—Aveiro Institute of Materials (FCT (Fundação para a Ciência e a Tecnologia) ref. UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020) and the COMPETE 2020 Operational Thematic Program for Competitiveness and Internationalization (Project POCI-01-0145-FEDER-030075), co-financed by national funds through the FCT/MCTES (PIDDAC) and the European Union through the European Regional Development Fund under the Portugal 2020 Partnership Agreement. D.M.G. (grant ref. 2021.04756.BD) acknowledges the FCT for PhD grant (State Budget, European Social Fund (ESF) within the framework of PORTUGAL2020, namely through the Centro 2020 Regional Operational Program). The position held by MMA was funded by national funds (OE) through FCT, IP, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of article 23 of the Decree-Law 57/2016 of 29 August, changed by Law 57/2017 of 19 July.

References

1. D. M. Gomes, P. Neves, M. M. Antunes, Fernandes A. J. S. Fernandes, M. Pillinger, A. A. Valente, *Catalysts,* 2022, **12**, 1513-1534

Boron-doped diamond surface as a platform for the development of an enzymatic biosensor

Bernardo L. Tavares[1,*], Diogo R. Fernandes[1], Leandro R. Freitas[1], Valéria C. Ebinuma-Santos[2] , João C. F. Nunes[2], Márcia C. Neves[1], Ana V. Girão[3], Miguel A. C. Neto[3] , Ana P. M. Tavares[1]

[1]*Chemistry Department, CICECO–Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Department of Engineering of Bioprocesses and Biotechnology, School of Pharmaceutical Sciences, São Paulo State University (UNESP), Brasil*
[3]*Department of Materials and Ceramics Engineering, CICECO—Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
**bernardo.tavares@ua.pt*

L-Asparaginase (ASNase) is an enzyme used as an anti-leukemic biopharmaceutical that acts in the reduction of L-asparagine (Asn), a compound that favors tumoral growth in patients with acute lymphoblastic leukemia (ALL).[1] Thus, the control of depletion levels of Asn in patients treated with ASNase is important. Since the methods currently used for this purpose are sophisticated, time consuming and expensive, there is a continuous effort to develop new alternatives.[2] In this regard, ASNase-based biosensors have been developed for the quantification of Asn.[3] Due to its unique properties, diamond has been used as an ideal platform for the development of a new generation of superior biosensors.[4,5] This work aims at the immobilization of ASNase on the surface of temperature sensitive O2 and NH3 plasma functionalized polycrystalline CVD diamond, using the HFCVD technique, on monocrystalline silicon, to allow the development of a biosensor for the treatment monitorization of ALL. Several microcrystalline diamond films were deposited, in which the ASNase was immobilized by physical adsorption. The success of the enzyme attachment was confirmed through activity tests. The diamond surface before and after enzyme immobilization was characterized by FTIR-ATR, SEM, RAMAN and OCA allowing to further understand the conditions in which the enzyme was immobilized. Concluding, the obtained results encourage the development of the proposed diamond-based biosensor.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). Miguel A. C. Neto thanks the FCT for the research contract funded by national funds (OE), through FCT, in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. Ana P. M. Tavares and Márcia C. Neves acknowledge FCT for the research contract CEECIND/2020/01867 and CEECIND/00383/2017, respectively. Valéria C. Santos-Ebinuma acknowledges FAPESP for financial support. João C. F. Nunes acknowledges SPQ and FCT for the PhD fellowship (SFRH/BD/150671/2020).

References
1. B. S. Sekhon, *Thai Journal of Pharmaceutical Sciences*, 2010, **34**, 1–19.
2. W. Salzer, B. Bostrom, Y. Messinger, A. J. Perissinotti and B. Marini, *Leuk Lymphoma*, 2018, **59**, 1797–1806.
3. R. O. Cristovao, M. R. Almeida, M. A. Barros, J. C. F. Nunes, R. A. R. Boaventura, J. M. Loureiro, J. L. Faria, M. C. Neves, M. G. Freire, V. C. Ebinuma-Santos, A. P. M. Tavares and C. G. Silva, *RSC Adv*, 2020, **10**, 31205–31213.
4. M. A. Neto, D. Esteves, A. V. Girão, F. J. Oliveira and R. F. Silva, *Diam Relat Mater*, 2020, **109**, 108036.
5. J. Zhao, D. Wu and J. Zhi, *Journal of Electroanalytical Chemistry*, 2009, **626**, 98–102.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Sustainable production of lignin nanoparticles assisted by green solvents

Nalin Seixas[1,*], Fábio Almeida[1], Ana Margarida[1], Ricardo J. B. Pinto[1], Armando J. D. Silvestre[1], André M. da Costa Lopes[1,2]

[1]CICECO, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, Aveiro, Portugal; [2]CECOLAB - Collaborative Laboratory Towards Circular Economy, R. Nossa Senhora da Conceição, 3405-155 Oliveira do Hospital, Portugal
**nalinseixas@ua.pt*

The production of lignin nanoparticles (LNPs) is advancing as a promising route to produce homogeneous lignin-based products with high value applications. However, the production of LNPs is still in its early stages and remains a challenging process due to a lack of complete understanding about their assembly and their physicochemical property modification.[1] The primary objective of this work was to fill this gap through the investigation of different variables that can impact the LNP formation. The findings from this study provides valuable insights into the control of LNP properties. Therefore, a set of variables, including the methodology of LNP formation (antisolvent to lignin solution - method A, or lignin solution to antisolvent - method B), the lignin solvent (tetrahydrofuran – THF; ethanol – EtOH; ethylene glycol – EtGly; and γ-valerolactone - GVL), the flow rate of solvent/antisolvent addition (0.03 – 3.0 mL·min-1), the lignin solution loading (1.1 - 25 v/v%), and the washing step (centrifugation or dialysis) were studied. Remarkably, applying method B enabled to successfully obtain the desired LNPs (127.4 - 264.9 nm) (**Figure 1**), while method A induced the formation of lignin microparticles (582.8 - 7820 nm). Among examined lignin solvents, EtOH demonstrated the ability to produce LNPs with the lowest hydrodynamic diameter mean (method B = 127.4 nm), while the largest particles (method A = 7820 nm) were obtained with EtGly. These latest particles were characterized as heterogeneous (PDI = 0.365-0.505), irregular, and highly aggregated when compared with GVL counterparts, which showed the most homogeneous (PDI = 0.057-0.077) and spherical particles. Moreover, no significant impact of the lignin solvent addition flow rate was observed on LNP properties when GVL was used, while decreasing lignin solution loading enabled reduction on LNP sizes and Zeta potential up to 85.5 nm and -34 mV, respectively. In comparison to the centrifuged counterparts, the formation of LNPs using dialyzed samples was advantageous. Dialyzed samples allowed the formation of LNPs with lower hydrodynamic size, reduced the particle aggregation, increased the homogeneity as well as it provided high stability to LNPs at various hydrodynamic sizes for at least 35 days. This stability prevented the occurrence of particle coalescence, ensuring the integrity of the LNPs over time.

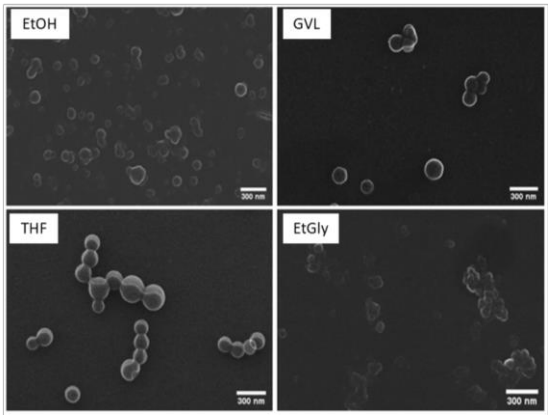


Figure 1: SEM image of LNPs produced with method B.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). André M. da Costa Lopes thanks his research contract funded by Fundação para a Ciência e Tecnologia (FCT) and project CENTRO-04-3559-FSE-000095 - Centro Portugal Regional Operational Programme (Centro2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF).

References
1. S. Li, S. Zhou and G. Zhao, *Ind Crops Prod*, 2021, **171**, 113860.

Photo-NMR: a tool for *in situ* irradiation of NMR samples

Luís F. B. Fontes[1,2,*], João Rocha[2], Artur M. S. Silva[1], Samuel Guieu[1,2]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal;
[2]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal.
**lfontes@ua.pt*

We have always relied on our perception of color to differentiate between a clear blue sky and a sunset sky or a green apple and a red one. Our understanding of molecules has been directly linked to our perception of color and how different colors witness molecular differences. Chemistry has built upon this fundamental knowledge to produce molecules that exhibit a range of colors and interact with light in various ways like photochromic or luminescent materials.[1,2] In our work we study how light shapes molecules (Figure 1), by observing transformations with *in situ* illumination Nuclear Magnetic Resonance (Photo-NMR).[3] We examined the photophysical properties of benchmark photochromic materials and Excited-state Proton Transfer (ESPT) dyes, as well as employing computational calculations to understand these fundamental mechanisms.[2] Like artisans, with this work we want to sculp molecules, design and synthesize novel organic dyes and light-responsive materials in a smarter and more efficient way.

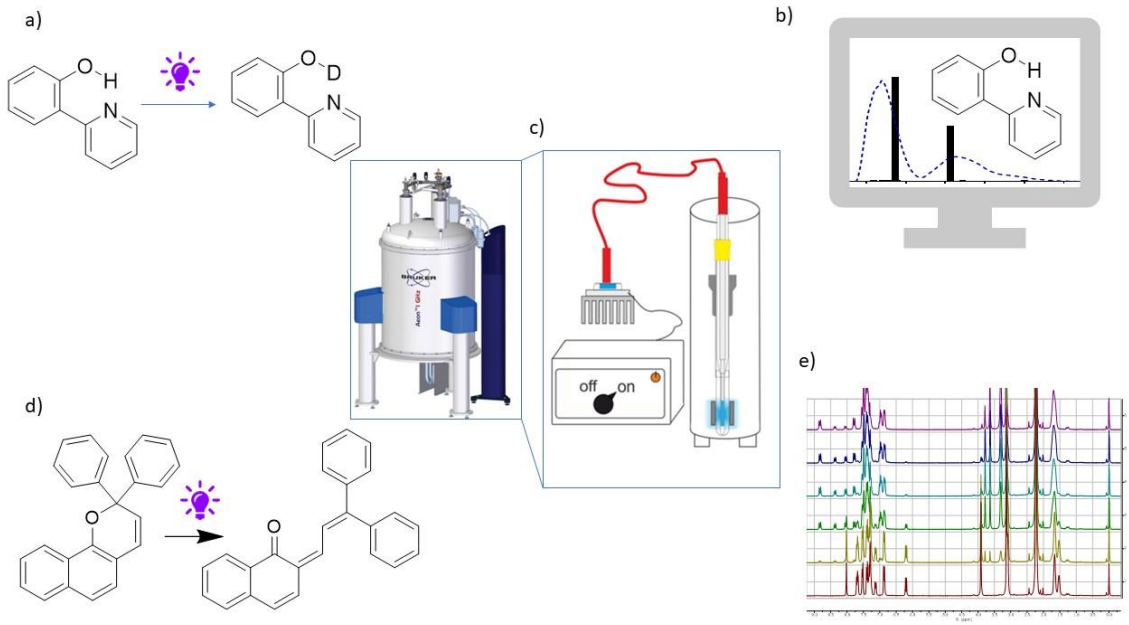


Figure 1: Study of light-responsive materials: a) Study of ESPT dyes; b) Computational calculations (DFT); c) Assembling of *in situ* NMR setup; d) Study of photochromic compounds; e) NMR studies.

Acknowledgements
Fundação para a Ciência e a Tecnologia. Grant Numbers: LAQV-REQUIMTE (UIDB/50006/2020), CICECO-Aveiro Institute of Materials (UIDB/50011/2020 & UIDP/50011/2020), Portuguese NMR Network, LFBF PhD grant SFRH/BD/150663/2020.

References

1. V. Graça, C. M. Sousa, P. J. Coelho, *Dyes Pigm*, 2021, **187**, 109110.
2. L. F. B. Fontes, R. Nunes da Silva, A. M. S. Silva, S. Guieu, *ChemPhotoChem*, 2020, **4**, 5312-5317
3. P. Nitschke, N. Lokesh, R. M. Gschwind, *Prog Nucl Magn Reson Spectrosc*, 2019, **114–115**, 86–134.

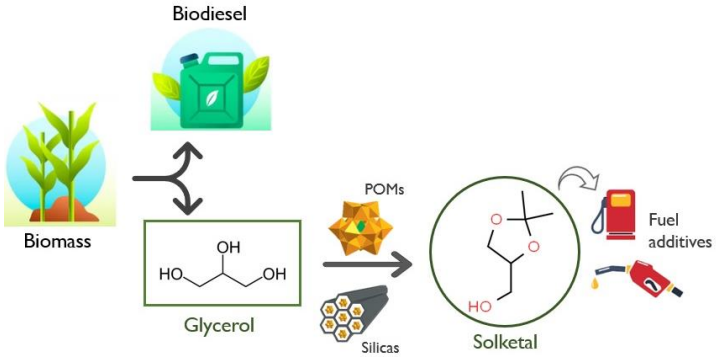
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Preparation of catalysts for a sustainable conversion of glycerol into fuel additives

C. N. Dias[1,*], C. A. R. Gomes[2], I. Santos-Vieira[3], S. S. Balula[4]

[1]REQUIMTE/LAQV & Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal; [2]CIIMAR & Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal; [3]CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [4]REQUIMTE/LAQV & Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal
**catarinandias3@gmail.com*

The growing interest in more environmentally friendly energy alternatives has increased the search for renewable energy sources. Biomass, the energy that stems from organic materials (edible or non-edible), has been widely used in fuel formulation, originating the non-toxic and biodegradable biodiesel. Biodiesel is obtained by transesterification of fatty acids, which produces glycerol as a by-product (approximately 10% of total biodiesel production), leading to an overabundance in the industry.[1] Acetalization is a chemical process widely used in the production of oxygenated fuel additives. The acetalization of glycerol originates solketal, a greener fuel additive, under sustainable conditions, with high atomic efficiency and without the presence of waste by-products.[2] Polyoxometalates, also referred to as heteropolyacids, have been widely used and reported as very active catalysts for acetalization reactions.[3] Three heteropolyacids were studied in their homogeneous form: phosphomolybdic acid ($H_3PMo_{12}O_{40}$), phosphotungstic acid ($H_3PW_{12}O_{40}$) and silicotungstic acid ($H_4SiW_{12}O_{40}$). Optimization of the experimental conditions was performed (temperature, amount of catalyst) and the activity of the different catalysts was compared in the presence of glycerol, using acetone as a substrate. Phosphomolybdic and phosphotungstic acids showed promising catalytic behaviour, achieving 97% conversion of glycerol with high selectivity for solketal (97% and 98%, respectively). The heteropolyacids were studied in their heterogeneous form, through their immobilization in solid supports. Composites using mesoporous silica and heteropolyacids (SBA-15_APTES@PMo_{12} and SBA-15_APTES@PW_{12}) were prepared and characterized. Optimization of the experimental conditions was achieved. The composites showed satisfactory catalytic behaviour, allowing reutilization and recycling studies. Therefore, this communication tends to introduce innovative methods of heterogenization for heteropolyacids and their catalytic application in sustainable and effective glycerol conversion.



Scheme 1: Graphical abstract of the production of glycerol, and its transformation into solketal.

Acknowledgements
The research work developed in our research group received financial support from Portuguese national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the strategic project UIDB/50006/2020 (for LAQV / REQUIMTE). Salete S. Balula thank FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus Ref. CEECIND/03877/2018. This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC).

References

1. F. Akram, I. u. Haq, S. I. Raja, A. S. Mir, S. S. Qureshi, A. Aqeel and F. I. Shah, *Journal of Cleaner Production*, 2022, **370**.
2. I. Corrêa, R. P. V. Faria and A. E. Rodrigues, *Sustainable Chemistry*, 2021, **2**, 286-324.
3. D. Juliao, F. Mirante and S. S. Balula, *Molecules*, 2022, **27**.

Functional Zr-MOF-based materials as high potential catalysts under sustainable conditions

C. E. S. Ferreira[1,*], I. S. Vieira[2], C. A. R. Gomes[3], S. S. Balula[1], L. C. Silva[1]

[1]LAQV-REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences of University of Porto, Rua do Campo Alegre, 687, 4169-007, Porto, Portugal; [2] CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, Aveiro, 3810-193, Portugal; [3]CIIMAR & Department of Chemistry and Biochemistry, Faculty of Sciences of University of Porto, Rua do Campo Alegre, 687, 4169-007, Porto Portugal
**up201804944@fc.up.pt*

Research into recyclable materials that can effectively turn organic chemicals into more valuable products is a field that is constantly evolving. Metal-organic frameworks (MOFs) are porous crystalline materials having an internal structure made up of discrete metal or metal clusters and organic ligands. These materials frequently feature large specific surface areas, high porosities, and an adaptable structure, which are qualities that are highly desirable for catalysis and other applications. MOF composites and hybrids have already been created using a variety of functional elements, including metallic nanoparticles, quantum dots, polyoxometalates, and others.[1]

Polyoxometalates (POMs) are interesting molecules from both economic and environmental standpoints as catalysts in a variety of oxidative processes, but their effectiveness in pure form is quite constrained due to their solubility in organic solvents.[2] In order to solve this issue, this work presents the immobilization of an catalytic active POM ($H_3PMo_{12}O_{40}$, abbreviated as PMo_{12}) on porous MOF-808 as suitable solid support for catalytic use, resulting in the composite PMo_{12}@MOF-808.[3] Briefly, the MOF-808 consists of a polyhedral structure formed by the Zr(IV) metal cluster, $[Zr_6O_4(OH)_4\ (-CO_2)_6]_6+$, that is coordinated by benzene-1,3,5-tricarboxylic acid, H_3BTC). Two alternative methods - solvothermal and at room temperature - were used to prepare the MOF-808. The preparation of the composite PMo_{12}@MOF-808 at room temperature is more cost-effective and sustainable and therefore the most desired for the catalytic application. The composite material was tested as a heterogeneous catalyst and promising results were found for geraniol oxidation. In addition, new Zr-based MOFs such as the UiO-66-NH_2 and MOF-801 were also prepared and modified by careful thermal control. The thermal-modified materials (MOF-808TT and UiO-66-NH_2TT) have been evaluated as catalysts for epoxide ring-opening reactions. The catalytic performance of these materials was compared and the reusing and recycling capacity of the most active were studied.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia (FCT) from Portugal, for financial support. This research work received financial support from Portuguese national funds (FCT/MCTES) through the strategic project UIDB/50006/2020 (for LAQV-REQUIMTE), and also from the European Union (FEDER funds through COMPETE POCI-01-0145-FEDER-031983). This work was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). LCS and SSB thank FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus (Ref. CEECIND/00793/2018 and Ref. CEECIND/03877/2018, respectively).

References
1. F. W. Wang, R. X. Xue, Y. J. Ma, Y. Z. Ge, Z. J. Wang, X. W. Qiao and P. Zhou, *Rsc Adv*, 2021, **11**, 32955-32964.
2. C. M. Granadeiro, A. D. S. Barbosa, S. Ribeiro, I. C. M. S. Santos, B. de Castro, L. Cunha-Silva and S. S. Balula, *Catal Sci Technol*, 2014, **4**, 1416-1425.
3. S. C. Fernandes, A. M. Viana, B. de Castro, L. Cunha-Silva and S. S. Balula, *Sustain Energ Fuels*, 2021, **5**, 4032-4040.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Stability enhancement of a ranolazine co-amorphous system

Joana F. C. Silva[1,*], Pedro S. Pereira[2], Manuela Ramos Silva[2], Elvira Fantechi[3], Laura Chelazzi[3], Samuele Ciattini[3], M. Ermelinda S. Eusébio[1], Mário T. S. Rosado[1]

[1]CQC-ICM, Departamento de Química, Universidade de Coimbra, 3004-535 Coimbra, Portugal
[2]CFisUC, Departamento de Física, Universidade de Coimbra, 3000-370, Coimbra, Portugal
[3]CRIST, Università degli Studi di Firenze, 50019, Sesto Fiorentino, Firenze, Italy.
joana.silva@qui.uc.pt

The increasing number of drugs with poor aqueous solubility is a serious issue for the industry, calling for new strategies to overcome this. Amorphization has been emerging as one of the most viable alternatives.[1] However, amorphous solids are intrinsically metastable phases due to their higher free energy than their crystalline counterpart, prone to relax to more stable and less soluble crystalline phases. For this reason, stabilization of amorphous drugs by interaction with safe small molecules, producing co-amorphous systems, can be successful as a reasonable compromise between desired solubility enhancement and stability.[2]
This study aimed to stabilize the amorphous phase of ranolazine with tryptophan by co-amorphization. The co-amorphous systems were prepared by milling at low temperatures, and their amorphous content was monitored by Powder X-Ray Diffraction, FTIR-ATR, and DSC. X-ray diffraction showed a stability improvement from less than a couple of hours to at least two months. The solubility advantage of the ranolazine co-amorphous system with the best thermal stability (higher glass transition temperature) was found to be greatly enhanced, comparing to the respective crystalline counterpart.
The pure amorphous components followed different stepwise relaxation paths to crystalline polymorphs, depending on the experimental conditions. Furthermore, for the first time, phase transitions between tryptophan polymorphic forms were investigated, and experimental evidence of the presence of traces of the neutral form of a vital amino acid was found in pure solid phases at room temperature.

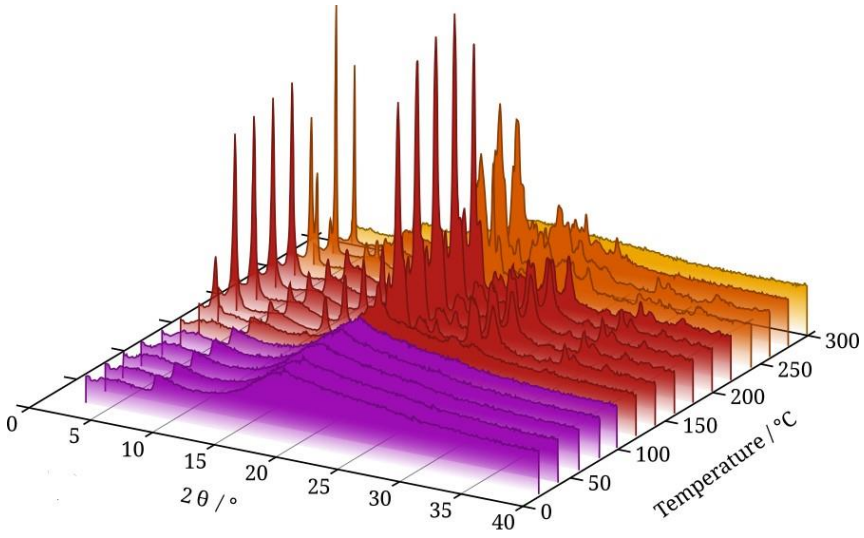


Figure 1: Stepwise relaxation of amorphous tryptophan followed by Powder X-Ray Diffraction.

Acknowledgements
Acknowledgments: CQC-IMS and CFisUC are funded by Fundação para a Ciência e Tecnologia (FCT) projects UIDB/00313/2020 and UID/FIS/04564/2020, respectively. Access to TAIL-UC facility, funded under QREN-Mais Centro Project ICT/2009/02/012/1890, is gratefully acknowledged. Joana F. C. Silva acknowledges FCT for the SFRH/BD/146809/2019 Ph.D. scholarship.

References
1. Kim, D.; Kim, Y.; Tin, Y.-Y.; Soe, M.-T.-P.; Ko, B.; Park, S.; Lee, J. *Pharmaceutics* **2021**, *13* (8), 1318.
2. Liu, J.; Grohganz, H.; Löbmann, K.; Rades, T.; Hempel, N.-J. *Pharmaceutics* **2021**, *13* (3), 389.

Uncovering raspberry seeds' biomolecules

Paloma Lopes[1,2]*, Isabel M. P. L. V. O. Ferreira[2], Manuel A. Coimbra[1], Sílvia Petronilho[1,3], Cláudia P. Passos[1]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]LAQV-REQUIMTE, Department of Chemical Sciences, Laboratory of Bromatology and Hydrology, Faculty of Pharmacology – University of Porto, 4050-313 Porto, Portugal; [3]Chemistry Research Centre-Vila Real, Department of Chemistry, University of Trás-os-Montes and Alto Douro, Quinta de Prados, 5001-801 Vila Real, Portugal
**palomalopes@ua.pt*

Raspberries seeds (RS) are the main byproduct generated during raspberry fruits processing for the manufacture of juices, jams, jellies, and desserts, among others[1]. RS are known for possessing a specialty oil in the form of raspberry seed oil (RSO), that is rich in polyunsaturated fatty acids (PUFAs) and other bioactive compounds like vitamins and phytosterols. Despite that, RS have been mainly discarded by the food industry, and any commercial RSO extraction done is driven for cosmetic applications[2]. Furthermore, the remaining composition of RS remains unknown, including its polymeric fractions (polysaccharides and proteins), that can be valorized in novel food applications. In this work, RS was defatted by *n*-hexane Soxhlet extraction followed by ethanol to recover the RSO and a phenolic-rich extract (RSP), respectively. Then, the remaining material was submitted to microwave-assisted extractions (MAE)[3] applying a fractionated design of experiences to maximize the recovery of polysaccharides and proteins from the RS. Four factors with 2 levels were studied: controlling temperature (120-200 ºC), time (2-10 min), mass (2-6 g), and acidity (0-0.3M acetic acid). The results revealed that RSO was rich in PUFAs (96% of the triacylglycerols content) and had antioxidant effect equivalent to 6.3 mM of vitamin E. Besides, RSP showed an antioxidant activity equivalent to 8.0 mM of vitamin E. Furthermore, it was revealed that RS possesses a total of 23% of carbohydrates, mainly glucans, arabinoxylans, pectins and xyloglucans, and 8% of protein. After MAE extraction, a total of ca. 14% of soluble material was recovered being ca. 4 times richer in protein and ca. 1.5 times in carbohydrates when compared to the RS. Thus, RS revealed to have biomolecules of interest to be explored in added value applications that can be recovered by green technologies like MAE, following circular economy concepts.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCTES for the financial support of LAQV-REQUIMTE (UIDB/50006/2020 + UIDP/50006/2020) research unit and CQ-VR at UTAD Vila Real (UIDP/00616/2020) through PT national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement, Compete 2020. Thanks are also made to the financial support of NORTE 2020 under the PT 2020, through ERDF and FSE. FCT is also thanked for the post-doc grant SFRH/BPD/117213/2016 (SP) and for the Individual Call to Scientific Employment Stimulus (CPP, CEECIND/01873/2017).

References
1. J. Milala, K. Grzelak-Błaszczyk, M. Sójka, M. Kosmala, A. Dobrzyńska-Inger and E. Rój, *J Food Process Preserv*, 2018, **42**, 1–7.
2. A. Ispiryan, J. Viškelis and P. Viškelis, *Plants*, 2021, **10**, 944.
3. C. P. Passos and M. A. Coimbra, *Carbohydr Polym*, 2013, **94**, 626–633

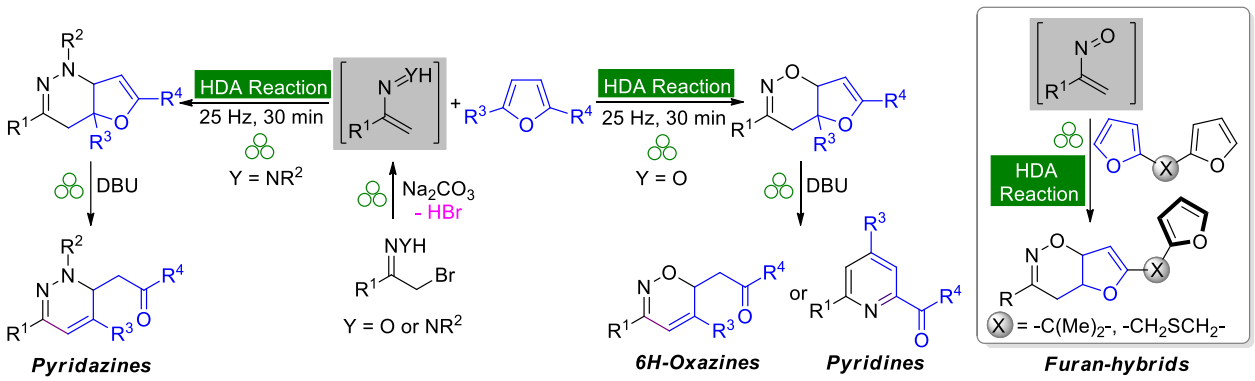
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Mechanochemical transformations of furans: Sustainable methodologies for the synthesis of heterocycles

Bruna Duarte*, Josélia Sousa, Ricardo Casaleiro, Maria Moura, Teresa M. V. D. Pinho e Melo, Ana L. Cardoso, Marta Pineiro

University of Coimbra, Coimbra Chemistry Centre – Institute of Molecular Sciences (CQC-IMS) and Department of Chemistry, 3004-535 Coimbra, Portugal.
**brunaeliduarte@hotmail.com*

The chemical industry and, in particular, the pharmaceutical industry has been essential for the development of humanity and for increasing life expectancy and well-being. However, it is essential to strengthen the transition to more sustainable production patterns. It is necessary to develop new synthetic methodologies that incorporate the principles of Green Chemistry, in order to achieve sustainable development in the production of high added value products, such as active pharmaceutical ingredients.[1] In this context, the main objective of this work is to establish sustainable methodologies based on the reactivity of furans towards *in situ* generated nitroso- and azoalkenes.[2] Through the selective hetero-Diels-Alder reaction (HAD) under mechanochemical conditions, in a single step and without solvent, furan derivatives were transformed into bicycles (furan-dihydrooxazines and furan-tetrahydropyridazines) and furan-hybrids in short reaction time with yields up to 95%. In addition, these bicycles could be further transformed into other functionalized heterocycles (*e.g.* 6*H*-oxazines, pyridines and pyridazines) by DBU-promoted ring-opening reactions of furans, under mechanical conditions (Scheme 1). The development of these methodologies allows the sustainable transformation of furans into new families of compounds increasing the structural diversity and therefore the applicability of compounds derived from biomass. In this presentation, details of this study and the mechanisms underlying these transformations will be disclosed.



Scheme 1: Novel sustainable synthetic routes towards heterocycles.

Acknowledgements
Thanks are due to Coimbra Chemistry Centre – Institute of Molecular Sciences (CQC-IMS), supported by the Portuguese Agency for Scientific Research "Fundação para a Ciência e a Tecnologia" (FCT), through projects UIDB/00313/2020 and UIDP/00313/2020, co-funded by COMPETE2020-UE, and the IMS special complementary funds provided by FCT. This work was also supported by Project PTDC/QUI-QOR/0103/2021, funded by national funds (PIDDAC). The authors also acknowledge the UC-NMR facility for obtaining the NMR data (www.nmrccc.uc.pt).

References

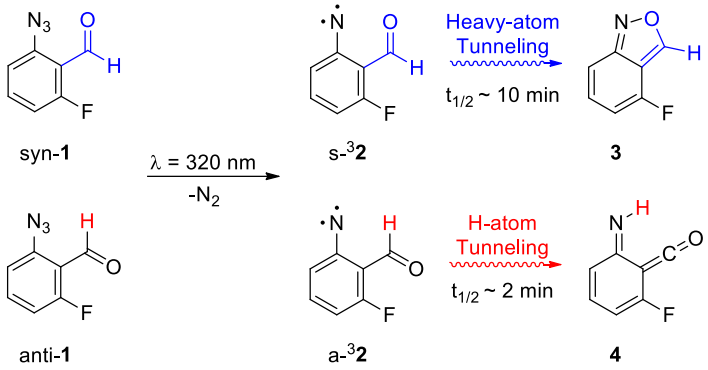
1. Anastas, P.; Eghbali, N. Green Chemistry: Principles and Practice. *Chem. Soc. Rev.* **2010**, 39, 301–312.
2. a) Lopes, S. M. M.; Cardoso, A. L.; Lemos, A.; Pinho e Melo, T. M. V. D., *Chem. Rev.* **2018**, 118, 11324-11352. b) Lopes, S. M. M.; Henriques, M. S. C.; Paixão, J. A.; Pinho e Melo, T. M. V. D., *Eur. J. Org. Chem.* **2015**, 6146-6151. c) Alves, A. J. S.; Lopes, S. M. M.; Henriques, M. S. C.; Paixão, J. A.; Pinho e Melo, T. M. V. D., *Eur. J. Org. Chem.* **2017**, 4011-4025.

Simultaneous Tunneling Control in Conformer Specific Reactions

José P. L. Roque[1,*], Cláudio M. Nunes[1], Luís P. Viegas[1], Srinivas Doddipatla[1], Samuel A. Wood[2], Robert J. McMahon[2], Rui Fausto[1]

[1]*University of Coimbra, CQC-IMS, Department of Chemistry, Rua Larga, 3004-535, Coimbra, Portugal*
[2]*University of Wisconsin−Madison, Department of Chemistry, Wisconsin 53706-1322, Madison, United States*
**jroque@qui.uc.pt*

The classical interpretation of chemical selectivity is based on relative potential energies and barrier heights, leading to thermodynamic and kinetic control. However, it has recently been shown that these concepts are not comprehensive and that quantum tunneling can also direct chemical selectivity.[1] Quantum tunneling is very sensitive to the barrier width of a reaction, which is measured by the mass-weighted displacement of the atoms involved on it. Reactions that occur exclusively through higher, yet narrower, barriers than other alternative paths are considered to operate through tunneling control. There is the perspective that tunneling control might be essential to understand chemical reactivity.[2]
In 2016, our groups reported the first occurrence of a tunneling reaction in a nitrene intermediate, specifically the [1,4]H-shift reaction of parent triplet 2-formylphenylnitrene to singlet 6-imino-2,4-cyclohexadien-1-ketene.[3] Since then, 2-formylphenylnitrene derivatives have been used by us as a gateway to study complex tunneling phenomena.[4] The present communication will highlight the most recent discoveries on the rich chemistry of 2-formyl-3-fluorophenylnitrene (**s-^{3}2** and **a-^{3}2**) isolated in a nitrogen matrix at 10 K, which depending on the conformation undergo either ring cyclization to benzoxazole **3** or [1,4]H-shift to the corresponding imino-ketene **4** (Scheme 1).[5] The mechanisms underlaying such reactivity and the role of tunneling control will be discussed both theoretically and experimentally.



Scheme 1: Tunneling reactions occurring in different conformers of triplet 2-formyl-3-fluorophenylnitrene (**a-^{3}2** and **s-^{3}2**) in a nitrogen matrix at 10 K.

Acknowledgements
This work was supported by Project PTDC/QUI-QFI/1880/2020, funded by National Funds via the Portuguese Foundation for Science and Technology (FCT). The Coimbra Chemistry Centre − Institute of Molecular Sciences (IMS) is supported by FCT through projects UIDB/00313/2020 and UIDP/00313/2020 cofunded by COMPETE and the IMS special complementary funds provided by FCT. J.P.L.R. acknowledges FCT for a PhD (SFRH/BD/04467/2020) grant. C.M.N. acknowledges FCT for an Auxiliary Researcher grant.

References
1. P. R. Schreiner, *J. Am. Chem. Soc.*, 2017, **139**, 15276–15283.
2. P. R. Schreiner, *Trends Chem.*, 2020, **2**, 1–10.
3. C. M. Nunes, S. N. Knezz, I. Reva, R. Fausto and R. J. McMahon, *J. Am. Chem. Soc.*, 2016, **138**, 15287–15290.
4. C. M. Nunes, L. P. Viegas, S. A. Wood, J. P. L. Roque, R. J. McMahon and R. Fausto, *Angew. Chemie - Int. Ed.*, 2020, **59**, 17622–17627.
5. C. M. Nunes, J. P. L. Roque, S. Doddipatla, S. A. Wood, R. J. McMahon and R. Fausto, *J. Am. Chem. Soc.*, 2022, **144**, 20866–20874.

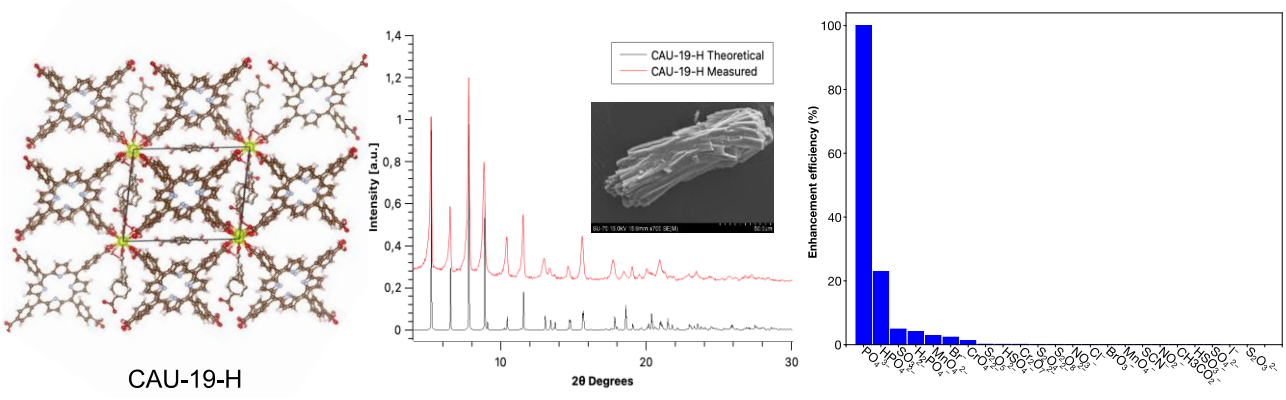
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Metal-organic frameworks: Development of a sensor for phosphate detection

E. Andrade*, F. A. A. Paz, F. Figueira

Department of Chemistry & CICECO, Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal.
**eduardaandrade@ua.pt*

Over the past few decades, Metal-Organic Structures (MOFs) have been widely studied for a wide variety of properties and applications. Their main characteristics are high porosity, large specific surface area, and adjustable composition.[1] Lately, interest has grown in the use of luminescent MOFs for detection systems due to their range of applications in chemical detection and bio imaging. The source of the luminescence can originate from metal centers, chromophore ligands, or a combination of both. Lanthanide ions are a good example of metal centers due to their optical properties but also in terms of network stability and structural diversity.[2] The phosphate molecule is composed of elements such as phosphorus (P) and oxygen (O). The element P is the 11th most abundant on planet Earth, which makes phosphate mines widely exploited for a variety of applications.[3] Besides the importance of phosphates in the biological environment, agriculture and industry, these compounds also play a key role at the environmental level. These compounds are widely used in agriculture in the form of fertilizers that when infiltrated into the soils will subsequently contaminate the waters and significantly increase the number of phosphates present in the aquatic environment.[4] Although phosphates are an essential nutrient, when too much of it is presence, it can also be harmful to the environment, more in particular to the aquatic environment. The eutrophication process occurs when there are high concentrations of nutrients, such as phosphates, in the aquatic environment, which facilitates the proliferation of harmful algae and associated problems as a consequence.[5] Thus, with this work it is intended to develop a phosphate sensor for application in measuring the level of phosphates present in aquatic ecosystems in order to control/prevent eutrophication.



Scheme 1: MOF structure, XRD diffractogram and fluorescence. (Color scheme: Gray - Nitrogen; Red - Oxygen; Brown - Carbon; Green - Cerium).

Acknowledgements
We acknowledge University of Aveiro and FCT/MCTES (Fundação para a Ciência e a Tecnologia, Ministério da Ciência, da Tecnologia e do Ensino Superior) for financial support to to CICECO—Aveiro Institute of Materials (Refs. UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) through national founds (PIDDAC) and, where applicable, co-financed by the European Regional Development Fund (FEDER), within the PT2020 Partnership Agreement. The research contract of FF (REF-168-89-ARH/2018) is funded by national funds (OE), through FCT, in the scope of the framework contract foreseen in Nos. 4, 5 and 6 of article 23 of the Decree-Law 57/2016, of 29 August, changed by Law 57/2017, of 19 July.

References

1. S. A. Younis, N. Bhardwaj, S. K. Bhardwaj, K.-H. Kim, A. Deep, *Coordination Chemistry Reviews* **2021**, *429*.
2. Z. Hu, B. J. Deibert, J. Li, *Chem Soc Rev* **2014**, *43*, 5815-5840.
3. H. Tiessen, in *The Ecophysiology of Plant-Phosphorus Interactions* (Eds.: P. J. White, J. P. Hammond), Springer Netherlands, Dordrecht, **2008**, pp. 1-7.
4. G. S. Zhang, Z. W. Ni, *Soil Use and Management* **2018**, *34*, 266-275.
5. D. W. Schindler, S. R. Carpenter, S. C. Chapra, R. E. Hecky, D. M. Orihel, *Environmental Science & Technology* **2016**, *50*, 8923-8929; bN. Lucy, T. Robert, in *Phosphorus* (Ed.: Z. Tao), IntechOpen, Rijeka, **2018**, p. Ch. 4.

Oxime functionalization towards the enhancement of photophysical properties of BODIPYs

João C.S. Simões*, Diogo Veiga, Sofia F. Duarte, Susana M. M. Lopes[1], Ana Clara B. Rodrigues[1], Sérgio J. Seixas de Melo[1], Marta Pineiro[1], Teresa M.V.D. Pinho e Melo[1]

University of Coimbra, Coimbra Chemistry Centre-Institute of Molecular Sciences and Department of Chemistry, Coimbra, Portugal.
**joao95simoes@gmail.com*

BODIPYs are a class of highly conjugated heterocyclic compounds with photophysical properties relevant to their use as fluorescence imaging agents.[1] By introducing specific substituents into their core structure, it is possible to generate new derivatives with distinct properties. In our research group, we have devised innovative methods for synthesizing and functionalizing dipyrromethanes using nitroso- and azoalkenes chemistry. These dipyrromethanes served as precursors of novel BODIPYs containing an oxime group (e.g., compound **1**).[2-6] The analysis of UV-Visible and fluorescence spectra demonstrated the enhancement of BODIPY's photophysical characteristics through oxime functionalization. Those derivatives which were substituted at the *α*-position showed better features than *meso*-substituted BODIPYs, highlighting the importance of the position of the substituent when designing imaging agents such as BODIPYs. In summary, the presence of the oxime moiety at the *α*-position (compound **1**) plays a significant role in influencing the fluorescence quantum yield, with the oxime-functionalized BODIPY retaining the photophysical characteristics of the model (520 nm) while showing a red-shifted broad band (543 nm).

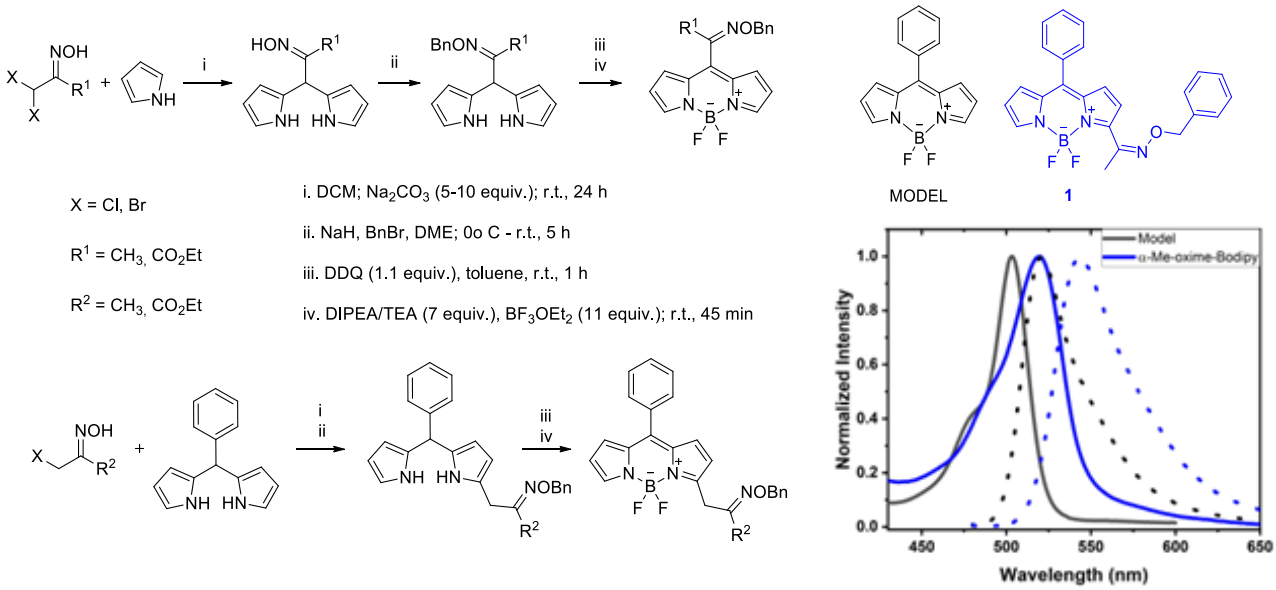


Figure 1: i) Schematic routes for BODIPYs synthesis and functionalization with oxime or hydrazone groups, ii) normalized absorption (solid line) and emission spectra (dotted line) of oxime functionalized BODIPYs on the meso/ α-position.

Acknowledgements
The Coimbra Chemistry Centre – Institute of Molecular Sciences (CQC-IMS) is supported by Portuguese Foundation for Science and Technology (FCT) through projects UIDB/00313/2020 and UIDP/00313/2020 (National Funds) and the IMS special complementary funds provided by FCT. This work was also supported by Project PTDC/QUI-QOR/0103/2021, funded by national funds (PIDDAC) via FCT.

References
1. R. Jorda, S.M.M. Lopes, E. Řezníčková, V. Kryštof, and T.M.V.D. Pinho e Melo, ChemMedChem, 2017, **12**,701-711.
2. S.M.M. Lopes, and T.M.V.D. Pinho e Melo, *J. Org. Chem.,* 2020, **85**, 3328–3335.
3. N.A.M. Pereira, S.M.M. Lopes, A. Lemos, and T.M.V.D. Pinho e Melo, Synlett, 2014, **25**, 0423–0427.
4. S.M.M. Lopes, A.L. Cardoso, A. Lemos, and T.M.V.D. Pinho e Melo, Chem. Rev., 2018, **118**, 11324– 11352.
5. S.C.C. Nunes, S.M.M. Lopes, C.S.B. Gomes, A. Lemos, A.A.C.C. Pais, and T.M.V.D. Pinho e Melo, J. Org. Chem., 79 (2014), 10456–10465.
6. S.M.M. Lopes, A. Lemos, T.M.V.D. Pinho e Melo, Eur. J. Org. Chem., 2014, 7039-7048.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Unraveling the supramolecular self-assembly mechanism of a wine-inspired pyranoflavylium

Alexandra Borges[1*], Victor de Freitas[1], Joana Oliveira[1], Nuno Basílio[2]

[1]LAQV – REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, 687, 4169- 007 Porto, Portugal; [2]LAQV – REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
**alexandra.borges@outlook.pt*

Dye aggregates have been widely explored in the past decades as they exhibit outstanding characteristics, such as dynamic and responsive behavior, that are not observed in the individual dye molecule but only after its self-assembly[1]. Supramolecular polymerization mechanisms are often divided into two major groups: isodesmic models, the simplest mechanism that is frequently observed in dye aggregation, and cooperative mechanisms that are observed in a great number of important biological processes namely the polymerization of actin and islet amyloid polypeptide.[2-4]

In this work, the self-assembly of a wine-inspired pyranoanthocyanin in water was studied by evaluating temperature and concentration-dependent color changes throughout the supramolecular assembly process. Although the cooperative behavior is commonly observed in biological systems, kinetic and thermodynamic studies revealed that the self-assembly of this pyranoanthocyanin follows a cooperative aggregation mechanism, that leads to strong temperature and concentration-dependent chromatic changes (Figure 1). Detailed studies show that the aggregations kinetics presents a direct correlation with pH, salt concentration and solvent. Finally, atomic force microscopy (AFM) allowed to obtain further information about the shape of the dye aggregates.

We envisage that this interesting discovery holds potential for new applications of these bio-inspired dyes, as novel molecular probes to investigate complex self-assembly phenomena in aqueous solution or as sophisticated time-dependent thermochromic labels.

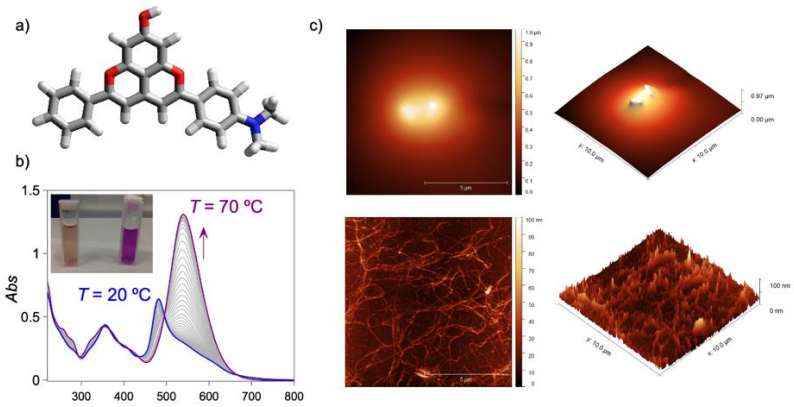


Figure 1: a) Structure of the pyranoflavylium compound. b) Effect of temperature on compound aggregation. c) AFM images of the dye in 100% EtOH (up) and 10% EtOH (down).

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry – LAQV (UIDB/50006/2020) which is financed by national funds from FCT/MCTES. The authors thank the Fundação para a Ciência e a Tecnologia for the doctoral grant from (UI/BD/151270/2021) (AB). The authors also thank FCT/MCTES for research contracts CEECIND/00466/2017 (NB) and CEEC 2022.00042.CEECIND/CP1724/CT0017 (JO).

References

1. Chen, Z.; Lohr, A.; Saha-Möller, C. R. and Würthner, F., Chemical Society Reviews 2009, 38 (2), 564-584.
2. Korevaar, P. A.; George, S. J.; Markvoort, A. J.; Smulders, M. M. J.; Hilbers, P. A. J.; Schenning, A. P. H. J.; De Greef, T. F. A.; Meijer, E. W., Nature 2012, 481 (7382), 492-496.
3. Padrick, S. B. and Miranker, A. D., Biochemistry 2002, 41 (14), 4694-703.
4. De Greef, T. F.; Smulders, M. M.; Wolffs, M.; Schenning, A. P.; Sijbesma, R. P.; Meijer, E., Chemical Reviews 2009, 109 (11), 5687-5754.

Magnetic zeolite-based adsorbents for water remediation

G. Grous[1,*], M. Karmaoui[2], C. M. Granadeiro[1]

*[1]LAQV-REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Science, University of Porto, R. Campo Alegre, s/n 4169-007 Porto, Portugal; [2]University of Science and Technology, Faculty of Chemistry, P.O. Box 1505, 31000 Oran, Algeria. *gisantos143@gmail.com*

The escalating use of antibiotics for disease treatment has led to the exponential increase of antibiotic residues in various matrices, including food and water, posing significant risks to human health and the environment. The third-generation quinolone antibiotic, levofloxacin (LVX), is specifically targeted due to its high resistance and widespread presence in surface and groundwater.[1] The World Health Organization (WHO) recognizes the emergence of antibiotic resistance as a global health threat and highlights the misuse and overuse of antibiotics as contributing factors.[2] Faced with this problem, several water treatment solutions have been proposed, including adsorption. Adsorption has been successfully applied in the removal of several water pollutants due to its relatively simple design, ease of operation, low cost, efficiency and versatility.[3] Zeolites, natural or synthetic, have been extensively applied as adsorbents owing to their porosity, low cost, abundance, thermal stability and high adsorption capacity under mild operating conditions.[4]

This work addresses the urgent need to mitigate the adverse effects of antibiotic residues by investigating the application of magnetic zeolite-based composites as adsorbents for water remediation. The use of different composite materials, obtained by impregnation of magnetic nanoparticles into different types of zeolites, proved to be an effective process for the removal of LVX from aqueous medium. The prepared materials combine the porosity and stability of zeolites with the magnetic separation capacity of MNP. The prepared materials were extensively characterized by several techniques, namely, PXRD, FTIR – ATR, SEM/EDX, ICP, nitrogen adsorption-desorption isotherms, and zeta potential, allowing to confirm the successful preparation of the composites. Among the adsorbent agents tested, Fe_3O_4@CHA exhibited the best adsorptive performance, reaching a removal efficiency of 75.8% in the preliminary tests. Parameter optimization studies were conducted leading to a contact time of 5 hours, a pH of the initial LVX solution of 8 and an adsorbent mass of 10.00 mg. Kinetic studies were performed for the adsorption of LVX by Fe_3O_4@CHA and the results suggest that the adsorption process follows a pseudo-second order model. The stability and recyclability of the adsorbent along consecutive adsorption cycles was also evaluated, revealing that the material still exhibits a high uptake capacity up to the 5th cycle. In this work, it was possible to develop an efficient antibiotic removal system with magnetic separation capacity, high recyclability and sustainability. The proposed materials combine the low cost of the precursors, easy magnetic separation and adsorptive performance highlighting their exceptional potential for application in water remediation.

Acknowledgments

This research work received financial support from the Portuguese National Funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the strategic project UIDB/50006/2020 for LAQV/REQUIMTE. FCT/MCTES is also acknowledged for funding through the Individual Call to Scientific Employment Stimulus with the reference 2022.02651. CEECIND/CP1724/CT0011 (C.M.G.).

References

1. SAYA, L. et al. A comprehensive review on recent advances toward sequestration of levofloxacin antibiotic from wastewater. Science of The Total Environment, v. 813, p. 152529, 2022. DOI: 10.1016/j.scitotenv.2021.152529.
2. WORLD HEALTH ORGANIZATION (WHO). Fact sheets: Antimicrobial Resistance. 17th November 2021. Available at: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance. Assessed on: 11th December 2022.
3. FLORES, D. et al. Tailoring of mesoporous silica-based materials for enhanced water pollutants removal. Molecules, v. 28, p. 4038, 2023. DOI: 10.3390/molecules28104038.
4. BASKAN, G. et al. Investigation of adsorption Properties of oxytetracycline hydrochloride on magnetic zeolite/Fe3O4 particles. Advance Powder Technology, v. 33, n. 6, p. 103600, 2022. DOI: 10.1016/j.apt.2022.103600.

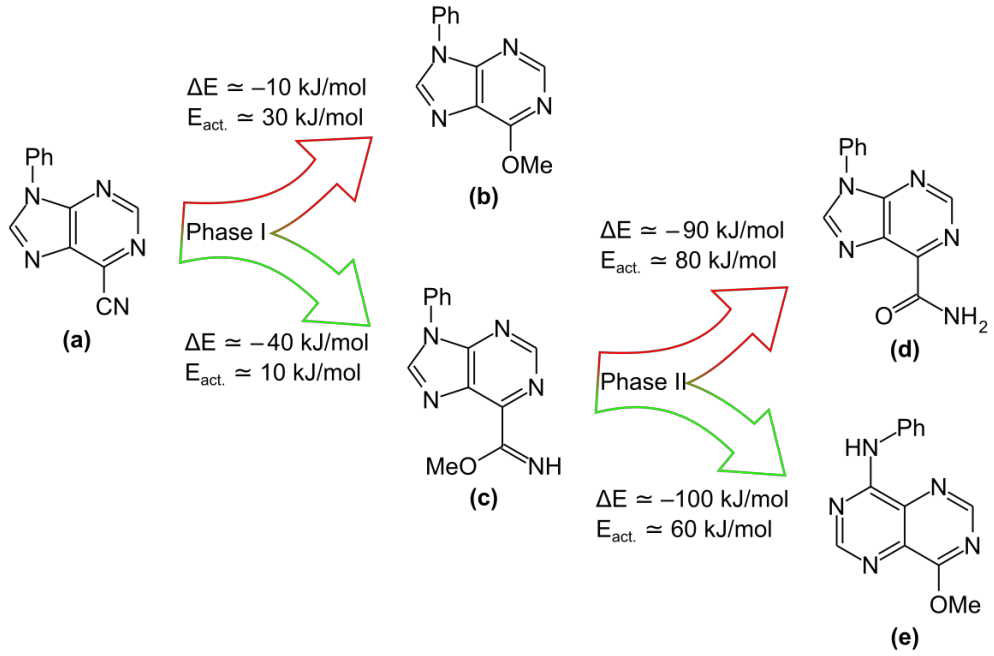
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Walking the garden of bifurcating paths: Theoretical studies on the nucleophilic addition of methoxide to 6-cyanopurines

F.Teixeira*, M. Alice Carvalho

Centre of Chemistry, University of Minho, 4710-057 Braga, Portugal
**fteixeira@quimica.uminho.pt*

The development of highly efficient methods for preparing new purine derivatives is in high demand due to their potential biological activity. Nucleophilic substitution at the 6-position of the purine ring by an alkoxide and the addition of an alkoxide to the nitrile group present at C6 have been reported as an interesting way to prompt the development of promising new purine derivatives under mild conditions[1]. However, the outcome of this reaction has been shown to be highly dependent on the reaction conditions[1].
In this work, we carried out a systematic computational survey of all possible reaction channels connecting known products of the reaction between 6-cyano-9-phenylpurine and methoxide using well established DFT techniques[2,3]. The results suggest a two-phase mechanism (Cf. Scheme 1) The first phase (fast) is dominated by mild processes with relatively low energy barriers connecting the initial purine (a) to either the substitution product (b) or the preferred addition product (c). The second phase (slow) emerges from (c) and leads to either products (d) or (e). This second phase is dominated by a multiplicity of reaction channels leading to each product. Indeed, the formation of (d) appears to benefit from the fact that it is connected to (c) via a plethora of reaction channels with mild thermochemistry and low activation barriers.



Scheme1: Summarized depiction of the possible outcomes of the nucleophilic addition of metoxide to 6-cyano-9-phenylpurine, with approximate energy balance and activation barrier for the most favorable reaction channels.

Acknowledgements
This work was supported by the Portuguese Foundation for Science and Technology (FCT) under the programmatic funding to CQUM (UID/QUI/00686/2020).

References

1. M.A.Carvalho *et al.*, *Org. Biomol. Chem.*, 2004, **2**, 1019-1024
2. F. Teixeira, A. Melo, M. N. D. S. Cordeiro, *Comput. Theor. Chem.*, 2013, **1012**, 54-59
3. F. Teixeira *et al.*, *Inorg Chem.*, 2017, **56**, 2124-2134

Trilayered bacterial nanocellulose patches loaded with acyclovir and hyaluronic acid for dual mode treatment of herpetic lesions

Ana C. Q. Silva*, Armando J. D. Silvestre, Carla Vilela, Carmen S. R. Freire

CICECO – Aveiro Institute of Materials and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**ana.cristina.silva@ua.pt*

Acyclovir (ACV) is an antiviral drug widely used to treat herpes simplex virus-1 (HSV-1) infections that manifest as fluid-filled blisters on the perioral region (commonly known as herpes labialis or cold sores), often accompanied by burning, tingling or itching sensations.[1,2] Current topical treatments, namely ACV-based creams like Zovirax®, have limitations, such as frequent re-application and susceptibility to removal by external factors (e.g., rubbing, eating). Skin patches, such as Compeed®, offer an efficient alternative by maintaining a moist environment and providing a protective barrier for the affected region. However, these patches do not contain any pharmaceutical agents and focus primarily on the wound treatment.
In this study, we aimed to develop biopolymeric patches with both antiviral and wound-healing capabilities for treating herpes labialis. Bacterial nanocellulose (BNC) membranes, known for their high purity, mechanical strength, porosity, water-holding capacity, and biocompatibility, were chosen as the matrix. In addition to ACV, hyaluronic acid (HA), a natural polysaccharide known to promote wound healing and cell proliferation[3], and glycerol (Gly), owing to its humectant and plasticizer capabilities[4], were also incorporated into the BNC membranes by simple diffusion of the corresponding aqueous solutions into the wet BNC porous network. Subsequently, BNC membranes with variable compositions were assembled into three layers, yielding two different trilayered patches (Figure 1). The patches were characterized in terms of their structure, morphology, thermal stability, UV-barrier properties, mechanical performance, moisture- and water-uptake capacity, and in vitro drug release profile. Moreover, the in vitro biocompatibility with dermal fibroblasts and wound healing capacity in a simulated wound were assessed. The patches exhibited good mechanical performance, adequate moisture- and water-uptake capacity, and effective UV-barrier properties. Additionally, they were non-cytotoxic to dermal fibroblasts and promoted cell adhesion and proliferation. These trilayered patches show great potential for simultaneous drug delivery and wound healing, offering a promising approach for the dual-action treatment of herpes labialis.

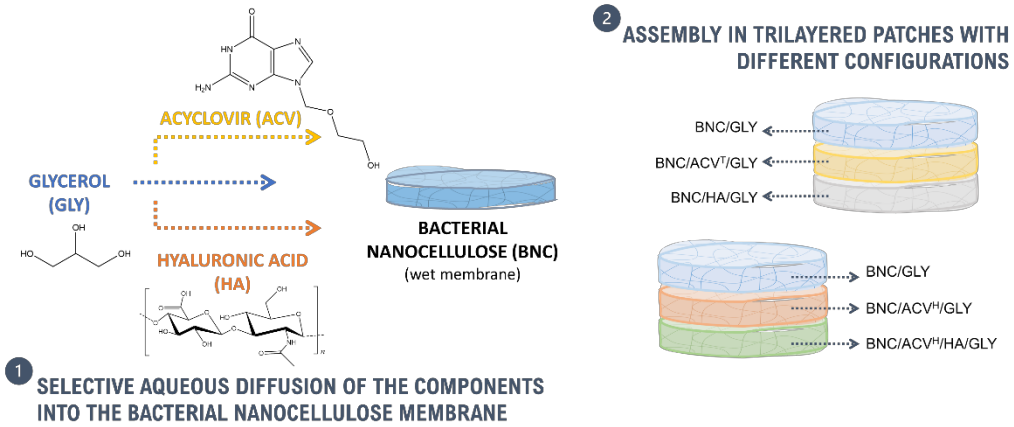


Figure 1: Preparation of the trilayered nanostructured patches.

Acknowledgements
This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). FCT is also acknowledged for the doctoral grant to A.C.Q.S. (SFRH/BD/140230/2018 and COVID/BD/152979/2022) and the research contracts under Scientific Employment Stimulus to C.V. (CEECIND/00263/2018 and 2021.01571.CEECIND) and C.S.R.F. (CEECIND/00464/2017).

References
1. D. Mondal, in *Reference Module in Biomedical Sciences*, Elsevier, 2016, pp. 1–5.
2. C. James, M. Harfouche, N. J. Welton, K. M. E. Turner, L. J. Abu-Raddad, S. L. Gottlieb and K. J. Looker, *Bull. World Health Organ.*, 2020, **98**, 315–329.
3. Z. Hussain, H. E. Thu, H. Katas and S. N. A. Bukhari, *Polym. Rev.*, 2017, **57**, 594–630.
4. I. Cielecka, M. Szustak, H. Kalinowska, E. Gendaszewska-Darmach, M. Ryngajłło, W. Maniukiewicz and S. Bielecki, *Cellulose*, 2019, **26**, 5409–5426.

P52

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Preparation of a tri-hybrid composite material through wetness impregnation method for the desulfurization of heavy fuel oil

S. C. Fernandes[1,*], P. Leo[2], B. de Castro[1], L. Cunha-Silva[1], S. S. Balula[1]

[1]*LAQV/REQUIMTE, Faculdade de Ciências da Universidade do Porto, 4169-007, Porto, Portugal*
[2]*Department of Chemical and Environmental Technology, Universidad Rey Juan Carlos, 28933, Móstoles, Spain*
**up201603496@fc.up.pt*

The combustion of sulfur-based compounds present in fuels results in the emission of hazardous gases, namely sulfur oxides (SO_x). Currently, strict legislation has been established demanding low sulfur limits for road fuels (S < 10 ppm) and marine fuels (S < 500 ppm).[1] The traditional method for the removal of sulfur in fuels, hydrodesulfurization (HDS), is well established but is based on expensive technology, requiring severe experimental conditions to achieve high efficiency in diesel. Maritime fuels until 2020 were based on heavy fuel oils (HFOs). The high viscosity and high molecular weight of HFOs do not allow the use of HDS technology. A promising technology to treat HFO is the oxidative desulfurization (ODS). Through ODS, sulfur compounds can be effectively removed from fuels using moderate temperatures and atmospheric pressure.[2]
Polyoxometalates (POMs), such as $H_3PMo_{12}O_{40}$ (PMo_{12}), show high catalytic performance in several oxidative reactions; however, they are highly soluble in catalytic media and behave as homogeneous catalysts. Therefore, their heterogenization in solid supports, such as metal-organic frameworks (MOFs), leads to active heterogeneous catalysts with robustness and easy recovery from the reaction. The effectiveness of POM@MOF catalysts has been shown in previous studies.[3] Our research group recently prepared a novel material PMo_{12}@MOF-808 that was revealed to be active and recyclable for ODS using a multicomponent model fuel.[4] However, the sturdiness provided by MOFs isn't always sufficient to ensure structural stability and prolonged recycling reaction cycles using the same portion of the catalyst under severe reactional media, such as the treatment of HFO. Thus, the robustness of POM@MOF catalysts has been enhanced by the preparation of composites combining MOFs and mesoporous silicas, MOF@silica.[5] The incorporation of MOFs in silicas allows the final composite to retain micropores from the MOF, selective in size and shape for certain molecules; and mesopores from the silica that allow access to active sites, improving product and substrate diffusion.[6]
Reported studies on hybrid materials combining POM, MOF, and silica are very scarce.[7] A novel tri-hybrid material by incorporation of the composite, PMo_{12}@MOF-808, in mesoporous silica SBA-15 was prepared in this work. Two different methods were followed: solvothermal (PMo_{12}@MOF-808@SBA-15-ST) and incipient wetness impregnation (PMo_{12}@MOF-808@SBA-15-IWI). The composites were characterized by FTIR, PXRD, SEM-EDS, and ICP-OES and have been tested as catalysts for ODS using a multicomponent model fuel containing refractory sulfur compounds. H_2O_2 was used as oxidant and the ionic liquid $[BMIM]PF_6$ as extraction solvent. The recycling capacity and stability of the heterogeneous catalysts were also investigated. Furthermore, the activity and stability of the composite prepared by IWI was evaluated for ODS in a more complex model fuel, more representative of heavy fuel oil (HFO).

Acknowledgements
The research work developed in our research group received financial support from Portuguese national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the strategic project UIDB/50006/2020 (for LAQV / REQUIMTE). P. Leo thanks the Ministry of Universities for grant CAS21/00417.

References

1. V. Chandra Srivastava, *RSC Advances*, 2012, **2**, 759-783.
2. M. Zhang, J. Liu, H. Li, Y. Wei, Y. Fu, W. Liao, L. Zhu, G. Chen, W. Zhu and H. Li, *Applied Catalysis B: Environmental*, 2020, **271**, 118936.
3. X.-m. Zhang, Z. Zhang, B. Zhang, X. Yang, X. Chang, Z. Zhou, D.-H. Wang, M.-H. Zhang and X.-H. Bu, *Applied Catalysis B: Environmental*, 2019, **256**, 117804.
4. S. C. Fernandes, A. M. Viana, B. de Castro, L. Cunha-Silva and S. S. Balula, *Sustainable Energy & Fuels*, 2021, **5**, 4032-4040.
5. N. Yuan, X. Zhang and L. Wang, *Coordination Chemistry Reviews*, 2020, **421**, 213442.
6. C. Chen, N. Feng, Q. Guo, Z. Li, X. Li, J. Ding, L. Wang, H. Wan and G. Guan, *Journal of Colloid and Interface Science*, 2018, **513**, 891-902.
7. S.-W. Li, J.-R. Li, Q.-P. Jin, Z. Yang, R.-L. Zhang, R.-M. Gao and J.-S. Zhao, *Journal of hazardous materials*, 2017, **337**, 208-216.

Characterization of a small cytochrome *c* from *Wolinella succinogenes* a putative electron donor of "Clade II" cytochrome *c* N_2O reductase

Vitor H. Mordido[1,2,*], Marta S. P. Carepo[2], Cristina Cordas[2], Jörg Simon[3], Isabel Moura[2], Sofia R. Pauleta[1]

[1]Microbial Stress Lab, UCIBIO – Applied Molecular Biosciences Unit, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal and Associate Laboratory i4HB - Institute for Health and Bioeconomy, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal. [2]LAQV, REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal; [3]Microbial Energy Conversion and Biotechnology, Department of Biology, Technische Universität Darmstadt, Schnittspahnstraße 10, 64287 Darmstadt, Germany
**v.mordido@campus.fct.unl.pt*

Nitrous oxide reductases (N_2OR) are enzymes capable of reducing N_2O from the environment, one of the biggest contributors to the greenhouse effect and destruction of the ozone layer.[1] These enzymes possess two copper centres, CuZ and CuA, being the catalytic and the electron transferring centre, respectively. N_2OR can be divided into two families, based on the organisation of the *nos* cluster gene: "Clade I" and "Clade II".[2] Some "Clade II" N_2ORs have an additional domain in the C-terminus that binds a *c*-type haem which has been postulated to be part of the electron transfer pathway from the quinol pool or other redox protein to the CuA centre.[2] The redox partners identified for "Clade I" N_2OR are small *c*-type haem or type-I copper proteins.[3] *Wolinella succinogenes* genome encodes for a "Clade II" N_2OR with the additional *c*-type haem binding domain. The electron donor has been proposed to be a small periplasmic cytochrome *c*.[4,5] The gene encoding this *W. succinogenes* small cytochrome *c* was cloned in an expression vector and the protein heterologously produced in *Escherichia coli*. The production of this protein was optimized, as well as its purification. The purified protein was biochemically characterized by different spectroscopic techniques.

Acknowledgements
This work was supported by Fundação para a Ciência e Tecnologia by national funds: 2022.01152.PTDC (to IM), VH thanks this project for the BI scholarship; UIDP/04378/2020 and UIDB/04378/2020 of the Research Unit on Applied Molecular Biosciences - UCIBIO and the project LA/P/0140/2020 of the Associate Laboratory Institute for Health and Bioeconomy - i4HB, and UIDB/50006/2020, UIDP/50006/2020 and LA/P/0008/2020 to Associate Laboratory for Green Chemistry-LAQV.

References
1. S. R. Pauleta, M. S. P. Carepo and I. Moura, Coordination Chemistry Reviews, 2019, **387**, 436-449.
2. S. Hein and J. Simon, Adv. Microb. Physiol., 2019, **75**, 137-175.
3. C. Carreira, M. M. C. dos Santos, S. R. Pauleta and I. Moura, Bioelectrochemistry, 2020, **133**, 107483.
4. Zhang and T. C. Hollocher, Biochimica Et Biophysica Acta – Bioenergetics, 1993, **1142(3)**, 253–261.
5. C. Baar et al., Proc. Natl. Acad. Sci. U.S.A., 2003, **100 (20)**, 11690-11695.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Decoding the exercise mimetic: An exploratory proteomic approach of plasma-derived extracellular vesicles

Ana Carolina Pinto[1], Patrícia Tavares[1,2,3], Pedro Oliveira[1], Francisco Amado[1], Daniel Moreira-Gonçalves[2], F. Bruno Neves[3], Rui Vitorino[1,3], Rita Ferreira[1]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Aveiro, Portugal; [2]CIAFEL, University of Porto, Porto, Portugal; [3]iBiMED, University of Aveiro, Aveiro, Portugal
**anacarolinapinto@ua.pt*

Extracellular vesicles (EVs) play a critical role in intercellular communication, making their study essential for understanding the health benefits of exercise[1]. In this exploratory study, we focused on the characterization of EVs isolated from plasma samples of athletes after an exercise session and from age-matched sedentary subjects by ultracentrifugation. GeLC-MS/MS analysis allowed the identification of over 200 proteins with at least 2 peptides and $p < 0.05$ in both fractions (EVs and plasma without EVs). Of these proteins, 150 had a Gravy score below zero, indicating a predominantly hydrophilic nature. In contrast, 9 proteins had a Gravy Score above zero, indicating higher hydrophobicity. According to SignalP v6.1, 61 proteins are predicted to be secreted via the canonical pathway, while 17 proteins are predicted to be secreted via the non-canonical pathway. The data suggest that most of the identified proteins are predicted not to be secreted. When the EV proteome of the two groups of subjects was compared, greater interindividual proteome variability was found in the EVs of the trained subjects, with 14 proteins differing from those of the sedentary group. Most of these proteins were derived from the immune system. Of note are LRG1 and APOM, both of which have been previously associated with health-related changes. LRG1 has been linked to angiogenesis and tumor progression[2], whereas APOM is involved in adipose tissue homeostasis and insulin sensitivity and plays a role in regulating metabolism[3]. In addition, higher levels of AGP were found in the EVs of individuals who exercised. While AGP has been associated with various cancers[4], it is noteworthy that levels also increase immediately after exercise. However, the exact molecular and cellular role of these proteins in EVs after intense muscle contraction is not fully understood. This comprehensive characterization of plasma-derived EVs provides new insights into their proteomic composition and their contribution to promoting the health benefits of exercise. Understanding the molecular profiles of EVs may pave the way for the development of targeted therapeutic strategies for a variety of diseases that can be prevented or ameliorated by physical training.

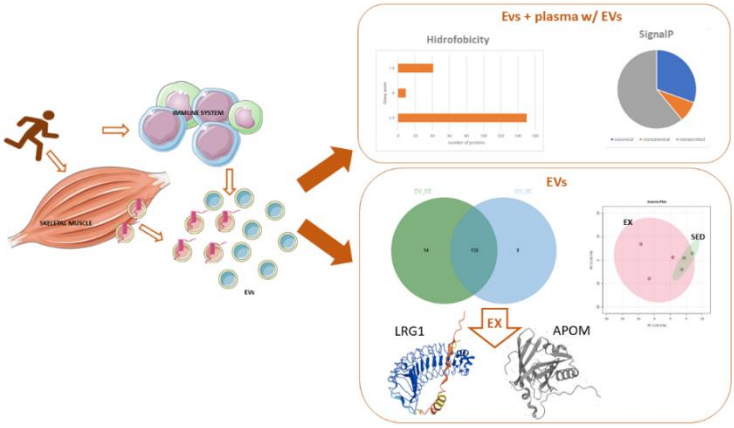


Figure 1: Proteomics characterization of EVs and plasma without EVs from sedentary and trained subjects.

Acknowledgements
This work was supported by Calouste Gulbenkian Foundation and Portuguese Foundation for Science and Technology (FCT), the European Union, FEDER, COMPETE and research units LAQV-REQUIMTE (UIDB/50006/2020), iBiMED (UIDB/04501/2020), CIAFEL (UIDB/00617/2020) and RNEM (LISBOA-01-0145-FEDER-402-022125).

References

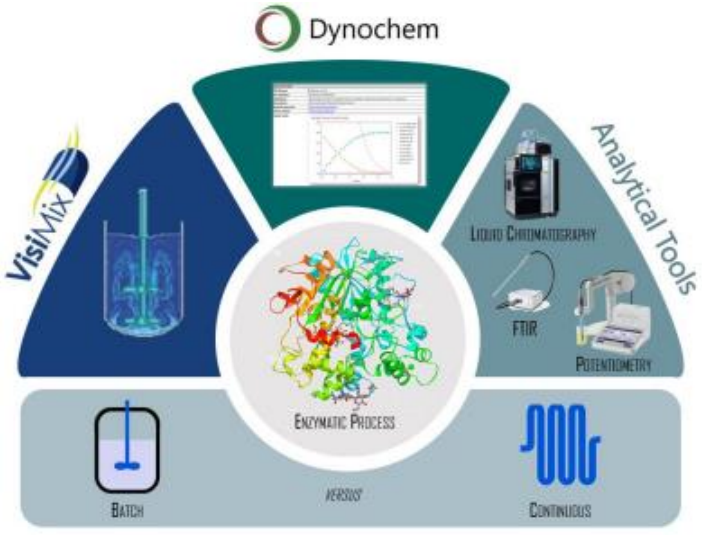
1. Trovato E, Di Felice V, Barone R. Front Physiol. 2019;10:522.
2. Wang X., Abraham S., McKenzie J.A.G., Jeffs N., Swire M., Tripathi V.B., Luhmann U.F.O, Lange C.A.K., Zhai Z., Arthur H.M., Bainbridge J., Moss S.E., Greenwood J. Nature. 2013; 499(7458):306-11.
3. Tavernier G., Caspar-Bauguil S., Viguerie N. Curr Opin Lipidol. 2020; 31(1):8-14.
4. Matsusaka K., Fujiwara Y., Pan C., Esumi S., Saito Y., Bi J., Nakamura Y., Mukunoki A., Takeo T., Nakagata N., Yoshii D., Fukuda R., Nagasaki T., Tanaka R., Komori H., Maeda H., Watanabe H., Tamada K., Komohara Y., Maruyama T. Cancer Res. 2021; 81(17):4545-4559.

A model-based approach for the development and scale-up of enzymatic processes in fine chemical industry

Filipe Estanislau[1,2,*], Claudia Bento[1,2], Nuno Lousa Pereira[1], Carlos A. M. Afonso[2], Marianna Katz[1]

[1]Hovione Farmaciência S.A. Estrada do Paço do Lumiar, Campus do Lumiar, 1649-038 Lisbon, Portugal; [2]Faculty of Pharmacy, University of Lisbon, Avenida Professor Gama Pinto, 1649-003 Lisbon, Portugal
**festanislau@hovione.com*

In recent years, there has been growing interest in the use of enzymatic processes in fine chemical industry due to their selectivity, mild reaction conditions, and sustainability. However, the development and scale-up of such processes can be challenging due to their complex mechanism and sensitivity. This work describes a model-based approach for the development and scale-up of a process wherein, where an enzyme is being used to overcome selectivity issues. During the process conditions screening stage, the application of a biocatalyst resulted in significant improvement in purity, therefore a specific set of experiments were performed to understand the complex mechanism involving multiple substrates and products, following the Quality by Design principles which include Design of Experiments and mechanistic modeling.[1] Dynochem allowed us to elucidate the reaction mechanism and investigate the effect of substrate concentration on reaction rates. Towards this end, we leveraged data obtained from an array of offline analytical techniques including high-performance liquid chromatography (HPLC), mass spectrometry (MS), UV spectroscopy, as well as process analytical technology (PAT) such as FTIR spectroscopy to monitor the reaction progression. Due to the sensitivity of enzymatic processes and their challenges during scale-up, the Visimix software was used to determine the heat and mass transfer characteristics of the laboratory and manufacturing equipment.[2-3] Furthermore, the process was performed using batch and flow mode, and the performance of the two approaches was compared. In fact, the use of biocatalysts in flow represents a cutting-edge approach that integrates the remarkable catalytic capabilities of enzymes with the advantages of continuous flow systems, by confining enzymatic reactions within a controlled and continuous flow environment, this innovative methodology facilitates enhanced reaction rates, improved selectivity, operational simplicity, and reduces waste generation, thereby offering tremendous potential for the development of greener, more cost-effective, and easier-to-scale chemical processes with significant sustainability implications for the pharmaceutical and fine chemicals industries.[4] The integration of diverse techniques and tools coupled with mechanistic modeling allowed a deeper understanding of the mechanism and its influential parameters, aiming at a more straightforward scale-up and sustainable manufacturing operations.



References
1. M. Wagner, J. Chem. Educ., 1976, 53, A472.
2. Dynochem - Scale-up Systems, https://www.scale-up.com/dynochem, (accessed May 3, 2023).
3. VisiMix - Mixing Simulation Software and Mixing Optimization Tool, https://visimix.com/, (accessed May 3, 2023).
4. B. Poznansky, L. A. Thompson, S. A. Warren, H. A. Reeve and K. A. Vincent, Org. Process Res. & Dev., 2020, 24, 2281– 2287.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Rethinking potato chips industry byproducts for the development of active cheese packaging

Sílvia Petronilho[1,2,*], Ana M. Peixoto[1], M. Rosário Domingues[3,4], Fernando M. Nunes[2], Joana Lopes[1,5], Marit K. Pettersen[6], Magnhild S. Grøvlen[6], Elin M. Wetterhus[6], Idalina Gonçalves[5], Manuel A. Coimbra[1]

[1]LAQV-REQUIMTE, Department of Chemistry, Campus Universitário de Santiago, University of Aveiro, 3810-193 Aveiro, Portugal; [2]CQ-VR, Department of Chemistry, University of Trás os-Montes and Alto Douro, Quinta de Prados, 5001-801 Vila Real, Portugal; [3]Mass Spectrometry Centre, Department of Chemistry, Campus Universitário de Santiago, University of Aveiro, 3810-193 Aveiro, Portugal; [4]CESAM-Centre for Environmental and Marine Studies, Department of Chemistry, Campus Universitário de Santiago, University of Aveiro, 3810-193 Aveiro, Portugal; [5]CICECO-Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, Campus Universitário de Santiago, University of Aveiro, 3810-193 Aveiro, Portugal
[6]Nofima-Norwegian Institute of Food, Fisheries and Aquaculture Research, NO-1431 Ås, Norway
**silviapetronilho@ua.pt*

Potato chips industry gives rise to byproducts, such as starch-rich washing slurries and brownish frying residues, potential sources of thermoplastic biomolecules and melanoidins, respectively, that can be formed during nonenzymatic browning reactions (i.e., Maillard reaction) involving compounds with amino and carbonyl groups. In this work, it was hypothesized that a brownish water-soluble extract (BrE) extracted from defatted potato frying residues can be used as a source of antioxidant compounds of interest to develop active starch-based packaging materials suitable to storage sliced cheese, a foodstuff susceptible to lipid oxidation, while following a circular approach.

BrE was composed of carbohydrates (66.9%), protein (5.7%), and small amounts of phenolics, esterified fatty acids, and melanoidins. When incorporated into starch-based formulations and casted, BrE at 5%, 10%, and 15% w/w (dry starch weight) give rise transparent and yellowish films. BrE increased the films' water tolerance, tensile resistance, elasticity, and antioxidant activity. Furthermore, starch/15% BrE-based films showed diminished water vapor and good UV-light barrier properties, when compared to the neat films. Their direct contact with semi-hard sliced cheese did not change the products' hardness during refrigerated storage (14 days, 4 ºC, and 80% relative humidity), like the cheese packed in polyamide (PA)/polyethylene (PE) plastic, already used in food packaging. Nevertheless, a cheese weight loss and a yellow-color darkening were observed related with the migration of water from the cheese through the films. Moreover, a similar volatile profile was obtained in cheese packaged either with the biobased or the petroleum-derived plastics, although BrE constituents allowed to decrease the content of ketones, a chemical family of compounds responsible for oxidation aromas. Therefore, BrE can be used as an active additive capable of tuning the physicochemical and mechanical performance of starch-based films, potentiating their use in active food packaging.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCTES for the financial support of LAQV-REQUIMTE (UIDB/50006/2020 + UIDP/50006/2020), CICECO-Aveiro Institute of Materials (UIDB/50011/2020 + UIDP/50011/2020 + LA/P/0006/2020), and CESAM (UIDB/50017/2020 + UIDP/50017/2020 + LA/P/0094/2020) research units and CQ-VR at UTAD Vila Real (UIDP/00616/2020) through PT national funds and, where applicable, cofinanced by the FEDER, within the PT2020 Partnership Agreement, Compete 2020. FCT is also thanked for the postdoc grant SFRH/BPD/117213/2016 (SP) and for the Individual Call to Scientific Employment Stimulus (IG, CEECIND/00430/2017). Thanks are also given to the financial support of Norwegian Levy on Agricultural Products through the Strategic Program FutureFoodControl (Project no 314743). The authors thank POTATOPLASTIC project (POCI-01-0247-FEDER-017938), financed by FEDER through POCI, to "Isolago—Indústria de Plásticos, S.A.", the project leader, and to "A Saloinha, Lda." for providing the potato byproducts. CIRCUL-A-BILITY cost action (CA19124) is thanked for funding the Short-Term Scientific Mission (STSM) of JL, SP, and IG. SP also thanks the financial support of Norte Portugal Regional Operational Programme (NORTE 2020), under the PT 2020 Partnership Agreement, through the European Regional Development Fund (ERDF) and FSE.

References

1. A.M. Peixoto, S. Petronilho, M.R. Domingues, F.M. Nunes, J. Lopes, M.K. Pettersen, M.S. Grøvlen, E.M. Wetterhus, I. Gonçalves and M.A. Coimbra, *Foods,* 2023, **12**, 1167.

Pyrrolidine-fused chlorin conjugated gold nanoparticles: synthesis and characterization

Juliana Machado*, José Almeida, Miguel P. Almeida, Maria Enea, Eulália Pereira, Ana M. G. Silva

LAQV-REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal
**up201906486@up.pt*

Cancer is one of the deadliest diseases of our time. Among modern clinical treatments, photodynamic therapy (PDT) of cancer is particularly attractive because it leads to fewer side effects when compared to more commonly used therapies, such as radiotherapy and chemotherapy. PDT procedure consists of administering a photosensitizer (PS) that should ideally absorb light in the phototherapeutic window (650-850 nm). In the presence of oxygen, the excited PS can produce reactive oxygen species (ROS) that will affect the tumor cells, leading to cell death via necrosis or apoptosis.[1] Particularly, for deep light penetration into tissue, a PS with strong absorption bands in the visible region near and above 650 nm (phototherapeutic window) is required, where chlorins (2,3-dihydroporphyrins) are promising candidates.

In this work, we focus our attention on the synthesis of *N*-alkylated pyrrolidine-fused chlorins and their conjugation with gold nanoparticles (AuNPs), aiming to increase the action, targeting and enhance the photosensitizing activity of the PS.[2] The chlorin ($ChlorNH_2$), having a primary amine group, was synthesized through the 1,3-dipolar cycloaddition reaction of 5,10,15,20-tetrakis(pentafluorophenyl)porphyrin with an azomethine ylide, generated from glycine and paraformaldehyde, followed by the *N*-alkylation with 2-bromoethanaminium bromide.[3] This chlorin can be easily bonded to the carboxylic acid of 11-mercaptoundecanoic acid (MUA)-coated gold nanoparticles via carbodiimide (EDC) / *N*-hydroxy succinimide (NHS), forming an amide bond. The formed $ChlorNH_2$-AuNPs conjugate was characterized by multiple techniques, including UV-Vis, fluorescence, DLS and ELS. Detailed synthetic procedures and characterization of the synthesized PSs will be presented and discussed.

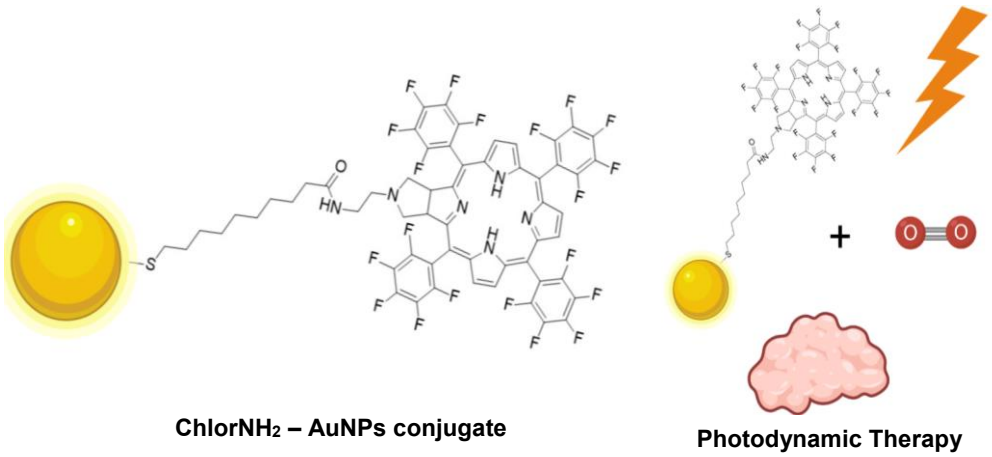


Figure 1: $ChlorNH_2$-AuNPs conjugate for PDT.

Acknowledgements
This work received financial support from the National Funds (FCT/MCTES), under the Partnership Agreement PT2020 through projects NORTE-07-0162-FEDER-000048, UIDB/50006/2020, UIDP/50006/2020, and EXPL/QUI-OUT/1554/2021. A. M. G. Silva thanks FCT for funding through program DL 57/2016 – Norma transitória.

References
1. J. M. Dąbrowski, B. Pucelik, A. Regiel-Futyra, M. Brindell, O. Mazuryk, A. Kyzioł, G. Stochel, W. Macyk and L. G. Arnaut, Coord. *Chem. Rev.*, 2016, **325**, 67–101.
2. R. A. Sperling, P. R. Gil, F. Zhang, M. Zanella and W. J. Parak, *Chem. Soc. Rev.*, 2008, **37**, 1896-1908.
3. J. Almeida, A. C. Tomé, M. Rangel and A. M. G. Silva, *Molecules*, 2023, **28**, 3833.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Delignification of olive tree pruning through eutectic solvents

I. Gómez-Cruz[1*], A. M. da Costa Lopes[1], E. Castro[2], A. J. D. Silvestre[1]

[1]CICECO – Aveiro Institute of Materials, Chemistry Department, University of Aveiro, Campus de Santiago, Aveiro 3810-193, Portugal; [2]Department of Chemical, Environmental and Materials Engineering and Center for Advanced Studies in Earth Sciences, Energy and Environment (CEACTEMA), Universidad de Jaén, Campus Las Lagunillas, 23071 Jaén, Spain.
**igcruz@ujaen.es*

Lignin is an intriguing natural and renewable resource for producing various chemical bioproducts and sustainable materials. Its valorization along with other biomass components is essential for the development of an integrated biorefinery in the context of circular economy. Yet, the development of efficient and eco-friendly biomass delignification processes is still required. In this context, eutectic solvents (ES) that exhibit excellent ability to solubilize lignin can be a good solution towards biomass delignification. In addition, these solvents impart favorable physicochemical properties to extracted lignin for its subsequent use in high value applications.

This study aims at evaluating the delignification efficiency of olive tree pruning (OTP) at different processing stages with two types of ES (binary and ternary) as well as their impact on the solid fractions obtained. Pristine OTP, aqueous extracted OTP in autoclave (120 ºC, 60 min, 10% solids) and acid pre-treated OTP (130 ºC, 84 min, 20% solids and 2.4% H_2SO_4) were used as biomass materials. Cholinium chloride (Ch[Cl]) was used as hydrogen bond acceptor (HBA), while ethylene glycol (EG) and p-toluenesulfonic acid (PTSA) were applied as hydrogen bond donors (HBDs) in the formulation of binary (Ch[Cl]:EG; 1:9) and ternary ES (Ch[Cl]:PTSA:EG; 1:1:9). The variation of temperature (80, 100, 120 and 140 ºC) and residence time (0.5, 1 and 2 h) in biomass delignification with DES was investigated.

For the three OTP materials, the use of Ch[Cl]:EG (1:9) did not present relevant differences in the delignification yields at examined temperatures and time. On the other hand, the extraction with Ch[Cl]:PTSA:EG (1:1:9) at 80 ºC showed increasing extraction yield up to 4 h. At this period of time, the best delignification yields, 60.7, 64.3 and 38.2%, were achieved for pristine, aqueous extracted and acid pre-treated OTP, respectively (Figure 1). The remaining solid fractions presented enriched cellulose content (between 53.8-62.9%) that can later be valorized. Finally, the isolated lignin was characterized by different analytical techniques such as FTIR, elemental analysis, ^{31}P NMR and 2D-HSQC NMR.

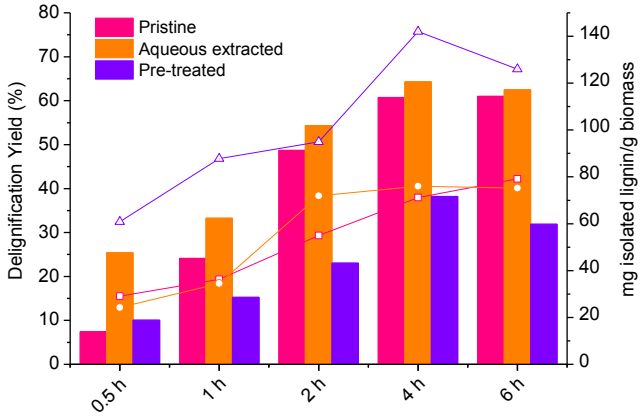


Figure 1: Delignification yield (%) and mg isolated lignin per g biomass (pristine, aqueous extracted and pre-treated OTP) obtained with Ch[Cl]:PTSA:EG during time.

Acknowledgements
The project CICECO–Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020), financed by national funds through the FCT/MEC (PIDDAC) are acknowledged. André M. da Costa Lopes acknowledges his research contract funded by the Fundação para a Ciência e Tecnologia (FCT) and project CENTRO-04-3559-FSE-000095—Centro Portugal Regional Operational Programme (Centro2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF). I. Gómez-Cruz expresses her gratitude to the University of Jaén and the Ministry of Universities for the financial support of the Grants for the Recalibration of the Spanish University System for 2021-2023 in the Margarita Salas modality for the training of young doctors.

Pteridium aquilinum compounds: The good and the bad

M. D. Catarino[1,*], T. Ferreira[2], B. Medeiros-Fonseca[3], A. M. S. Silva[1], P. Oliveira[3], S. M. Cardoso[1]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [2]Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [3]Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), Inov4Agro, University of Trás-os-Montes and Alto Douro, 5000-801 Vila Real, Portugal
**mcatarino@ua.pt*

Pteridium aquilinum, commonly known as common bracken, is a species of fern widely eaten in Korea, Japan, Russian Far East, and parts of China. In the United Kingdom where *P. aquilinum* is extremely successful, the rhizome was once consumed during and after World War I.[1] Indeed, this plant is rich in several bioactive compounds with interesting pharmacological activities, including antioxidant and anti-inflammatory[2], but also contains other substances that can cause serious health problems, of which ptaquiloside is the most well documented. Known to cause hemorrhagic diseases in ruminants, tumors and hematological problems in non-ruminants, consumption of bracken has been linked to esophageal and gastric cancer in humans, although there is not a definitive proof of the correlation between human consumption of bracken and carcinogenesis.[1]
In this work, rhizomes and crosiers, the two most commonly consumed parts of this plant, were used to produce different extracts (hot water and ethanol) and studied for their bioactive properties in vitro using several spectrophotometric assays ($ABTS^{\bullet+}$, $NO^{\bullet}$, and $O_2^{\bullet-}$), and chemical characterization via HPLC-MS, in order to investigate the presence of phenolics and ptaquiloside or its derivatives.
The crosiers 80% ethanolic extract revealed the overall best results, presenting more than twice the phenolic content of the other extracts (8.2 ± 0.2 g gallic acid equivalents/100 g extract), and the best radical scavenging activity towards $ABTS^{\bullet+}$ and $NO^{\bullet}$ (IC_{50} = 19.6 ± 2.0 and 192.1 ± 22.9 µg/mL, respectively). In turn, the crosiers aqueous extract, which showed the lowest phenolic content and activity on these two radicals, was the most active towards $O_2^{\bullet-}$ (IC_{50} = 189.1 ± 5.6 µg/mL), indicating this extract may have other compounds that have higher scavenging effects towards this particular radical. Interestingly, no ptaquiloside was detected in the HPLC-MS analysis of any of the extracts from crosiers origin, while these displayed a number of phenolic constituents, including caffeoylshikimic acid, kaempferol-hexoside or scutellarein-rutinoside.
Rhizomes´ extracts were also absent of ptaquiloside, although these contained several derivatives, including pteroside D, A and other isomeric forms. Ptaquiloside is known to be highly unstable at room temperature and to almost completely degrade in high temperature conditions,[3] which could explain why it was not detected. In turn, contrarily to ptaquiloside, pterosides, do not exert mutagenic effects and have actually been demonstrated to exert relevant anti-inflammatory properties and potential to control Alzheimer's disease.[4,5]
According to these results, it seems that, fern can indeed be a source of bioactive compounds with interesting positive health effects, provided that the absence of ptaquiloside is ensured. Considering the high instability of this compound together with the fact that the consumption of *P. aquilinum* always occurs after a previous processing step usually involving temperature, it is possible that the levels of this mutagenic are sufficiently reduced to not cause harmful effects, and this could explain why a conclusive direct correlation between human consumption of *P. aquilinum* and carcinogenesis has not been observed.

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.

References
1. Marrs, R. H.; Watt, A. S. Biological flora of the british isles: Pteridium aquilinum (L.) Kuhn. *J Ecol* **2006**, *94*, 1272-1321.
2. Dion, C.; Haug, C.; Guan, H. F.; Ripoll, C.; Spiteller, P.; Coussaert, A.; Boulet, E.; Schmidt, D.; Wei, J. B.; Zhou, Y. J.; Lamottke, K. Evaluation of the Anti-inflammatory and Antioxidative Potential of Four Fern Species from China Intended for Use as Food Supplements. *Nat Prod Commun* **2015**, *10*, 597-603.
3. Aranha, P. C. D.; Rasmussen, L. H.; Wolf-Jackel, G. A.; Jensen, H. M. E.; Hansen, H. C. B.; Friis, C. Fate of ptaquiloside-A bracken fern toxin-In cattle. *Plos One* **2019**, *14*.
4. Lu, W. R.; Li, H. J.; Cao, L.; Xiong, Y. F.; Huang, X. B.; Liu, J. Q.; Peng, C. Y.; Shu, J. C. Three new pterosins from Pteris semipinnata. *Nat Prod Res* **2022**.
5. Dai, R. H.; Sun, Y. N.; Su, R. L.; Gao, H. W. Anti-Alzheimer's disease potential of traditional chinese medicinal herbs as inhibitors of BACE1 and AChE enzymes. *Biomed Pharmacother* **2022**, *154*.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Intermolecular activation of pinacol-derived chlorosilane for stereoselective hydride transfer

João P. Castro[1,*], Nuno R. Candeias[1,2]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [2]Faculty of Engineering and Natural Sciences, Tampere University, 33101 Tampere, Finland
**jcastro@ua.pt*

Hydrosilylation is a useful tool having its place in both industry and academy. It allows the structural modification of compounds such as imines, alkenes, ketones, aldehydes, and others to obtain the corresponding unsaturated compounds. This type of reaction is generally catalyzed by transition metal complexes, however, due to their toxicity and the generation of polluting metal waste, the importance of using more sustainable catalysts became a trending topic. To avoid these problems, organocatalysts present as a promising way to perform hydrosilylation reactions.[1-4] In this work we studied the reactivity of a pinacol-derived chlorohydrosilane (PCS), a hydrosilylation agent previously observed to be activated by Lewis bases upon reaction with phenols,[5,6] and tested several natural alkaloids as potential catalysts for the reaction in order to develop a catalytic system for the enantioselective hydrosilylation of ketimines (figure). Here we present the preliminary data on the optimization of the transformation, specifically in the search for an organic base of strong Brönsted basicity but of weak Lewis basicity. This way, activation of the PCS by a stronger chiral Lewis base should ensure the desired enantioselectivity, without compromising the availability of the catalyst. In the process, the Brönsted base has a single role of sequester the HCl formed in the reaction upon reaction of the chlorosilane with a phenol.

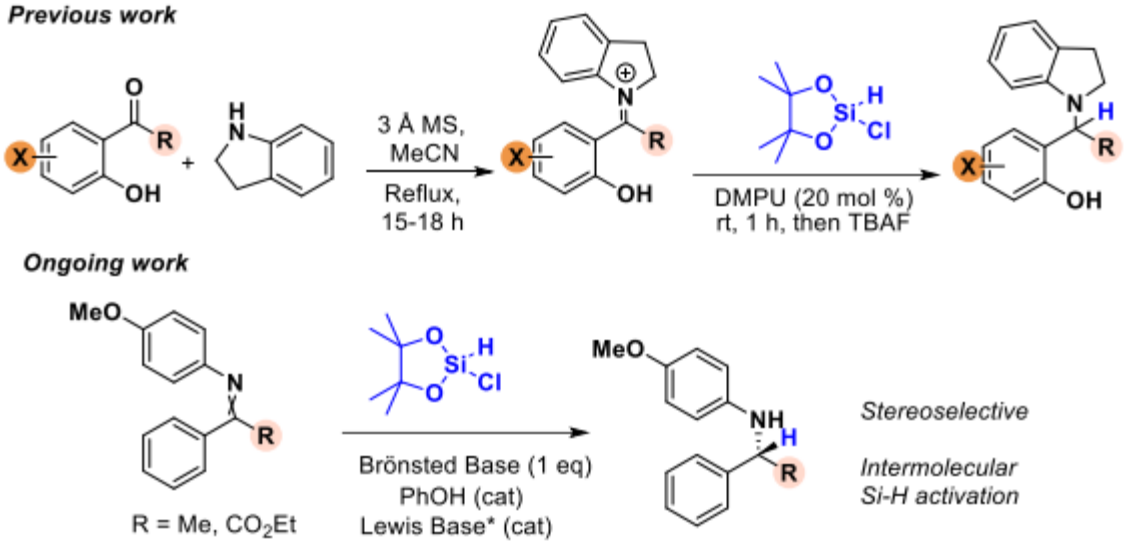


Figure: PCS activation with Lewis bases

Acknowledgments and Funding
This work received support and funding from PT national funds (FCT/MCTES) through the projects UIDB/50006/2020, UIDP/50006/2020, CEE-CINST/2018 and PTDC/QUI-QOR/1786/2021.

References

1. Obligacion, J. V., Chirik, P. J., *Nat. Rev. Chem.* 2018, **2** (5), 15.
2. Kuciński, K., Hreczycho, G., *Green Chem.* 2020, **22** (16), 5210.
3. Asgari, P., Hua, Y., Bokka, A., Thiamsiri, C., Prasitwatcharakorn, W., Karedath, A., Chen, X., Sardar, S., Yum, K., Leem, G., *Nat. Catal.* 2019, **2**, 164.
4. Oliveira, V.d.G.; Cardoso, M.F.d.C.; Forezi, L.d.S.M., *Catalysts* 2018, **8**, 605.
5. Assoah, B., Vale, J. R., Kalenius, E., Veiros, L. F., Candeias, N. R., *Eur. J. Org. Chem.* 2018, **23**, 2910.
6. Assoah, B.; Veiros, L. F.; Candeias, N. R., *Org. Lett.* 2019, **21** (5), 1402.

Carbon-silica composite nanoparticles with enhanced fluorescence emission for iron detection in water

J. Nogueira*, D. Ananias, S. Fateixa, A. Daniel-da-Silva

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**jh.nogueira@ua.pt*

Inorganic nanoparticles present several advantages compared to organic dyes in developing fluorescent probes, such as better photostability, narrow emission bands and wider wavelength range for the excitation source. Carbon dots are among the colloidal systems exhibiting such properties, together with the ability for exploring surface chemistry envisaging stable fluorescent properties and biocompatibility.[1] These features make them suitable for fluorescence probing of a variety of analytes. Carbon-based nanoparticles obtained by hydrothermal methods have gained prominence in the past years, namely due to the low cost and wide variety of carbon sources used in the synthesis.[2] In this work, novel fluorescent carbon-silica composite nanoparticles were prepared via microwave hydrothermal treatment of previously synthesized carrageenan/silica hybrid nanoparticles.[3] The resulting composite nanoparticles display a distinct emission spectrum and enhanced fluorescence emission compared to nanoparticles prepared by hydrothermal treatment of carrageenan in similar experimental conditions. They also displayed a detectable reduction in fluorescent intensity upon contact with Fe (III) ions in aqueous solution, at concentrations as low as 1 µM, (Figure 1) making them suitable for the ion's detection around its maximum recommended concentration in drinking water (5.37 µM).[4] Fluorescence decay curve measurements helped ascertain that the fluorescent intensity reduction was due to a quenching effect of the metal ion, with the emission lifetimes decreasing from 0.65, 3.03, and 10.21 ns to 0.36, 2.87 and 9.73 ns, from 0 to 20 µM Fe (III). In terms of detection limit, the nanomaterial is on par with other carbon-based Fe (III) fluorescent sensors in the literature,[5] and also displayed a selectivity to Fe (III) over other metal ions, including Fe (II).

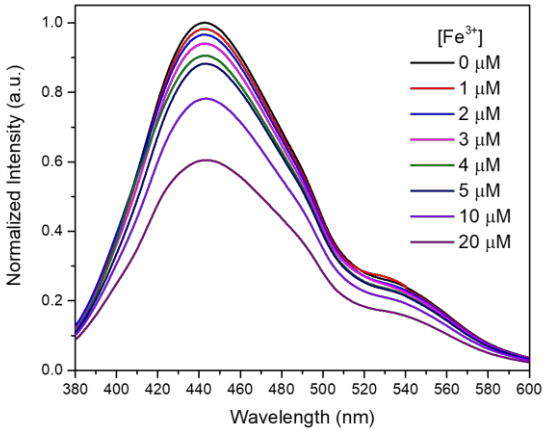


Figure 1: Fluorescent quenching of carbon-silica nanoparticles in correlation with aqueous Fe (III) concentration.

Acknowledgements
This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). J. Nogueira thanks the Fundação para a Ciência e a Tecnologia (FCT) for the PhD Scholarship SFRH/BD/146249/2019. The research contract of S. Fateixa was funded by national funds (OE), through FCT in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19.

References

1. M. Jorns and D. Pappas, A review of fluorescent carbon dots, their synthesis, physical and chemical characteristics, and applications, *Nanomaterials*, 2021, **11**, 1448.
2. Y. Tian, Z. Ran and W. Yang, Carbon dot-silica composite nanoparticle: An excitation-independent fluorescence material with tunable fluorescence, *RSC Adv.*, 2017, **7**, 43839–43844.
3. S. F. Soares, T. Trindade and A. L. Daniel-Da-Silva, Carrageenan-Silica Hybrid Nanoparticles Prepared by a Non-Emulsion Method, *Eur. J. Inorg. Chem.*, 2015, **2015**, 4588–4594.
4. Y. Wang, Y. Liu, L. Zhao, L. Sun, X. Zhao and Y. Xia, κ-Carrageenan-derived carbon dots for highly selective and sensitive detection of Fe3+ and oxytetracycline, *J. Mater. Sci.*, 2021, **56**, 1272–1285.
5. X. Sun and Y. Lei, Fluorescent carbon dots and their sensing applications, *TrAC - Trends Anal. Chem.*, 2017, **89**, 163–180.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Electrical conductivity of four 1-alkyl-3-methylimidazolium series: Evidence of nanostructuration in ionic liquids

Carlos F. P. Miranda*, Luís M. N. B. F. Santos

CIQUP, Institute of Molecular Sciences (IMS)- Departamento de Química e Bioquímica, Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre S/N, Porto, Portugal
carlospesqueiramiranda@gmail.com

This work presents an extensive study on the effect of the length of the cation's alkyl chain on the electrical conductivity of imidazolium ionic liquids (ILs). The focus of the study were four 1-alkyl-3-methylimidazolium series, combined with common anions: the trifluoromethanesulfonate series $[C_nC_1im][OTf]$ n = 2, 4, 6, 8, 10 and 12, the bis(trifluoromethylsulfonyl)imide series $[C_nC_1im][NTf_2]$ n = 1 – 12, the tetrafluoroborate series $[C_nC_1im]BF_4$ n = 2 – 10 and 12, and the hexafluorophosphate series $[C_nC_1im]PF_6$ n = 3 – 10. The measurements were performed between 283 and 333 K (except for the ILs with higher melting temperatures) using a multi-frequency impedance methodology and were based on the scanning of resistance, R, and reactance, X, from 20 Hz to 500 kHz. The electrical conductivity of the ionic liquids was derived from the extrapolation of resistance to infinite frequency. The utilization of this analytical procedure in combination with the multi-frequency scanning allows the mitigation of polarization effects.[1]
The Vogel-Fulcher-Tammann (VTF) equation was used to fit the conductivity – temperature data, $\sigma(T)$, as well as to derive the pre-exponential coefficient and energy of barrier. The electrical conductivity was found to decrease with the increase of the alkyl chain as it was expected due to the decrease of dynamic in the system. Furthermore, for all series the dependence of the electrical conductivity data and VTF coefficients with the number of carbons on the alkyl chain highlights the presence of two regimes which is likely associated with the intensification of the nanostructuration of the ionic liquids as the nonpolar regions become larger.[2] Comparing the homologue series, the following overall trend of electrical conductivity was found NTf_2 > OTf ~ BF_4^- > PF_6^-. Additionally, the results describe an interesting balance between the pre-exponential coefficient (conductivity at infinite temperature) and energy barrier. The former is associated with the shape and dynamics of the ions, while the latter is an indication of the cohesive energy of the liquid. Based on that, it was found that the temperature dependence could be strong enough to change the sequential order of conductivity of the ILs.

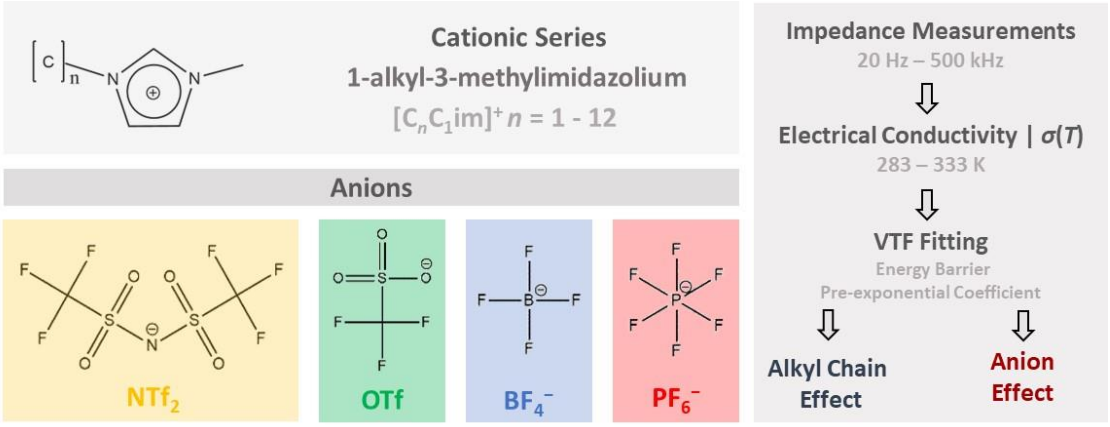


Figure 1: Representation of the studied imidazolium ionic liquid series

Acknowledgements
This work was supported by the Fundacão para a Ciência e Tecnologia (FCT) through the FCT/MCTES (PIDDAC) to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), IMS-Institute of Molecular Sciences (LA/P/0056/2020). Carlos F. P. Miranda is grateful to FCT for his research grant (Reference: 2020.05717.BD).

References
1. X. Paredes, C. S. G. P. Queirós and C. A. N. Castro, *J. Phys. Chem. Ref. Data* 2020, **49**, 043101-51.
2. J. N. A. Canongia Lopes and A. A. H. Pádua, *J. Phys. Chem. B* 2006, **110**, 3330-3335.

(Electro)catalytic performance of biochar-based materials for catalytic processes and oxygen reactions

I. S. Marques*, P. Miranda, R. Matos, A. F. Peixoto, D. M. Fernandes

LAQV/REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal.
**up201608306@fc.up.pt*

The current energy crisis and war has been stimulating new measures to reduce energy consumption and chemical production from fossil resources. In this regard, the concept of biorefinery is an essential strategy to convert biomass residues into value-added products and energy.[1] Conventional (electro)catalysts are based on noble metals and their oxides, such as Pt, Pd, RuO_2, and IrO_2. Therefore, it is imperative to develop a new generation of high sustainable and stable materials based preferentially in biomass wastes to contribute to the circular environment and economic benefits.[2]

Biochar, a carbon-rich and porous solid material obtained from thermochemical degradation of biomass can be a future alternative. The production of catalysts from natural and renewable sources - vineyard pruning waste (VPW) or shrimp shell waste (SSW) biochar - will be used for sustainable catalytic processes for value-added bioproducts and as electrocatalysts for demanding electrochemical reactions, oxygen reduction and evolution reactions (ORR and OER). In this project, we aim to produce nitrogen-doped supported metals and sulfonic acid-based catalysts to convert waste into wealth through innovative and potentially low-cost approaches. Biochar catalysts were prepared by wet impregnation or ball milling. The activation under chemical/physical experimental conditions resulted in high surface areas (BET > 200 m^2/g). The successful preparation of the functionalized catalysts was also verified by XPS, FTIR and SEM/EDS; the formation of highly porous structures was demonstrated by SEM and XPS resulting in a significant increase in N-functionalization after doping approach. The electrocatalysts demonstrated moderate ORR electrocatalytic performance in alkaline medium with diffusion-limiting current densities between -3.7 and -1.2 mA cm^{-2} and potential onset values of $0.88 \geq E_{onset} \geq 0.66$ V vs. RHE. The materials also presented moderate OER electrocatalytic performances in alkaline medium, with overpotential values between 0.4 and 0.7 V vs. RHE and maximum current densities above 45 mA cm^{-2}. The catalysts showed remarkable yields such as: 88% of furfuryl alcohol from CTH reaction of furfural; and, up to 90 % of ethyl levulinate (EL) from 5-HMF using mild experimental conditions (130 °C and 6 h reaction) using biochar functionalized with sulfonic acid.[3,4]

Funding
This work was funded by Portuguese funds through Fundação para a Ciência e a Tecnologia (FCT/MCTES) in the framework of the projects UIDB/50006/2020, UIDP/50006/2020.

Acknowledgments
We thank the Fundação para a Ciência e a Tecnologia for the project EXPL/BII-BIO/0436/2021. I.S.M. thanks FCT for the PhD fellowship 2022.10224.BD. R.M. thanks FCT for the PhD fellowship 2020.05342.BD. D.M.F. and A.F.P. thank FCT for funding through the Individual Call to Scientific Employment Stimulus (Refs. 2021.00771.CEECIND/CP1662/CT0007 and 2020.01614.CEECIND/CP1596/CT0007 respectively).

References

1. M. C. Gaspar, C. V. T. Mendes, S. R. Pinela, R. Moreira, M. G. V. S. Carvalho, M. J. Quina, M. E. M. Braga and A. T. Portugal, *ACS Sustainable Chemistry & Engineering*, 2019, **7**, 17154-17165.
2. B. Bradić, U. Novak and B. Likozar, *Green Processing and Synthesis*, 2020, **9**, 13-25.
3. A. F. Peixoto, R. Ramos, M. M. Moreira, O. S. G. P. Soares, L. S. Ribeiro, M. F. R. Pereira, C. Delerue-Matos and C. Freire, *Fuel*, 2021, **303**.
4. I. S. Marques, B. Jarrais, R. Ramos, V. K. Abdelkader-Fernandez, A. Yaremchenko, C. Freire, D. M. Fernandes and A. F. Peixoto, *Catalysis Today*, 2023, **418**.

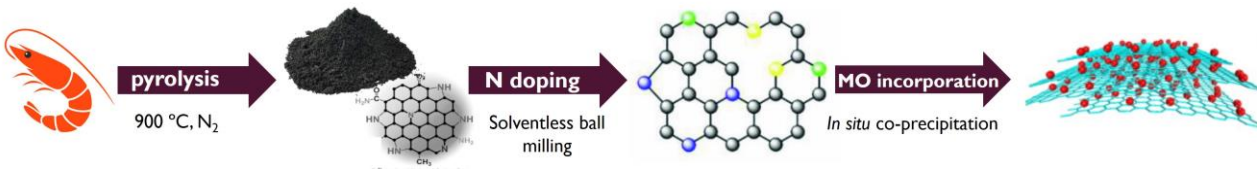
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Biomass-derived catalysts towards oxygen electroreduction

R. Matos*, I. S. Marques, A. F. Peixoto, D. M. Fernandes

LAQV/REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
**renata.matos@fc.up.pt*

The development of new alternatives to fossil fuels combustion has been a major research highlight in the last decades, with special focus being placed on energy conversion devices such as fuel cells and metal-air batteries. However, both technologies rely on several electrochemical processes, including the oxygen reduction reaction (ORR), whose sluggish kinetics and large overpotentials hinders their practical application.[1] These limitations can be overcome by the development of highly effective electrocatalysts.
While currently Pt-based materials are considered the state-of-the-art electrocatalysts towards ORR, N-doped carbon catalysts arose as promising precious metal-free alternatives.[2] Recently, carbon materials obtained from the pyrolysis of biomass, known as biochars, have attracted interest as highly sustainable catalysts, due to their tunable physical-chemical properties, renewable feedstock, and low production cost.[3] Shrimp shells derived biochars, in particular, have very interesting electrocatalytic properties, originated from the feedstock natural abundance in heteroatoms.[4]
Herein, carbon-based electrocatalysts were obtained from the pyrolysis of shrimp shell waste. In order to evaluate the effect of heteroatoms in the ORR performance, the most promising biochar was further doped with nitrogen through a solventless ball milling approach. Then, the N-doped biochars were functionalized with electroactive Co_3O_4 nanoparticles *via in situ* co-precipitation route (Scheme 1). All the prepared materials were fully characterized prior to their use as ORR electrocatalysts. The resulting hybrid materials showed excellent electrocatalytic performance in alkaline medium, displaying faster kinetics and lower overpotentials compared with the original biochar. Although these catalysts still present more negative E_{onset} and lower j_L values than the state-of-the-art Pt/C, they displayed very similar selectivity towards the desired 4 electron reduction and even significantly lower Tafel slopes than Pt/C.



Scheme 1: Preparation of shrimp shell derived electrocatalysts.

Funding
This work was funded by Portuguese funds through Fundação para a Ciência e a Tecnologia (FCT/MCTES) in the framework of the projects UIDB/50006/2020 and UIDP/50006/2020.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the project EXPL/BII-BIO/0436/2021. R.M. thanks FCT for the PhD fellowship 2020.05342.BD. I.S.M. thanks FCT for her PhD fellowship 2022.10224.BD. D.M.F. and A.F.P. thank FCT for funding through the Individual Call to Scientific Employment Stimulus (Refs. 2021.00771.CEECIND/CP1662/CT0007 and 2020.01614.CEECIND/CP1596/CT0007, respectively).

References
1. C. Freire, D. M. Fernandes, M. Nunes and V. K. Abdelkader, ChemCatChem, 2018, **10**, 1703-1730.
2. C. Hu, R. Paul, Q. Dai and L. Dai, Chemical Society Reviews, 2021, **50**, 11785–11843.
3. R. Ramos, V. K. Abdelkader-Fernández, R. Matos, A. F. Peixoto and D. M. Fernandes, *Catalysts*, 2022, **12**, 207.
4. Y. Ding, S. Huang, Y. Sun, Y. Li, L. Zhu and S. Wang, *ChemElectroChem*, 2021, **8**, 3745.

Sulfonic acid-functionalized biochar derived from shrimp shell waste as sustainable catalysts for ethyl levulinate production

P. Miranda*, I. S. Marques, A. F. Peixoto

LAQV-REQUIMTE, Chemistry and Biochemistry Department, Faculty of Science, University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
**up202008689@up.pt*

A major shift from a fossil fuel-based economy, dependent upon finite resources, towards a renewable biomass-based bioeconomy is occurring rapidly due to growing awareness and global demand for sustainable energy. In fact, the production of biofuels and bio-derived chemicals from biomass has become an important trend in sustainable development in the context of a biorefinery concept. Biorefinery is a cascading sustainable processing technology for the translation of whole or part biomass into multiple products.[1] Most of seafood wastes are currently disposed into landfills or back into the ocean being associated with several environmental issues contributing to an environment degradation and climate change and is potential renewable biomass source.[1] As example shrimp shells (SS) are mostly composed by protein (20-40%), calcium carbonate (20-50%) and chitin (15-40%) which can be reused in many applications, including the preparation of new biochar based materials, catalysts and, chitin-derivatives can also be transformed into novel platform molecules for the synthesis of industrially valuable chemicals.[1,2]
In this work, new series of SS-biochar based catalysts were prepared and used in the one-pot conversion of 5-hydroxymethylfurfural (HMF) in ethyl levulinate (EL), a potential fuel additive.[3] SS-Biochar were obtained by pyrolysis of shrimp shells underwent hydrothermal treatment at 900 ºC, under nitrogen atmosphere, for 2 hours The SS-biochar was functionalized with sulfonic acid groups, using different precursors in order to improve their acidity and to produce reusable catalysts.[3] The catalysts were prepared using different sulfonic acid sources and methodologies: A) The SS-biochar was mixed with sulfanilic acid, 1,3-propanesulfone and *p*-toluenesulfonic acid, assisted by ball milling mechanical functionalization and by functionalization using toluene as solvent; B) SS-biochar (500 mg) and the sulphanilic acid (740 mg) were introduced in the ball milling and were processed during 30 min at room temperature and constant frequency. Finally the catalysts were characterized by different techniques including nitrogen adsorption isotherms (BET analysis), FTIR, TGA, elemental analysis and XPS. The catalytic tests were performed in a high pressure 40 mL batch stirred reactor (Berghof) using 5 mL of ethanol, 50 mg of HMF, 20 µL of tetradecane (as internal standard) and the catalyst were added, sealed, and heated to the reaction temperature (autogenous pressure). The influence of temperature, (130 - 150 ºC), reaction time (6h - 10h) and catalyst amount (10 mg - 50 mg) was also evaluated. SS-biochar-(propanesultone)-SO_3H and SS-biochar-(sulfanilic acid)-SO_3H proved to be the most active in the conversion of 5-HMF into EL with 99% conversion and selectivity, at 150 ºC after 10h reaction. The product identification and quantification were carried out by GC (FID detector) equipped with a TG-5MS capillary column. The reusability tests will also be presented and discussed.

Acknowledgements
This work was funded by National funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., in the framework of the project EXPL/BII-BIO/0436/2021. A.F.P. also thanks FCT for the individual contract within the scope of the program "Call to Scientific Employment Stimulus" (Refs. 2020. 01614.CEECIND/CP1596/CT0007). I.S.M. thanks FCT for the PhD fellowship 2022.10224.BD. We also thank the company Mar Cabo for supplying the shrimp shells.

References
1. Max J. Hülsey, *Green Energy & Environment*, 2018, **3**(4), 318-327
2. N. Yan, X. Chen. *Nature*, 2015, **524**(7564), 155-157.
3. A. F. Peixoto, R. Ramos a, M. M. Moreira, O. Salomé G. P. Soares, L. S. Ribeiro, M. F. R. Pereira, C. Delerue-Matos, C. Freire. *Fuel*, 2021, **303**, 121227.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A new rosamine loaded metal-organic framework as a potent fluorescent sensor for Cu(II)

Fábio Martins[1,*], Carla Queirós[1], Andreia Leite[1], Paula Gameiro[1], Ana I. M. C. Lobo Ferreira[2], Luís M. N. B. F. Santos[2], Maria G. P. M. S. Neves[3], Ana M. G. Silva[1]

[1]LAQV-REQUIMTE, Department of Chemistry and Biochemistry (DQB), Faculty of Sciences, University of Porto (FCUP), 4169-007 Porto, Portugal; [2]CIQUP, Institute of Molecular Sciences (IMS), DQB, FCUP, 4169-007 Porto, Portugal; [3]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**up201704556@fc.up.pt*

Copper (Cu) is a key trace element with special roles in numerous biological processes that control the human body. However, when present in excess, this metal ion has been found to be involved in a number of neurodegenerative illnesses, including Wilson's, Menkes, Alzheimer's and Parkinson's. Therefore, the development of new and efficient sensors for monitoring the presence of Cu from different sources (e.g. industrial waste, water pipelines, drinking water) is of high relevance.[1]

Metal-organic frameworks (MOFs) have gained considerable traction over the past decade as versatile platforms for a variety of applications, including catalysis, adsorption, and notably as sensing materials capable of accurately and selectively monitor a wide range of analytes of interest.[2] Due to their special structural features namely high porosity, MOFs can be used as excellent chemical sensors. The goal of the current research is to create fluorescent materials that can overcome some of the drawbacks of organic dyes (e.g. rosamines), such as self-quenching brought on by aggregation and their poor water stability, while still maintaining their sensory ability to detect and quantify harmful substances in an accurate and selective manner.

With this in mind, we developed a number of new composites through the combination of MOFs, specifically UiO-66, with the rosamine dye RosCOOH by physical adsorption or *in-situ* synthesis (Figure 1). According to our findings, the *in-situ* inclusion of RosCOOH dye gave rise to a new and efficient sensing nanoplatform. In the synthetic approaches eco-friendly heating techniques, including microwave and ohmic heating were explored.[3] These approaches as well as the sensory properties of the resulting materials towards Cu ions will be presented and discussed.

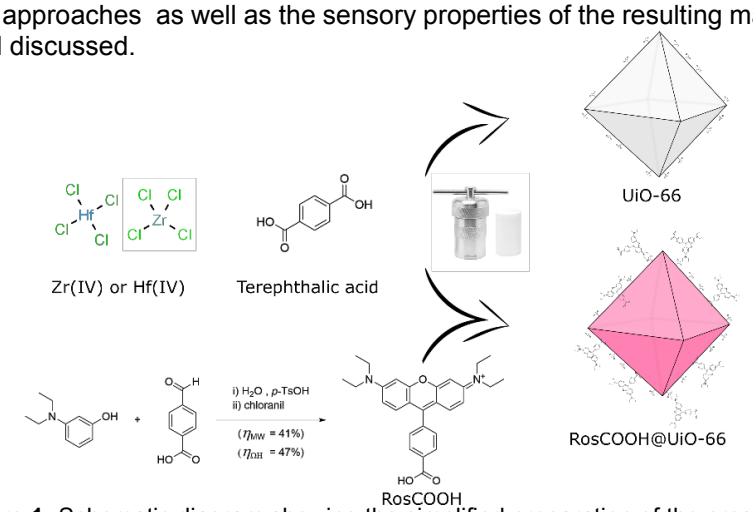


Figure 1: Schematic diagram showing the simplified preparation of the presented materials.

Acknowledgements
This work received financial support from National Funds (FCT/MCTES), under the Partnership Agreement PT2020 through projects NORTE-07-0162-FEDER-000048, UIDB/50006/2020, UIDP/50006/2020, PTDC/QUI-QIN/28142/2017 and EXPL/QUI-OUT/1554/2021. This work was supported by FCT (funded by national funds through the FCT/MCTES (PIDDAC)) to CIQUP, FCUP, (Project UIDB/00081/2020), IMS-Institute of Molecular Sciences (LA/P/0056/2020). F. Martins acknowledges FCT and ESF (European Social Fund) for his PhD grant (UI/BD/154485/2022). AL, AIMCLF and AMGS are financed by national funds through the FCT-I.P., in the framework of the execution of the program contract provided in paragraphs 4, 5 and 6 of art. 23 of Law no. 57/2016 of 29 August, as amended by Law no. 57/2017 of 19 July.

References

1. L. M. Gaetke, H. S. Chow-Johnson and C. K. Chow, *Arch. Toxicol.*, 2014, **88**, 1929.
2. L. Chen, D. Liu, J. Peng, Q. Du and H. He, *Coord. Chem. Rev.*, 2020, **404**, 213113.
3. A. Leite, L. Cunha-Silva, D. Silva, A. I. M. C. Lobo Ferreira, L. M. N. B. F. Santos, I. C. S. Cardoso, V. L. M. Silva, M. Rangel and A. M. G. Silva, *Chem. – A Eur. J.*, 2019, **25**, 15073–15082.

Preparation of all-cellulose composites by partial dissolution of different cellulosic substrates

Maria C. Teixeira*, Armando J. D. Silvestre, Carla Vilela, Carmen S. R. Freire

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
*maria.teixeira@ua.pt

Cellulose is the most abundant natural polymer. Although the main source of this biopolymer are plants, some microorganisms such as algae, fungi and bacteria can also produce extracellular forms of cellulose. For example, bacterial nanocellulose (BNC), produced by several non-pathogenic bacteria as a highly swollen hydrogel (~90% water), which can be dried to form thin films or membranes, is characterized by a three-dimensional network of highly crystalline nano- and microfibrils with 10–100 nm width. In general, cellulose is characterized by its renewability, biocompatibility and biodegradability, high chemical stability, and excellent mechanical properties. Due to these features, cellulosic substrates have been extensively used to fabricate different materials, particularly polymer composite materials.[1] In this context, the development of all-cellulose composites (ACCs) has gained significant research interest in recent years. ACCs are mono-component polymer composite materials produced solely of cellulose (or cellulose derivates), in which the matrix is a regenerated (or modified) cellulose phase, while the reinforcing phase is generally composed of high-strength cellulosic fibers. ACCs exhibit the advantages of the cellulose substrates, but their mechanical, optical and barrier properties are remarkably superior when compared to common cellulose-based materials. Thus, ACCs can be used to produce different materials (e.g., aerogels, hydrogels, fibers membranes) for distinct applications, such as packaging, biomedical engineering, photoelectronic, textiles, and coatings.[2]
ACCs can be prepared by different methods, with the partial dissolution process as the one with more potential for industrial upscaling.[3] The partial dissolution method consists in a one-step approach, in which the cellulose reinforcing phase is retained in situ during the dissolution process, allowing to readily achieve a high-volume fraction of the reinforcing phase .
Following these premises, this work aims at the development of ACCs using different cellulose substrates, including BNC and *Eucalyptus* pulp fibers, by a partial surface dissolution method, using the NaOH/urea system as solvent. The effects of different parameters, such as the partial dissolution time and ratio solvent:cellulose on the properties of the resulting composites were investigated. The resultant ACCs were characterized in terms of physicochemical properties, structure and morphology, and mechanical performance.

Acknowledgements
The authors acknowledge the financial support from integrated project be@t – Textile Bioeconomy (TC-C12-i01, Sustainable Bioeconomy No. 02/C12-i01/202), promoted by the Recovery and Resilience Plan (RRP), Next Generation EU, for the period 2021 – 2026. The authors also acknowledge the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). FCT is also acknowledged for the research contracts under Scientific Employment Stimulus to C.S.R.F. (CEECIND/00464/2017) and C.V. (CEECIND/00263/2018 and 2021.01571.CEECIND).

References
1. C. Vilela, R. J. B. Pinto, A. R. P. Figueiredo, C. P. Neto, A. J. D. Silvestre and C. S. R. Freire, in *Advanced Composite Materials: Properties and Applications*, De Gruyter Open, Aveiro, Portugal, 2017, vol. 4, pp. 1–65.
2. S. Tanpichai, A. Boonmahitthisud, N. Soykeabkaew and L. Ongthip, *Carbohydr. Polym.*, 2022, **286**, 119192.
3. B. Baghaei and M. Skrifvars, *Molecules*, 2020, **25**, 2836.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Multielements profile to trace authenticity markers of fruit cake fillings

Ana M. S. Costa[1,*], Elisabete Coelho[1], Lina Carvalho[2], Eugénio Soares[2], Eduarda Pereira[1,2], Manuel A. Coimbra[1]

[1]Chemistry Department, LAQV – REQUIMTE, University of Aveiro, Campus Universitário de Santiago, Aveiro 3810-193, Portugal; [2]Central Laboratory of Analysis (LCA), University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal
**anamariacosta@ua.pt*

The authenticity of food products with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) labels is crucial for the food industry, providing added value and allowing them to stand out in the European economy. Given the growing interest in certified products by pastry industries, the identification of authenticity markers is essential to sell fruit fillings with PDO and PGI certification, as they hold significant economic value. Fruits (apples and pears) are consumed fresh and can be used as ingredients in cake fillings. Processed products require the identification of unique characteristics that can serve as markers of authenticity. The content of selected elements in food may vary depending on plant growth conditions such as fertilization, climatic conditions, differences in soil types, or field history. Mineral elements in agricultural products were less influenced by technological processing and storage time and to be used to determine the geographical origin of products. It is possible that fruits grown in a specific region possess distinct characteristics associated with the environment, which can help identify them even after processing. To address this need, a study was conducted to analyze the mineral profiles of PDO "Pera Rocha do Oeste" pears and PGI "Maçã de Alcobaça" apples, both in their fresh state and as fruit fillings. The study aimed to determinate the geographical origin and authenticity multielement markers using Inductively Coupled Plasma (ICP) analysis and chemometric tools. The results revealed that four elements (Mn, Ce, B, and Rb) showed significant differences between PDO pear fillings and pear fillings from Alentejo. In the case of apples, PGI fresh apples and fruit fillings exhibited lower concentrations of caesium (Cs) and rubidium (Rb) compared to apples and fruit fillings from other Portuguese regions. These variations can be attributed to differences in soil characteristics. The study demonstrates that the combination of multielement analysis using Inductively Coupled Plasma (ICP) and chemometric tools enables the discrimination of processed fruits and provides valuable insights for identifying geographical origin and authenticity markers of PDO pears and PGI apples in fruit fillings.

Acknowledgements: Conducted under the project “MobFood – Mobilizing scientific and technological knowledge in response to the challenges of the agri-food market” (POCI-01-0247-FEDER-024524), by “MobFood” Consortium, and financed by European Regional Development Fund (ERDF), through the Incentive System to Research and Technological development, within the Portugal2020 Competitiveness and Internationalization Operational Program. Thanks to FCT/MEC for the financial support to the research unit LAQV/REQUIMTE (UIDB/50006/2020 & UIDP/50006/2020) through national funds and FEDER, within the PT2020 Partnership Agreement. Elisabete Coelho Research contract was also funded by national funds (OE), through FCT, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. Ana M.S. Costa thanks the Ph.D. grant from Fundação para a Ciência e Tecnologia (FCT)— 2021.08633.BD.
Funding: This work was financially supported by Fundação para a Ciência e Tecnologia (FCT) and by Compete2020, Lisb@2020, Portugal2020, European Regional Development Fund.

References

1. Commission Regulation (EC) No 492/2003 of 18 March 2003. Official Journal of the European Union, available at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:073:0003:0004:EN:PDF (Accessed May 17, **2022**).
2. Commission Regulation (EC) No 1107/96 of 12 June 1996. Official Journal of the European Union, available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31996R1107&qid=1574383462504&from=PT (Accessed May 17, **2022**).
3. Inês Coelho, Ana Sofia Matos, Rita Teixeira, Ana Nascimento, João Bordado, Olivier Donard, Isabel Castanheira. Journal of Food Composition and Analysis. **2019**, 77, 1-8.
4. Sónia M. Rodrigues, Marta Otero, André A. Alves, Joana Coimbra, Manuel A. Coimbra, Eduarda Pereira, Armando C. Duarte, Journal of Food Composition and Analysis, **2011**, 24, 548–562.

Valorization of rice husk: novel adsorbent materials for water treatment applications

Inês Marques, Paula Gameiro, Andreia Leite*

LAQV-REQUIMTE, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007; Porto, Portugal
**acleite@fc.up.pt*

Nowadays, water quality preservation is one of the most crucial environmental challenges due to the growing population and the rapid industrialization. Ground and surface water polluted with organic and inorganic pollutants pose risks to human health and other living organisms. Heavy metals, the main inorganic pollutants, are present in the wastewaters of many industrial processes, including mining, metal plating, painting, petroleum refining, fertilizer production, pesticide use, and others. These harmful contaminants (e.g., Cu, Ni, Co, Pb, etc) are non-biodegradable and often survive in nature and accumulating in living tissues. Therefore, it has become crucial in recent decades to remove the aforementioned contaminants before they are discarded into the environment [1].

Moreover, the agriculture sector generates a lot of by-products, among which rice husk deserves particular attention. Rice Husk (RH) is a potential residue for valorization since it is highly available and is disposed by rice mill industry as a waste. Silica-rich RH is primarily underutilized, being burned on-site, landfilled, leading to environmental problems [2]. From the calcination process at high temperature the resulting waste, designated rice husk ash (RHA) is obtained with a microporous structure and contains around 85% to 90% of silica [3]. From RHA is also possible to obtain a sodium silicate solution that can be used to synthetize ordered mesoporous silicas, namely SBA-15. With that in mind, in this work, the potential of RHA and SBA-15 as adsorbents for treating cooper containing wastewater was evaluated. For that, the effect of pH and contact time was studied to optimize the adsorption capacity of these materials. According to our findings, SBA-15 has the best adsorption capacity with an adsorption rate of 90%.

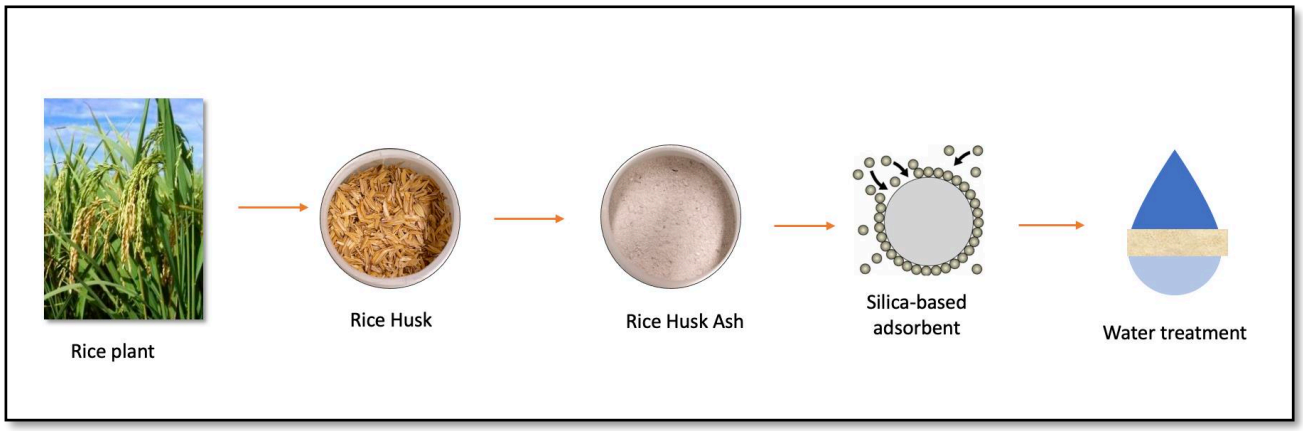


Figure 2: Rice Husk Application.

Acknowledgements
This work received financial support from National Funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência), under the Partnership Agreement PT2020 through project QIN/28142/2017and the projects NORTE-07-0162-FEDER-000048, UIDB /50006/2020, UIDP/50006/2020. A. Leite thanks FCT for funding through program DL 57/2016 – Norma transitória.

References
1. Z. Shamsollahi and A. Partovinia, *J Environ Manage*, 2019, **246**, 314–323.
2. A. P. Gupte, M. Basaglia, S. Casella and L. Favaro, *Renewable and Sustainable Energy Reviews*, 2022, **167**, 112673.
3. B. Singh, in *Waste and Supplementary Cementitious Materials in Concrete*, Elsevier, 2018, pp. 417–460.

P70

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Sputter deposition of metal nanoparticles in ionic liquid films obtained via thermal evaporation

Alexandre C. P. M. Alves*, Luís M. N. B. F. Santos, Margarida Bastos, José C. S. Costa

CIQUP, Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry, Faculty of Science, University of Porto, Porto, Portugal
**up201503618@up.pt*

This study investigates the sputter deposition of metal nanoparticles (silver and gold) onto thin films of different imidazolium-based ionic liquids (ILs). The influence of different anions, such as acetate, trifluoroacetate, triflate, and bis(trifluoromethylsulfonyl)imide, was explored to access their effect on the formation and stabilization of metal nanoparticles. Additionally, it was examined the impact of modifying the alkyl chain length and symmetry of the cationic moieties. The specific combinations of ILs studied included $[C_2C_1im][Ac]$, $[C_2C_1im][TFA]$, $[C_2C_1im][OTF]$, $[C_2C_1im][NTf_2]$, $[C_4C_1im][NTf_2]$, $[C_8C_1im][NTf_2]$, $[C_2C_2im][NTf_2]$, and $[C_5C_5im][NTf_2]$. The ILs were used not only as a medium to capture metal atoms but also as stabilizers during the formation of nanoparticles. Remarkably, the ILs have a propensity to facilitate the formation of small and uniformly-sized aggregates of nanoparticles.[1–3]

Glass substrates coated with indium tin oxide (ITO) were used as the base for the deposition of ionic liquid (IL) films of various thicknesses, achieved through the process of vacuum thermal evaporation. These IL films were obtained in the form of micro- and nanodroplets. The process of thermal evaporation was conducted by carefully controlling the effusion temperature, deposition rate, and deposition time. The use of Knudsen cells as evaporation sources was fundamental to achieving precise and reproducible control over the mass flow rate.[4,5] The sputtering process of the metals onto ILs when conducted simultaneously with argon plasma promoted the coalescence of micro- and nanodroplets of ILs and the incorporation and stabilization of silver (AgNPs) or gold nanoparticles (AuNPs) in the coalesced IL films. The formation and stabilization of metal nanoparticles into the IL films were confirmed through high-resolution scanning electron microscopy (SEM) and UV-Vis spectroscopy.[1]

Based on the experimental findings, the investigated IL films showed excellent suitability as capture media for the formation and stabilization of AgNPs. On the other hand, achieving favorable conditions for the formation of AuNPs proved to be more challenging. The gold particles tended to aggregate and form a thin film on the surface of the studied IL films. Considering the formation of AgNPs, it was observed that IL films with greater thicknesses provided a more favorable environment for the formation of small metal particles. Among the ILs investigated, those containing longer alkyl chains in the cation and comprising the anion NTf_2 exhibited superior results in terms of AgNPs formation. Additionally, ILs containing the acetate anion were found to be particularly conducive to the formation of large silver aggregates. Among the ILs studied, $[C_5C_5im][NTf_2]$ showed notable potential for the stabilization of AgNPs. When subjected to argon plasma and silver bombardment, larger IL droplets served as effective confining agents, impeding the aggregation of AgNPs and promoting their stabilization within the IL films.[1]

Acknowledgments
The authors thank the Portuguese Foundation for Science and Technology (FCT) for financial support to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), and IMS-Institute of Molecular Sciences (LA/P/0056/2020), Faculty of Science, University of Porto. A.C.P.M.A. also thanks the FCT for the award of a Ph.D. Research Grant (ref. 2022.11108.BD).

References

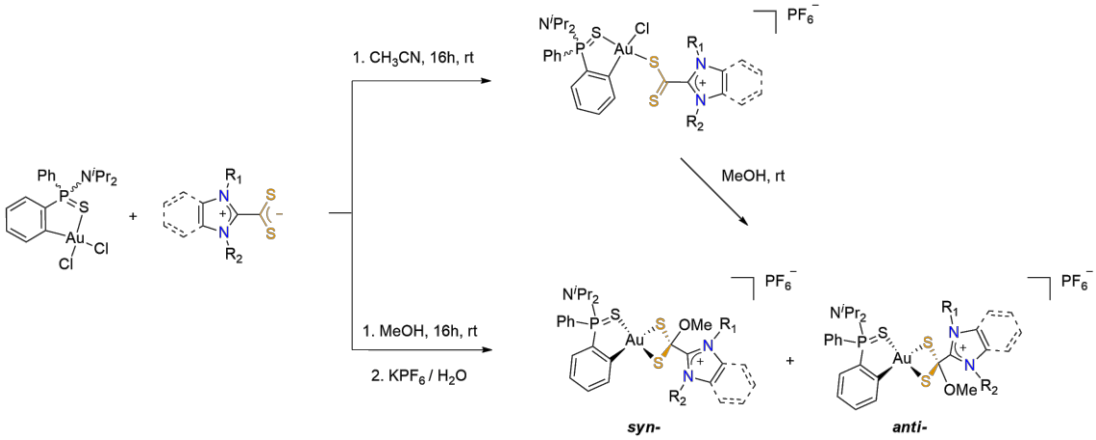
1. A. C. P. M. Alves, L. M. N. B. F. Santos, M. Bastos and J. C. S. Costa, *Molecules*, 2023, **28**, 3029.
2. L. Calabria, J. A. Fernandes, P. Migowski, F. Bernardi, D. L. Baptista, R. Leal, T. Grehl and J. Dupont, *Nanoscale*, 2017, **9**, 18753–18758.
3. T. Torimoto, K. I. Okazaki, T. Kiyama, K. Hirahara, N. Tanaka and S. Kuwabata, *Appl. Phys. Lett.*, , DOI:10.1063/1.2404975.
4. J. C. S. Costa, A. C. P. M. Alves, M. M. H. M. Bastos and L. M. N. B. F. Santos, *Phys. Chem. Chem. Phys.*, 2022, **24**, 13343.
5. J. C. S. Costa, A. F. S. M. G. Coelho, A. Mendes and L. M. N. B. F. Santos, *Appl. Surf. Sci.*, 2018, **428**, 242–249.

The surprisingly behavior of Au(III) with azoli(ni)um-2-dithiocarboxylate ligands. Synthesis, characterization, DFT studies and catalytic activity

D. Elorriaga*, P. Pérez-Ramos, D. García-Vivo, H. Rodríguez-Solla, R. G. Soengas

Departamento de Química Orgánica e Inorgánica, Facultad de Química, Universidad de Oviedo, Julián Clavería 8, 33006 Oviedo, Spain
** E-mail:elorriagadavid@uniovi.es*

During many centuries, metallic gold has been on the focus due to its use in jewelry, in ancient civilizations for coinage, and more recently in manufacture of electronic components. However, gold chemistry was not explored until recently. In the past few years, gold has attracted much attention undergoing a great development specially for gold(I) complexes.[1] Nevertheless, gold(III) chemistry remained virtually unexplored and consequently is growing in interest; thus, gold(III) complexes are becoming a part of the chemist´s toolbox because its versatility as catalysts,[2] bioactive agents[3] and the application as luminescent materials.[4] In that vein, one of the most interesting application for gold(III) complexes is in the dual gold-silver dual catalysis for organic substrates activations.[5]
Herein we report the swipeable synthesis “a le cartè” and characterization of a novel family of (C^S)-cyclometalated gold(III) complexes bearing azoli(ni)um-2-dithiocarboxylate ligands as κ^1S-donor or κ^2S-donor. DFT studies were conducted to understand the mechanisms of the reaction. Moreover, their performance as catalysts in the reaction of indoles alkylating was tested.



Scheme: Synthesis of (C^S)-cyclometalated gold(III) complexes bearing azoli(ni)um-2-dithiocarboxylate ligands as κ^1S-donor or κ^2S-donor,

Acknowledgements
This work has received financial support from the Principado de Asturias (FICYT AYUD/2021/51542), MINECO (PID2019-109253RB-I00), Instituto de Salud Carlos III (PI22/00148) and the European Union (European Regional Development Fund-ERDF). Partial financial support by Arcelor Mittal (R&D-Principado de Asturias; FUO-22-130) is gratefully acknowledged. P.P.R. thanks Principado de Asturias for a predoctoral contract (Programa Investigo, AYUD/2022/9313). We thank the SCBI of the Universidad de Málaga, Spain, for access to computing facilities.

References
1. Z. Li, C. Brouwer, C. He, Chem. Rev., 2008, **108**, 3239
2. L. Rocchigiani, M. Bochmann, Chem. Rev. 2021, **121**, 8364.
3. B. Bertrand, M. R. M. Williams, M. Bochmann, Chem. Eur. J., 2018, **24**, 11840.
4. R. Malmberg, K. Venkatesan, Coord, Chem. Rev., 2021, **449**, 214182.
5. H-M. Ko, K. K-Y. Kung, J-F. Cui, M-K. Wong, Chem. Comm., 2013, **49**, 8869.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of artificial enzymes based on the copper enzyme tyrosinase

Gabriel N. Valério[1,2], Åsmund K. Røhr[2], José J. G. Moura[1], Cristina M. Cordas[1,*]

[1]*LAQV, REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal*
[2]*Faculty of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences (NMBU), PO Box 5003, 1432 Ås, Norway*
**c.cordas@fct.unl.pt*

Carbon dioxide and nitrogen oxides mitigation are emergent world goals since these compounds' emissions are responsible for the global warming and climate change. At the same time these abundant compounds are interesting feedstock for valuable chemicals/fuels production. Some obstacles for the conversion of CO_2 and NOx towards added-value compounds are related to their stable chemical properties and the required reactions are highly energy consuming. Nature, however, has created enzymes that can react with CO_2 and NOx, such as RuBisCo (Ribulose-1,5-biphosphate Carboxylase), responsible for CO_2 fixation, resulting in two molecules of glyceraldehyde 3-phosphate subsequently converted to biomass[1]. For NOx, there are enzymes like nitrate reductases that are involved in the denitrification route[2]. In this work, a promising type-3 copper (T3Cu) protein, a tyrosinase (Figure 1), was identified through a sequence similarity network. The enzyme is being used to construct an efficient artificial enzyme towards substrate compounds like CO_2 and NOx, through proper catalytic site mutations. The selected tyrosinase was overexpressed and purified and is being characterized for its natural activity. The next step will be the characterization of the possible activity towards CO_2 and NOx. Structural characterization is under study using AlphaFold2, to predict the structure, and x-ray crystallography. Mutations in key residues are also being applied to produce an enzyme with a catalytic center more prone to bind CO2 and NOx. A preliminary electrochemical characterization was also performed to understand the intrinsic redox behavior and activity.

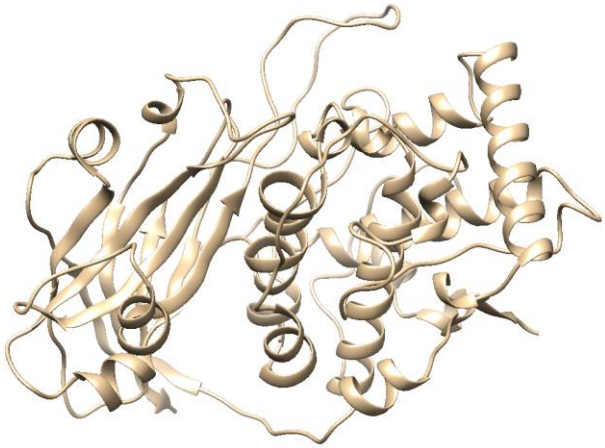


Figure 1: AlphaFold2 model of a Tyrosinase from *Bacillus polymyxa*.

Acknowledgements
GNV acknowledge FCT/MCTES for funding through grant number 2021.06216.BD. This work was supported by the Associate Laboratory for Green Chemistry—LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020) and the Research council of Norway, grant number 301022.

References

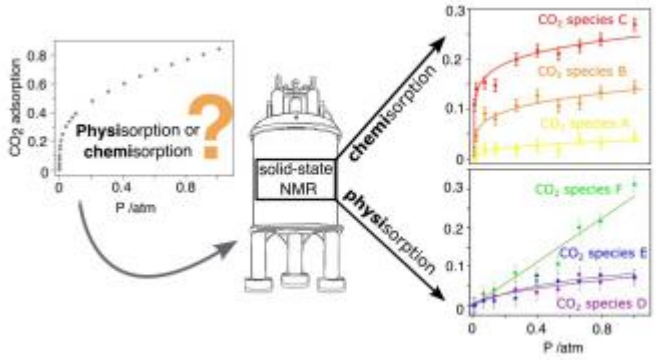
1. Schwander T, et al. Science. (2016)354(6314):900-904. doi: 0.1126/science.aah5237. PMID: 27856910; PMCID: PMC5892708.
2. Carreira C, et al. PeerJ. (2018);6:e5603. doi: 10.7717/peerj.5603. PMID: 30258713; PMCID: PMC6152468.

Solid-state NMR-assisted adsorption techniques for CO_2 capture assessment in porous sorbents

M. Ilkaeva*, R. Vieira, J. Pereira, M. Sardo, I. Marin-Montesinos, L. Mafra

CICECO - Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, Aveiro, Portugal
**marinailkaeva@ua.pt*

Growing concern about rising level of atmospheric CO_2, a green-house gas, due to the excessive exploitation of fossil fuels demands immediate actions to be taken. The decades-old industrial technology based on liquid amine absorbents suffers from several limitations such as poor chemical stability and high regeneration energy requirements. Hence, the use of solid sorbents able to selectively capture CO_2 is a desirable alternative. To improve the performance of solid sorbents and make them feasible at the industrial level, it is crucial to elucidate CO_2 capture mechanisms. In addition to conventional techniques, such as volumetric and gravimetric gas adsorption, the use of spectroscopic techniques, namely ssNMR, can be a great asset, as it unveils extremely useful information on the CO_2 adsorption mechanisms.1,2 Adsorption isotherms are widely used to assess the gas adsorption performance of solid sorbents. Nevertheless, there is always ambiguity regarding the contributions of chemi- and physisorption processes to the total retained gas volume. To address this question, in this work, we employ a solid-state NMR-assisted approach. This method is based on quantitative NMR measurements at variable CO_2 pressures. We demonstrate the applicability of it by recording $^{13}CO_2$ adsorption isotherm for a model sorbent - amine-modified SBA-15 mesoporous silica. To validate the obtained data, conventional manometric adsorption technique was used for comparison. Importantly, the designed ssNMR-assisted technique reveals individual contributions of chemi- and physisorption to the total amount of adsorbed CO_2. Moreover, it was possible to collect separate isotherms for three chemi- and three physisorbed CO_2 species, which is beyond the reach of conventional methods for recording adsorption isotherms (Scheme 1). Ultimately, different adsorption models were applied to describe all registered adsorption isotherms. Our study demonstrates that ssNMR can be seen as not only complementary to the existing conventional adsorption assessment methods, but as a powerful independent tool for revealing and quantifying different CO_2 species formed on the surface of the solid sorbents.



Scheme 1: ssNMR-assisted approach enables the separation of six individual isotherms for chemi- and physisorbed CO_2 components.

Acknowledgements
We thank CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC), projects PTDC/QUI-QFI/28747/2017 and PTDC/QUI-ELT/2593/2021, financed through FCT/MEC and cofinanced by FEDER under the PT2020 Partnership Agreement. The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project 022161 (cofinanced by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). This work has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant Agreements 865974 and 101039748). FCT is also acknowledged by R.V., M.I. and M.S. for Researcher Positions (CEECIND/02127/2017, CEECIND/00546/2018 and CEECIND/00056/2020, respectively) and by J.P. for a Ph.D. Studentship (SFRH/BD/145004/2019).

References

1. L. Mafra, T. Čendak, S. Schneider, P. V. Wiper, J. Pires, J.R.B Gomes and M. Pinto, *J. Am. Chem. Soc.*, 2017, **139**, 389–408.
2. R. Vieira, I. Marin-Montesinos, J.M.P. Pereira, R. Fonseca, M. Ilkaeva, M. Sardo and L. Mafra, *J. Phys. Chem. C*, 2021, **125**, 14797–14806.
3. M. Ilkaeva, R. Vieira, J.M.P. Pereira, M. Sardo, I. Marin-Montesinos and L. Mafra, *J. Am. Chem. Soc.*, 2023, **145**, 8764–8769

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Green extraction of fatty acids from *Codium tomentosum*: Unlocking the potential of eutectic solvents

S. Patinha[1,2,*], J. Resende[1], A. J. D. Silvestre[1], H. Abreu[3], S. M. Rocha[2], S. A. O. Santos[1]

[1]*CICECO-Aveiro Institute of Materials & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*LAQV-REQUIMTE & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[3]*ALGAplus-Prod. e Comerc. De Algas e Seus Derivados, Lda., Ílhavo, 3830-196, Portugal*
**jsamuelpatinha@ua.pt*

Macroalgae have been widely studied in the last decades as a promising source of a wide range of interesting bioactive compounds that can have high-value applications in pharmaceutical, cosmetic or nutraceutical industries. *Codium tomentosum*, a green macroalga that grows in the Portuguese coast, is known for its high content on fatty acids including polyunsaturated fatty acids (PUFAs).[1,2] The exploitation of these compounds for nutraceutical applications requires the development of safe and sustainable extraction methodologies, notably to overcome the use of (often toxic) organic solvents. The use of alternative solvents and more recently eutectic solvents has gained increased attention due to their low toxicity, biodegradability and tailored solvent properties.[3]

In this work, the extraction of fatty acids from the macroalga *C. tomentosum* was studied using six different eutectic mixtures: M:C8; M:C10; M:T; C8:C10; T:1,8-octanediol; ChCl:Gly (M=menthol, C8=octanoic acid, C10=decanoic acid, T=thymol, ChCl=choline chloride, Gly=glycerol). The extraction yield and fatty acids profile were investigated using gas chromatography-mass spectrometry (GC-MS) and compared with those obtained by conventional Soxhlet extraction with dichloromethane. Fatty acids yields ranged from 315±59 mg kg^{-1} dw (for extraction with ChCl:Gly) to 7018±1267 mg kg^{-1} dw (for extraction with M:C10).

Eutectic solvents proved to play an important role in the extraction of fatty acids from *C. tomentosum* and in the development of more sustainable extraction methodologies in this area.

Acknowledgements

This work was developed within the scope of the projects CICECO-Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) and LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), financed by national funds through the FCT/MCTES (PIDDAC); co-financing, when adequate, by FEDER under the PT2020 Partnership Agreement. This work was also developed within the project (ALGREEN, 2022.04670.PTDC), financially supported by national funds (OE), through FCT/MCTES. Acknowledgements are also due to FCT/MCTES for the PhD grants to S. Patinha (SFRH/BD/148555/2019) and J. Resende (SFRH/BD/08821/2020) and for the research contract under Scientific Employment Stimulus to S. A. O. Santos (2021.03348.CEECIND).

References

1. S. A. O. Santos, C. Vilela, C. S. R. Freire, M. H. Abreu, S. M. Rocha and A. J. D. Silvestre, Food Chem, 2015, **183**, 122–128.
2. M. D. N. Meinita, D. Harwanto and J. S. Choi, Journal of Applied Phycology 2022 34:6, 2022, **34**, 2827–2845.
3. C. J. Clarke, W. C. Tu, O. Levers, A. Bröhl and J. P. Hallett, Chem Rev, 2018, **118**, 747–800.

Sustainable approach to phytosterol extraction from macroalgae using alternative solvents

J. Resende[1,*], F. H. B. Sosa[1], H. Abreu[2], J. A. P. Coutinho[1], J. Rocha[1], A. J. D. Silvestre[1], S. A. O. Santos[1]

[1]CICECO-Aveiro Institute of Materials & Department of Chemistry, Campus Universitário Santiago, University of Aveiro, 3810-193 Aveiro, Portugal
[2]ALGAplus- Produção e Comercialização de Algas e seus Derivados, Lda., 3830-352 Ílhavo, Portugal;
**judite.resende@ua.pt*

Macroalgae, also known as seaweed, are a diverse group of marine organisms that have garnered significant interest as a sustainable source of a wide range of valuable secondary metabolites, some of them with unique biological properties, produced in response to the surrounding environment.[1] Among those, phytosterols are described as having antibacterial, anti-inflammatory and antiproliferative activities, which make them very promising for high-value nutraceutical or pharmaceutical applications.[2] However, their exploitation in these fields has been hindered by the lack of environmentally friendly and efficient extraction methodologies.[3] Fulfilling the principles of Green Chemistry, eutectic solvents (ES) and bio-based solvents have been suggested as environmentally friendly alternatives to hazardous solvents for the selective extraction of natural bioactive compounds from biomass.[4]

In this work, an assessment was conducted on various eutectic solvents (ES) and bio-based solvents to determine their effectiveness in extracting phytosterols from *Codium tomentosum*. For ES, the conductor-like screening model for real solvents (COSMO-RS) was used as an initial screening tool to predict the chemical potential of individual compounds in eutectic mixtures and decrease the number of experiments necessary. ES composed of terpenes, fatty acids and some alcohols were predicted to be the most suitable for phytosterols extraction. After validation of the predicted solubility using a standard mixture, solid-liquid extraction of *C. tomentosum* was performed using the selected ES and their ability to obtain phytosterols was evaluated by gas chromatography coupled to mass spectrometry (GC-MS) and compared with the predictions made by COSMO-RS and with results from the extraction with conventional solvents.

When considering bio-based solvents for the extraction process, three options were chosen: ethanol, ethyl acetate, and 2-methyltetrahydrofuran (2-MeTHF). Among these solvents, ethyl acetate exhibited the most promising results in terms of phytosterols extraction and it was selected as the solvent of choice to perform a sequential extraction procedure. Overall, the use of alternative solvents provides a promising sustainable and environmentally friendly approach for obtaining bioactive phytosterols enriched extracts from macroalga *C. tomentosum*.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). This work was also developed within the project (ALGREEN, 2022.04670.PTDC), financially supported by national funds (OE), through FCT/MCTES. Acknowledgments are also due to FCT/MCTES for the PhD grant to J. Resende (SFRH/BD/08821/2020) and for the research contract under Scientific Employment Stimulus to S. Santos (2021.03348.CEECIND).

References
1. A. A. El Gamal, Biological importance of marine algae, *Saudi Pharm. J.*, 2010, 18, 1–25.
2. G. Lopes, C. Sousa, P. Valentão and P. B. Andrade, in *Bioactive Compounds from Marine Foods*, John Wiley & Sons Ltd, Chichester, UK, 2013, pp. 173–191.
3. C. I. L. Justino, K. Duarte and A. C. Freitas, in *Comprehensive Analytical Chemistry*, Elsevier, 2014, vol. 65, pp. 35–57.
4. F. Chemat, M. A. Abert Vian, H. K. Ravi, B. Khadhraoui, S. Hilali, S. Perino and A.-S. F. Tixier, Review of Alternative Solvents for Green Extraction of Food and Natural Products: Panorama, Principles, Applications and Prospects, *Molecules*, 2019, 24, 3007.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Levodopa-Functionalized Gold Nanourchins: Efficient nanosensors for food contaminant detection

Marina Justi[1,*], Sara Fateixa[1], Violeta A. Girão[1], Mónica Almeida[2], Miguel Oliveira,[2] João A. P. Coutinho[1], Ricardo Pinto[1], Ana M. Ferreira[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2] Department of Biology & CESAM, University of Aveiro, 3810-193 Aveiro, Portugal
**marinasetubalj@ua.pt*

In recent years, the development of innovative materials for faster and more sensitive detection of food additives and contaminants has paved the way for safer and healthier consumption. Gold nanoparticles (AuNPs) have attracted much attention in this field due to their wide range of applications, including the development of nanosensors. These nanostructures have been used as suitable substrates for surface-enhanced Raman scattering (SERS) spectroscopy to detect many specific molecules.[2] Anisotropic morphologies, such as nanourchins, offer several advantages over isotropic nanoparticles due to their branched morphology, as they have "hot points" characterized by large electromagnetic fields.[1] Therefore, it is imperative to find new environmentally friendly approaches to obtain these Au anisotropic nanostructures with effective control over size and morphology while demonstrating that they are safe and effective in detecting various contaminants.

In this study, we synthesized Au nanostructures (nanourchins), using levodopa extract from *Mucuna pruriens,* and evaluated their potential as substrates to detect specific food contaminants (Figure 1). First, the effect of different reaction parameters, namely the use of polyethylene glycol, gold seeds concentration, gold salt concentration and levodopa extract concentration, on AuNPs morphology and size was investigated. Then, by an experimental design was determined the key parameters to achieve a specific morphology with controlled size. Low seed concentration and a high levodopa concentration led to large nanourchins morphology, while high seed concentration and low levodopa concentration resulted in spherical morphology. Balanced seed and levodopa concentrations produced smaller nanourchin morphology without protrusions. Three gold nanourchins of different sizes (44, 94 nm, and 38 nm without rounded tips) were selected as nanosensors for contaminant detection. The efficiency was then evaluated based on their ability to detect methylene blue and rhodamine B, toxic and carcinogenic compounds found in food. All gold nanostructures successfully detected both compounds, with 44 nm nanourchins exhibiting the strongest SERS signal. These results highlight the potential of these biobased gold nanostructures as efficient nanosensors to detect specific food additives and contaminants.

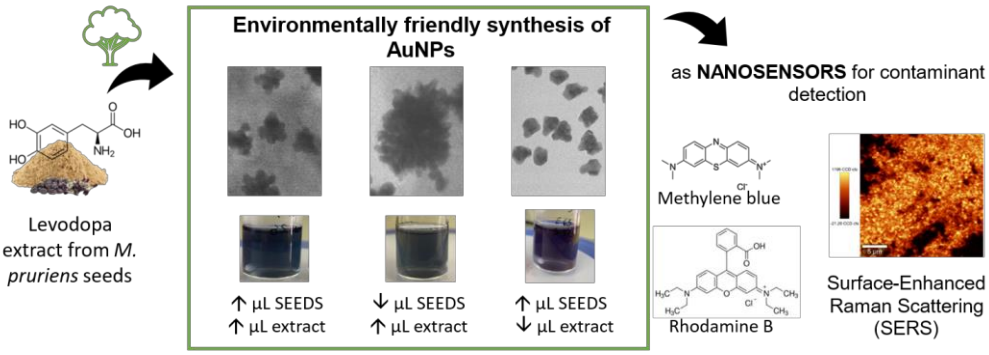


Figure 1: Using AuNPs synthesized with plant extract as SERS substrate to detect organic dyes, namely methylene blue and rhodamine B.

Acknowledgments
This work was partly developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). AMF acknowledges FCT for the CEECIND/00361/2022 contract under the Scientific Stimulus – Individual Call. The research contract of R.J.B. Pinto and S.Fateixa was funded by national funds (OE), through FCT in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. Thanks are due to FCT/MCTES for the financial support to the project NanoPlanet (2022.02340.PTDC) and CESAM (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020) through national funds.

References

1. C. Kohout, C. Santi and L. Polito, *Int J Mol Sci*, 2018, **19**, 3385.
2. Phys.Chem.Chem.Phys., 2015, **17**, 21046.

Galactomannan-based carriers for pulmonary administration of insulin – evaluating the preparation conditions

Miguel F. Galrinho[1,2*], Maria Sousa[1], Margarida Almeida[3], Ricardo J. B. Pinto[2], Pedro Oliveira[1], Ana Martins[1], Manuel A. Coimbra[1], Cláudia P. Passos[1]

[1]LAQV/REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193, Portugal
[3]CICECO – Aveiro Institute of Materials, Department of Materials, University of Aveiro, 3810-193, Portugal
**Miguel.fgalrinho@ua.pt*

Type I diabetes is characterized as an autoimmune disorder, leaving individuals dependent on insulin administrations to reduce glucose blood levels. Current strategies for insulin administration are considered suboptimal, consisting of an invasive route that can cause discomfort, pain, bruises, and risks of potential local infections to patients.[1] Alternatively, polysaccharides such as galactomannans from locust bean gum (LBG) can be used as possible insulin carriers, providing stability and protection to insulin which can be delivered through the pulmonary route, a non-invasive approach that complies with the lung's large surface area and low occurrence of metabolic processes.[2,3]

In this work, LBG was processed by microwave (MW) treatment, with a consequent viscosity reduction due to depolymerization, allowing the spray-drying processing. Depolymerized polysaccharides were ultrafiltered using different membrane cut-offs, namely 5 and 300 kDa, and spray-dried at 150 ºC with 10% insulin (w/w). The sugar composition was studied by gas chromatography (GC-FID) for carrier characterization. DNS assay was also applied for reducing sugars quantification. Size and morphology were analyzed by scanning electron microscopy (SEM). A chemical delivery was performed using an orbital shaker, followed by liquid chromatography (HPLC) to identify and quantify insulin release over time. Additional spray-drying assays were performed with and without an endo-mannanase at two pH conditions: pH 3 (endo-1,4-β-Mannanase from *A. niger*) and pH 8 (endo-1,4-β-Mannanase from *C. japonicus*). SDS-PAGE analysis was also performed to identify the protein content and eventual protein modifications in the different particles.

After the MW treatment and fractionation by ultrafiltration, both retentate fractions contained mannose and galactose, in agreement with a galactomannan-rich composition and about 10-12% of reducing sugars. SEM analysis revealed microparticles (MPs) with a raisin-like morphology and a size distribution between 1-10 µm. Insulin release assays were performed at pH 7.4 and 37ºC. The release occurred in a gradual linear manner until the full content release of the insulin within 1h. Contrary to the particles that were initially conditioned at pH3, in the pH8 conditioned particles, the release assay identified less than 20% of the available insulin. This effect was only visible when using the 5 kDa retentate sample, revealing a possible interference from protein modifications events during spray-drying in the presence of low molecular weight material. This effect was enhanced at higher pH conditions. These results show LBG as a source of galactomannans that can be prepared by combining MW treatment, ultrafiltration purification, and spray-drying techniques, as long as the potential carrier is prepared in acidic conditions. Then, the microparticles can be assembled to obtain an ideal release profile within the particle dimensions, allowing a non-invasive administration of insulin.

Acknowledgements
This work was financially supported by the project "PulManCar" - POCI-01-0145-FEDER-029560- funded by FEDER, through COMPETE2020 - Programa Operacional Competitividade e Internacionalização (POCI), and by national funds (OE), through FCT/MCTES. Thanks are due to the University of Aveiro and FCT/MCT for the financial support for the QOPNA and LAQV-REQUIMTE research units (FCT UID/QUI/00062/2019; UIDB/50006/2020) and CICECO-Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020), POCI-01-0145-FEDER-007679 (FCT Ref. UID/CTM/50011/2019) through national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement, and to the Portuguese NMR Network. The research contract of R.J.B. Pinto was funded by national funds (OE), through FCT in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. Cláudia Passos contract (CEECIND/01873/2017) was supported by FCT.

References

1. I. R. El Maalouf, K. Capoccia and R. Priefer, *Diabetes Metab. Syndr.*, 2022, 16, 102478.
2. S. A. Valente, G. R. Lopes, I. Ferreira, M. F. Galrinho, M. Almeida, P. Ferreira, M. T. Cruz, M. A. Coimbra and C. P. Passos, *Pharmaceutics*, 2023, 15, 1213.
3. A. Verma, A. Tiwari, P. K. Panda, S. Saraf, A. Jain and S. K. Jain, *Natural Polysaccharides in Drug Delivery and Biomedical Applications*, Elsevier, 2019, pp. 203–222.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Gold nanoparticle SERS immunoassays for the detection of *Toxoplasma gondii*

J. Manuel*, L. Ferreira, M. Enea, E. Pereira

LAQV/REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências da Universidade do Porto, Portugal
**up201906827@fc.up.pt*

Toxoplamosis is a worldwide common infection resulted by ingestion of contaminated products with the protozoan *Toxoplasma gondii* that can present severe effects including ocular damage, hydrocephaly, and stillbirth in foetus and immunocompromised individuals. Most detection tests, such as the ELISA, are expensive and can only be performed in laboratories.[1]
The use of gold nanoparticles based immunoassays for the detection of toxoplasmosis present great potential due to their good optical properties, high stability and low toxicity. The presence of the surface plasmon bands for the gold nanoparticles, grant them different colours dependent on their size and morphology.[2] This characteristic permits us to create a myriad of recognition methods, from colorimetric tests to SERS[3] (surface enhanced Raman spectroscopy) assays. Colorimetric tests rely mostly on the use of gold nanospheres and SERS analysis depend of other morphologies that present protuberances, like gold nanostars.
This work aims to produce star-shaped (AuNSs) and sphere-shaped (AuNPs) gold nanobioconjugantes optimal for development of lateral flow immunoassay (LFIA) as a bionanotechnology solution for simultaneous and separate detection of anti-Toxoplasmosis antibody IgM and IgG. Therefore, AuNPs and AuNSs were synthetized and functionalized with low molecular weight polyethylene glycol (PEG), so they are biocompatible, stable and easily functionalized with a synthetic peptide (GRA6), which is specific for Toxoplasmosis detection, via EDC/NHS (carbodiimide/*N*-hydroxy succinimide) using different ratios. Characterisation of the resulting GRA6II – AuNPs conjugate through UV-Vis spectrophotometry, Nanoparticle Tracking analysis and Dynamic light scattering of the resulting GRA6II – AuNPs conjugates will be presented and discussed. The results demonstrate the successful binding of the Gra6II to the AuNPs and obtaining otimized gold nanobioconjugates that can be further used for the development of the LFIA in Toxoplasmosis diagnostic.

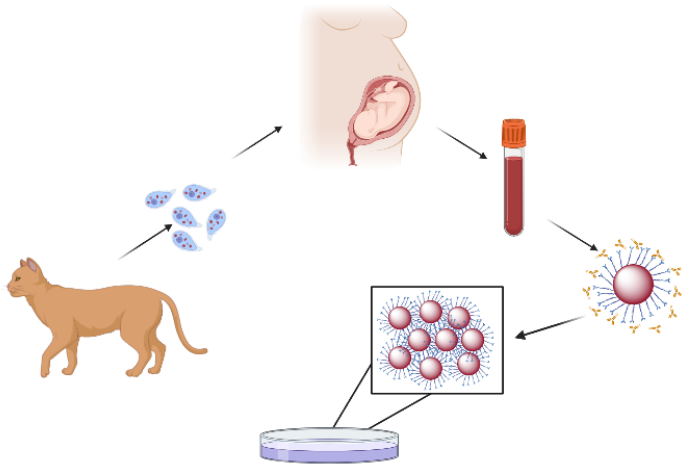


Figure 1: Route of infection to detection of Toxoplasma gondii. The colour blue of the solution indicates a positive test

Acknowledgements
This work received support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020. M.E. thanks LAQV for her Post-Doc grant ref. REQUIMTE 2022-06. J.M. thanks Fundação Calouste Gulbenkian for the New Talents Scholarship (2022-20223).

References
1. C. Pomares, B. Zhang, S. Arulkumar, G. Gonfrier, P. Marty, S. Zhao, S. Cheng, M. Tang, H. Dai and J. G. Montoya, *Diagnostic Microbiology and Infectious Disease*, 2017, **87**, 213-218.
2. S. Sousa, A. Castro, J. M. Correia Da Costa and E. Pereira, *Nanomaterials*, 2021, **11**, 2065.
3. Q. Su, X. Ma, J. Dong, C. Jiang and W. Qian, *ACS Applied Materials & Interfaces*, 2011, **3**, 1873-1879.

Cholesterol and phytol phenolipids – antioxidant efficiency in liposomes

V. Costa, R. Rebelo, F. Arques, M. Ferreira, P. G. Santos, F. Paiva-Martins*

REQUIMTE-LAQV, Departament of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Porto, Portugal.
**mpmartin@fc.up.pt*

Phenolic compounds are potent antioxidants that may play an important role both in biological systems and in formulated lipid dispersions. However, their efficiency is often limited by their solubility or bioavailability. Lipophilization of phenolic acids (phenolipids) with high radical scavenging properties, such as caffeic or dihydrocaffeic acids, may increase their solubility in lipophilic matrices and their penetration through lipid bilayers, conferring better antioxidant protection in food and biological systems.[1,2] Recently, attention has been given to some natural phenolipids such as steryl ferulates and caffeates.[3] The overall concentration of these compounds in some cereals may be ten times higher than that of total tocopherols, being very important antioxidants in cereals. These compounds have also shown cholesterol-lowering properties as well as anti-inflammatory and antitumor activity.

Although the esterification reaction has been widely studied, few reports concern the esterification of polyphenolic acids. These compounds have a particular stability that prevents the direct use of the more common esterification strategies. Previous protection of the aromatic hydroxyl groups is usually required. However, this strategy is time and material consuming and the overall yield is not great because the need of more reactional steps and purifications.

In this work, the synthesis of cholesterol and phytol esters (Figure 1) were studied in order to obtain phenolipids derived from caffeic, dihydrocaffeic, 3,4-dihydroxyphenyl ethanoic and protocatechuic acids in good yields. By changing temperature, catalyst type, acidity and solvent type, we were able to improve yields. Optimized reaction conditions were not the same for all phenolic acids and alcohols being in all cases very depend on the solvent used. The best conditions for phytol phenolipids were obtained with enzymatic catalysis with yields up to 95%. In contrast, cholesterol phenolipids were only efficiently obtained by chemical catalysis, with yields between 60-98%. Preliminary antioxidant evaluation of these phenolipids in soybean PC liposomes showed that these compounds have a much higher protecting efficiency against the AAPH-induced oxidative stress than tocopherol.

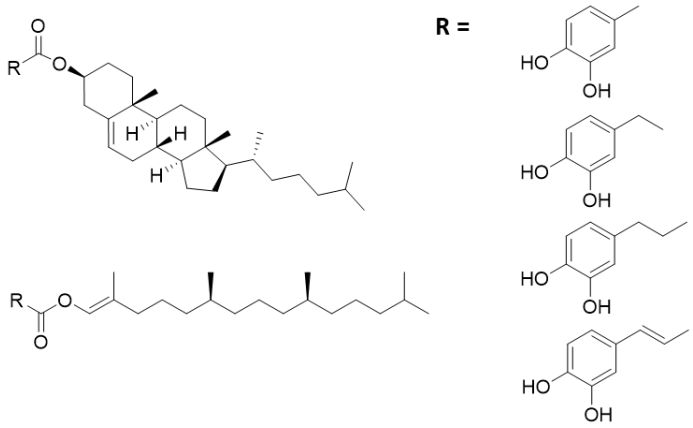


Figure 1: Phytol- and cholesterol-derived phenolipids studied in this work.

Acknowledgements
This work was financial supported with funding from FCT/MCTES (UIDP/50006/2020) through national funds.

References

1. S. Losada-Barreiro, Z. Sezgin-Bayindir, F. Paiva-Martins, C. Bravo-Díaz. Biomed., 2022, **10**, 3051.
2. R. Lopes, M. Costa, M. Ferreira, P. Gameiro, S. Fernandes, C. Catarino, A. Santos-Silva, F. Paiva-Martins BBA-Biomembranes, 2021, **1863**, 183727.
3. D. Rabiej-Kozioł, K. Roszek, M. P. Krzeminski , et al., Food Addit. Contam. Part A, **2022**, 39,1365.

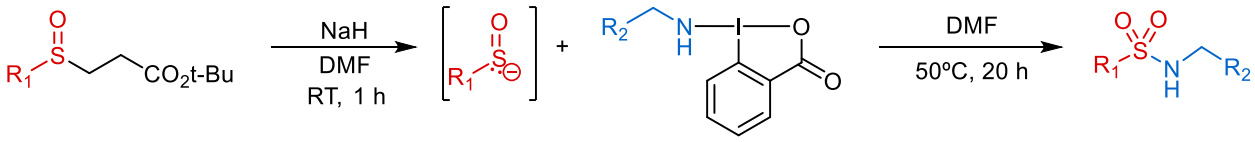
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of sulfonamides via electrophilic amination mediated by hypervalent iodine(III) reagents

J. da Cunha, C. S. Caldeira, J. Macara, B. Dedeiras, M. Manuel B. Marques*

LAQV@REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica (Portugal)
**msbm@fct.unl.pt*

Electrophilic sources of nitrogen-based groups have been known for many decades and are of great synthetic importance. Hypervalent iodine reagents (HIRs) bearing N-containing groups have emerged as an alternative to classical electrophilic amination reactions, and are capable of transferring a wide diversity of nitrogen-containing functional groups to organic molecules.[1]
In particular, cyclic HIRs - benziodoxol(on)es - incorporating the iodine atom in a heterocycle exhibit higher stability. The benziodoxol(on)es and benziodazoles have been the focus of interest, due to their excellent properties to act as electrophilic synthons of normally nucleophilic groups, emerging as powerful tools in electrophilic amination reactions.[2,3]
Our group has been exploring the umpolung reactivity of benzodixolones in the synthesis of sulfonamides,[4] and sulfinyl hydrazides.[5]
Recently we have disclosed the synthesis and reactivity of a novel class of HIRs bearing a transferable primary amine.[7]
In this study, we explored the use of these new HIRs on the electrophilic amination of β-sulfinyl esters, showcasing the synthetic versatility and advantages of this approach. The reactivity of the new HIRs with sulfenates generated in situ was investigated, affording the corresponding aminated products with good to excellent yields (Scheme 1). To gain insights into the reaction mechanism, we conducted control experiments and proposed a plausible reaction pathway.



Scheme 1: General scheme for sulfonamide synthesis

Acknowledgements
The authors thank the Fundação para a Ciência e Tecnologia (FCT, 2022.04623.PTDC and fellowship 2022.11629.BD (J. C.). The authors also thank the support by the Laboratório Associado para a Química Verde (LAQV), which is financed by national funds from FCT/Ministério da Ciência, Tecnologia e Ensino Superior (FCT/MCTES, UIDB/50006/2020, UIDP/50006/2020, and LA/P/0008/2020).

References
1. J. Macara, C. Caldeira, D. L. Poeira, M. M. B. Marques, *European Journal of Organic Chemistry*, 2023, DOI: https://doi.org/10.1002/ejoc.202300109
2. J. Waser., *Synlett*, 2016, **27**(20), 2761–2773. DOI: https://doi.org/10.1055/s-0036-1589409
3. D. L. Poeira, M. M. B. Marques, A. C. R. Negrão, J. Macara, *Current Organic Chemistry*, 2021, **25**(19), 2199–2216, DOI: https://doi.org/10.2174/1385272825666210728101125
4. D. L. Poeira, J. Macara, H. Faustino, J. A. S. Coelho, P. M. P. Gois, M. M. B. Marques, *European Journal of Organic Chemistry*, 2019, **2019**(15), 2695-2701, DOI: https://doi.org/10.1002/ejoc.201900259
5. J. Macara, C. Caldeira, J. da Cunha, J. A. S. Coelho, M. J. S. A. Silva, K. Krämer, C. W. Grathwol, S. Bräse, M. M. B. Marques, Organic & Biomolecular Chemistry, 2023, **10**, DOI: https://doi.org/10.1039/d2ob02160a
6. D. L. Poeira, A. C. R. Negrão, H. Faustino; J. A. S. Coelho, C. S. B. Gomes, P. M. P. Gois; M. M. B. Marques, *Organic Letters*, 2022, **24**(2), 776–781, DOI: https://doi.org/10.1021/acs.orglett.1c04312

Study of glycation and oxidation as naturally occurring chemical modifications in serotransferrin

Eduardo Ramos[1,*], Graça Porto[2], Mª Conceição Rangel[1,3], André Silva[1,3]

[1]LAQV-REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Portugal; [2]Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Portugal, Departamento de Hematologia, Centro Hospitalar Universitário de Santo António, Porto, Portugal and I3S, Instituto de Investigação e Inovação em Saúde, Porto, Portugal; [3]LAQV-REQUIMTE, Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Portugal
**up201805070@fc.up.pt*

Hereditary Hemochromatosis (HH) is the most widespread genetic autosomal recessive disease in populations of European ancestry. HH is characterized by excessive iron absorption and increased body iron stores. High systemic iron levels result in iron deposition in several organs, ultimately leading to skin hyperpigmentation, cardiovascular disease, hypogonadism, diabetes, arthropathy, and cirrhosis[1]. Transferrin (Tf) is the protein responsible for the transport of iron in circulation, possessing two equivalent lobes that can bind one Fe^{3+} each. Tf is also relevant in iron scavenging, redox protection, and pathogen infection control through iron withdrawal. Iron-binding by Tf is necessary for regulated cellular iron internalisation[2]. Additionally, Tf-bound iron acts as a signal for the regulation of iron metabolism[3]. Tf plays an important role in HH, binding excessive iron in circulation and mediating its distribution through different organs. However, post-translational modifications (PTMs) of Tf, such as glycosylation, phosphorylation, glycation, and oxidation, have the potential to modulate its iron-binding capacity and its function in a physiologically relevant manner[4]. PTMs are covalent events that alter the properties of proteins by adding functional groups to one or more residues, playing a key role in biological processes by affecting both the dynamics of proteins but also their structural properties[5]. The presence of new functional groups changes the polarity of protein, but the modifications might themselves as stereochemical blockers that affect protein-protein interactions but also drug-target interactions[6].
This work has the objective of characterizing PTMs in Tf that may compromise its function in the context of HH, an iron overload disease. Additionally, we aim at identifying how PTMs might affect iron distribution between Tf lobes and contribute to the occurrence of non-transferrin-bound iron species when Tf is not fully saturated.
Blood samples from an already existent Serum Bank of HH patients from Hospital Santo António were utilized to study these modifications and their site distribution. Patients under intensive treatment (N=15), subjects to weekly phlebotomies, and maintenance treatment (N=41), subjects to trimesterly phlebotomies, were studied. Controls (N = 30) were a group of healthy blood donors. Tf was purified from serum samples and analysed by native urea-gel electrophoresis and mass spectrometry-based proteomics. Results show that non-enzymatic glycation, oxidation, and carboxylation were found to be the most abundant PTMs. Control samples were found to have a higher degree of glycation in Lys206 and Lys534, residues which are part of the iron binding mechanism in the N-terminal and C-terminal binding sites, respectively. The modification rate in the Lys534 was 20%, which should significantly hamper access to the C-terminal iron-binding site. Controls also have a higher degree of oxidation in several residues. Carboxylation of Asp63, an iron-binding residue, has been identified in all groups, which could provide insight into the differential iron distribution in Tf-lobes. These resuls show that the identified PTMs mostly result from non-enzymatic chemical modifications which occur at residues involved in Tf iron-binding and are likely to compromise Tf iron-binding capacity. A better understanding of Tf biochemistry may shed light on differential clinical outcomes and disease-specific patterns of organ iron loading.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for providing financial support through the project 2022.06328.PTDC and unit UIDB/50006/2020|UIDP/50006/2020.

References
1. J. L. Porter and P. Rawla, in *StatPearls*, StatPearls Publishing Copyright © 2022, StatPearls Publishing LLC., Treasure Island (FL), 2022.
2. P. T. Gomme, K. B. McCann and J. Bertolini, *Drug Discov Today*, 2005, **10**, 267-273.
3. M. D. Kleven, S. Jue and C. A. Enns, *Biochemistry*, 2018, **57**, 1552-1559.
4. A. M. N. Silva, T. Moniz, B. de Castro and M. Rangel, *Coordination Chemistry Reviews*, 2021, **449**, 214186.
5. S. Ramazi and J. Zahiri, *Database (Oxford)*, 2021, **2021**.
6. M. G. Su, J. T. Weng, J. B. Hsu, K. Y. Huang, Y. H. Chi and T. Y. Lee, *BMC Syst Biol*, 2017, **11**, 132.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of 3,5-disubstituted nitrobenzenes and their applications

Telmo N. Francisco[1,*], Joana L. C. Sousa[1], Samuel Guieu[1,2], Artur M. S. Silva[1], Hélio M. T. Albuquerque[1]

[1]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
**telmofrancisco@ua.pt*

The most common method for the synthesis of nitrobenzenes involves the electrophilic aromatic nitration of arenes using the ordinarily known “mixed acid” methodology, consisting of a mixture of nitric and sulphuric acids. This type of compounds has been explored in the production of a variety of chemicals, like dyes, perfumes, and pharmaceutical ingredient.[1] Recently, alternative methods for the synthesis of the nitrobenzenes have emerged, such as the direct oxidation of anilines [2] or the *ipso*-nitration of aryl and heteroaryl precursors, allowing the preparation of multiple substituted nitro derivatives [3]. However, the harsh conditions that all these methods imply, keep raising problems of environmental nature, especially when applied in large-scale production of nitro group-containing compounds, or the use of transition-metals that will lead to the production of undesired waste.
Therefore, the search for alternative methods capable of producing these nitrobenzenes using milder conditions is of the utmost importance for both industrial and laboratory applications. Following the interest in chromones within our research group, we developed a new method for the synthesis of nitrobenzenes using 3-formylchromones that together with nitromethane, as the Michael donor, would lead to the one-pot formation of three new C–C allowing the preparation of 3,5-disubstituted nitrobenzenes over very mild conditions. These title compounds were obtained in a range of 52-86% isolated yields and the method was found to be compatible with a gram-scale protocol.4 To further explore this methodology, we plan on unlocking the synthesis of non-symmetrical nitrobenzenes allowing the synthesis of a whole new range of interesting compounds. To give further purpose to the 3,5-disubstituted nitrobenzenes, we submit them to multiple studies to check their biological and chemical applicability as photocatalysts. Post-modification reactions were also attempted to produce xanthone derivatives (Figure 1).

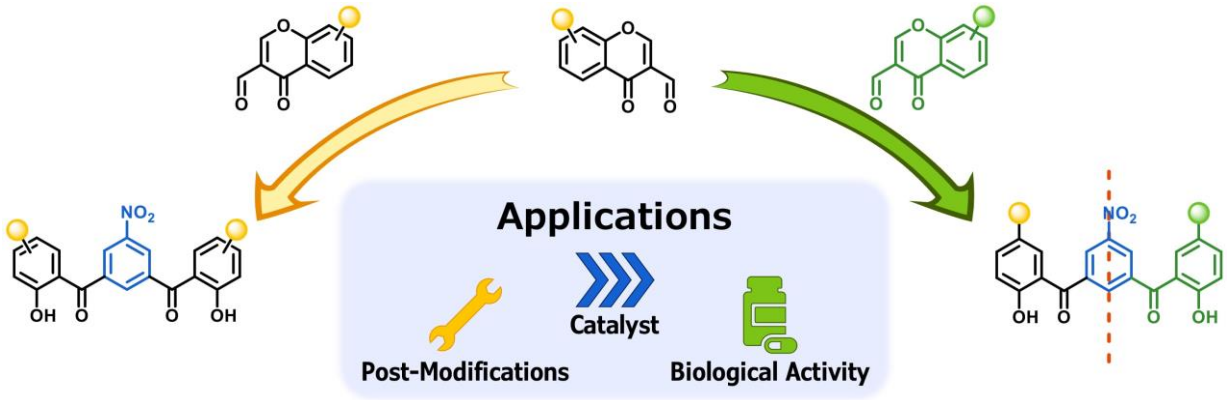


Figure 1: Representation of the synthesis of 3,5-disubstituted nitrobenzenes, symmetrically and non-symmetrically, and applicability studies.

Acknowledgements
This work received financial support from PT national funds (OE) through FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) within the projects: LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), and MuTaTher-AD – “Multi-target theranostics for Alzheimer’s disease” (2022.06064.PTDC). Joana Sousa gratefully acknowledges LAQV-REQUIMTE for her researcher contract. Telmo N. Francisco thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for his PhD grant (2022.12243.BD).

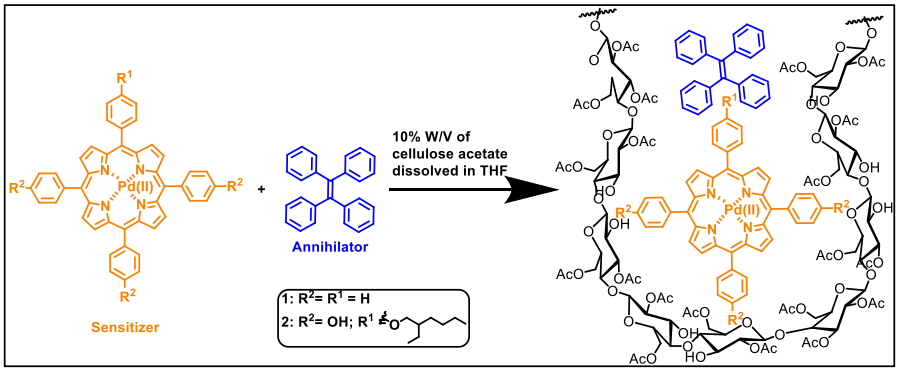
References
1. N. Ono, The Nitro Group in Organic Synthesis, Wiley-VCH, 2001.
2. D. Tanini, C. Dalia, A. Capperucci, Green Chem., 2021, **23,** 5680.
3. C. Wu, Q. Bian, T. Ding, M. Tang, W. Zhang, Y. Xu, B. Liu, H. Xu, H.-B. Li, H. Fu, ACS Catal., 2021, **11**, 9561.
4. T. N. Francisco, J. L. C. Sousa, S. Guieu, A. M. S. Silva, H. M. T. Albuquerque, Synlett, 2022, **33**, 1505.

Synthesis and characterization of palladium porphyrins for the construction of a TTA-UC system in a solid matrix

Yaroslav Hryhoryev*, Sara M. A. Pinto, João Pina, Mariette Pereira

University of Coimbra, CQC-IMS, Department of Chemistry, 3004-535 Coimbra, Portugal
**uc2017257261@student.uc.pt*

Porphyrin synthesis has received a lot of attention due to its flexibility and prospective uses in domains including catalysis[1,2], biological sensors[3,4], and photodynamic therapy[5,6]. Another proficient application of porphyrins bearing palladium is its use in nonlinear optics. Triplet-triplet annihilation photon upconversion (TTA-UC) is a multi-photon process wherein two triplet excited state species combine their energies to produce a higher-energy singlet excited state.[7] Herein, we present the synthesis and Pd(II) complexation, as well as its incorporation in cellulose acetate films and the evaluation of the Pd(II) derivatives as photosensitizers for TTA-UC. These Pd(II) derivatives display room temperature phosphorescence and long triplet lifetimes, which make them good candidates for the development of efficient TTA-UC systems. In this study metalloporphyrins and tetraphenylethylene (a known aggregation-induced emission fluorophore) were used as sensitizer/annihilator pairs with promising results as TTA-UC emitters in solid media. We conducted a comprehensive photophysical investigation of the sensitizers and annihilators, and the solid state TTA-UC polymeric blend (Scheme 1).



Scheme 1: Schematic representation of cellulose acetate immobilization of the sensitizer (Pd(II)Porphyrins) and annihilator (tetraphenylethylene) molecules in polymer films.

Acknowledgements
This work was supported by FCT (Fundação para a Ciência e Tecnologia), QREN/FEDER (COMPETE Programa Operacional Factores de Competitividade) through projects UIDB/00070/2020, UIDP/00070/2020, UIDB/00313/2020, UIDP/00313/2020 and UIDB/00285/2020. The authors thank Portuguese NMR Network for access to the UC-NMR facility which is supported in part by FEDER – European Regional Development Fund through the COMPETE Programme (Operational Programme for Competitiveness) and by National Funds through FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) through grants RECI/QEQ-QFI/0168/2012, CENTRO-07-CT62-FEDER-002012, and also through support to Rede Nacional de Ressonância Magnética Nuclear (RNRMN) and to Coimbra Chemistry Centre through grant UID/QUI/00313/2019.

References

1. Pereira, M. M.; Dias, L. D.; Calvete, M. J. F. *ACS Catal.* **2018**, *8*, 10784–10808.
2. Dias, L. D.; Batista de Carvalho, A. L. M.; Pinto, S. M. A.; Aquino, G. L. B.; Calvete, M. J. F.; Rossi, L. M.; Marques, M. P. M.; Pereira, M. M. *Molecules* **2019**, *24*, 52.
3. Guillén, M. G.; Gámez, F.; Roales, J.; Lopes-Costa, T.; Pinto, S. M. A.; Calvete, M. J. F.; Pereira, M. M.; Pedrosa, J. M. *Sens. Actuators B Chem.* **2018**, *260*, 116–124.
4. Esipova, T. V.; Karagodov, A.; Miller, J.; Wilson, D. F.; Busch, T. M.; Vinogradov, S. A. *Anal. Chem.* **2011**, *83*, 8756–8765.
5. Pucelik, B.; Sułek, A.; Drozd, A.; Stochel, G.; Pereira, M. M.; Pinto, S. M. A.; Arnaut, L. G.; Dąbrowski, J. M. *Int. J. Mol. Sci.* **2020**, *21*, 2786.
6. Filatov, M. A.; Senge, M. O. *Mol. Syst. Des. Eng.* **2016**, *1* , 258–272.
7. Dou, Q.; Jiang, L.; Kai, D.; Owh, C.; Loh, X. J. *Drug Discov. Today* **2017**, *22*, 1400–1411.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Modulating the composition of layered double hydroxides to improve mild catalytic oxidation of alkanes

A. Pastor[1,2*], M. V. Kirillova[2], A. M. Kirillov[2]

[1]Departamento de Química Inorgánica e Ingeniería Química, Instituto de Química para la Energía y Medioambiente, Universidad de Córdoba, Córdoba, Spain; [2]Centro de Química Estrutural, Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal
**q92paesa@uco.es*

Alkanes represent an abundant class of hydrocarbon substrates for the synthesis of different value-added chemicals. However, the transformation of alkanes into useful products usually requires several reaction steps and harsh conditions such as elevated temperatures and pressures. Thus, the development of effective reaction protocols and catalytic systems capable of functionalizing saturated hydrocarbons under mild conditions constitutes a challenging objective.[1,2]

While looking at simple, readily available, and low-cost catalytic systems for the mild oxidation of alkanes, we focused our attention on Layered Double Hydroxides (LDHs). These are lamellar compounds that have a structure derived from brucite, $Mg(OH)_2$, with some isomorphic substitutions of the divalent metal ions by tri- and/or tetra-valent ones, so the general chemical formula can be expressed as $[M^{z+}_{(1-x)}M'^{y+}_x(OH)_2]^{w+}(A^{n-})_{w/n}\cdot mH_2O$, where *M* and *M'* are metal cations, *z* is 2, *w* is 3 *or* 4 and A is an *n*-valent anion (Fig. 1).[3] Consequently, LDHs stand out for having enormous chemical versatility, high adsorption capacity, and simple synthesis. LDHs tend to show a stacking of the layers because of their high surface charge, rendering many active sites useless for catalytic reactions. In this sense, O'Hare et al. devised a treatment (AMOST, Aqueous Miscible Organic Solvent Treatment) for LDHs that improves the dispersion of sheets, leading to 2D systems with an increased specific surface area.[4]

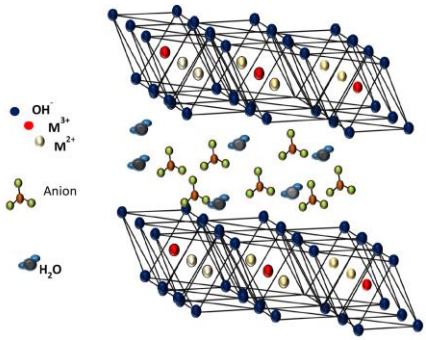


Figure 1: Example of LDH structure with carbonate as an interlayer anion.

Following our general interest in the C−H functionalization of alkanes, the main objectives of this work consisted in (1) the synthesis and characterization of a series of AMOST-LDHs containing different combinations of metal cations (tri- and tetra-heterometallic compounds) and (2) the evaluation of their catalytic activity in the mild oxidation alkanes to give alcohols, ketones, or carboxylic acids. Propane and cyclohexane were used as model substrates, along with hydrogen peroxide as a green oxidant.

We also attempted to tune the metal composition of AMOST-LDHs to modify their physico-chemical properties, which can potentially influence the catalytic activity. LDHs containing a variety of transition metals (Ni, Cu, Fe, Ti or Zn) were synthesized and characterized by standard methods including PXRD, FT-IR, TGA, and ICP-OES. Catalytic tests revealed a particularly high activity of an AMOST-LDH comprising Mg, Cu, Al, and Fe in the oxidation of alkanes with total product yields of up to 30% based on alkane substrate. Catalyst structure – activity correlations, reaction optimization and effects of different parameters will be showcased.

Acknowledgements
This work has been supported by the FCT (PTDC/QUI-QIN/3898/2020, CEECIND/03708/2017, UIDB/00100/2020, UIDP/00100/2020, and LA/P/0056/2020). Adrián Pastor is grateful for a Margarita Salas contract funded by Ministerio de Universidades (Plan de Recuperación, Transformación y Resiliencia) through European Union (NextGenerationEU).

References

1. I. F. M. Costa, M. V. Kirillova, V. André, T. A. Fernandes and A. M. Kirillov, Inorg. Chem. 2021, **60**, 14491.
2. L. S. Andrade, H. L. B. Lima, C. T. P. Silva, W. L. N. Amorim, J. G. R. Poço, A. López-Castillo, M. V. Kirillova, W. A Carvalho, A. M. Kirillov and D. Mandelli, Coord. Chem. Rev. 2023, **481**, 215042.
3. R. Trujillano, F. M. Labajos and V. Rives, Appl. Clay Sci. 2023, **238**, 106927.
4. Q. Wang and D. O'Hare, Chem. Commun. 2013, **49**, 6301.

Electron correlation in aromatic molecules: Analysis of conjugation in naphthalene and fluorene derivatives

Nuno A. S. Dias*, Marco A. L. Lima, Ana L. M. Oliveira, Luís M. N. B. F. Santos, Carlos F. R. A. C. Lima

CIQUP, Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry, Faculty of Science, University of Porto, Rua Do Campo Alegre s/n, P-4169-007 Porto, Portugal
alexsousadiaswork1@gmail.com

Electron correlation has been extensively studied in the last decades due to its central role in physical and quantum chemistry. The nature of this energy still eludes the chemists, being frequently distinguished in various forms, such as dynamic and static correlation.[1]
In this work, some naphthalene and fluorene derivatives were studied with the aim to comprehend how the correlation energy in relatively large aromatic systems behaves when certain changes to the molecule structure are made. To achieve this, the compounds were firstly synthesized and characterized using UV-Vis and NMR spectroscopy. The standard molar entropies, enthalpies and Gibbs energies of sublimation were measured using the Knudsen Quartz Crystal Effusion technique, by measuring the vapor pressures as a function of temperature. The standard molar enthalpies of formation in the crystalline phase were determined by mini-bomb Combustion Calorimetry. Using these results, the standard molar enthalpies of formation in the gas phase were derived. With the use of the homodesmotic reaction scheme shown in Figure 1, the π conjugation energy in the molecules studied was experimentally quantified, and its dependence on molecular structure (type of spacer and position of phenyl rings) analyzed. Molecular energetics was tentatively described by computational calculations using various levels of theory: DFT, HF, MP2, Coupled Cluster, and Configuration Interaction. Most of the molecules studied exhibited noteworthy energetic stabilization as a consequence of π conjugation, which was also manifested in their optical properties and more planar molecular structures (lower phenyl-spacer dihedral angles). However, the HF, MP2, and DFT results were unable to describe the experimental findings, suggesting the importance of static correlation in these systems.

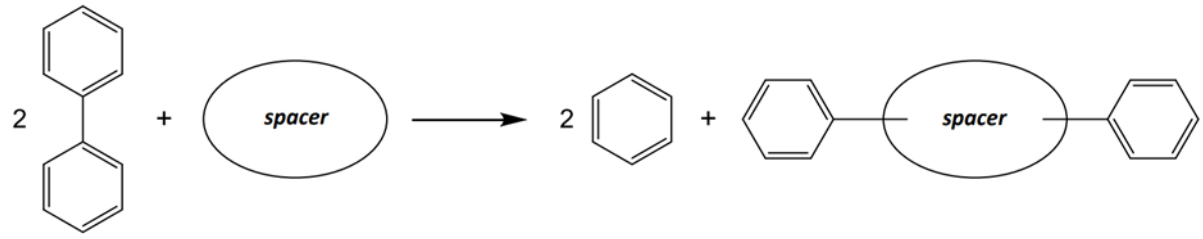


Figure 1: Homodesmotic reaction in the gaseous phase used to quantify π-electron conjugation in the molecules studied.

Acknowledgements
The authors thank the Portuguese Foundation for Science and Technology (FCT) for financial support to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), and IMS-Institute of Molecular Sciences (LA/P/0056/2020), Faculty of Science, University of Porto. CFRACL is financed by national funds through the FCT-I.P., in the framework of the execution of the program contract provided in paragraphs 4, 5, and 6 of art. 23 of Law no. 57/2016 of 29 August, as amended by Law no. 57/2017 of 19 July.

References
1. Raghavachari, K.; Anderson, J. B. Electron Correlation Effects in Molecules. The Journal of Physical Chemistry 1996, 100 (31), 12960–12973.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Rationalising the cooperativity and salient effects on Fe(III) spin crossover compounds

Paulo N. Martinho[1,*], Liliana P. Ferreira[2], Clara S. B. Gomes[3], H. Diogo[1]

[1]Centro de Química Estrutural - Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa; [2]Biosystems and Integrative Sciences Institute (BioISI), Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Lisboa and Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal; [3]LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal
**pnmartinho@ciencias.ulisboa.pt*

Spin crossover compounds exist among a limited group of $3d^4$–$3d^7$ transition metal ions. The most common examples are Fe(II), Fe(III) and Co(II). Fe(III) has an advantage for fabrication of SCO materials due to its redox stability. Recently, SCO research has been producing extraordinary solutions for real applications.[1]

We recently synthesised mononuclear Fe(III) compounds, all displaying spin crossover (SCO), that show to be highly sensitive to the substituent on the ligand. For example, halogen substituted compounds show SCO profiles that range from stepped to abrupt, two of which display hysteresis centred at room temperature.[2] We found that while the bromo-substituted compound undergoes a phase transition coupled with the thermosalient effect (TSE) resulting in crystal fragmentation with no loss of both SCO and hysteresis (Figure),[3] the iodo-subsituted undergoes a irreversible TSE-SCO.[4] We have also found that in amphiphilic Fe(III) SCO compounds self-aggregation in solution forms cooperative systems in dichloromethane.[5] Here I discuss the unexpected cooperative nature of these mononuclear Fe(III) spin labile compounds and attempts to rationalise how the substituent affects the cooperativity and the salient effects are also discussed.

Acknowledgements
We are grateful to Fundação da Ciência e a Tecnologia, FCT, for Project PTDC/QUI-QIN/0252/2021. Centro de Química Estrutural (CQE) and Institute of Molecular Sciences (IMS) acknowledge the financial support of Fundação para a Ciência e Tecnologia (Projects UIDB/00100/2020, UIDP/00100/2020, and LA/P/0056/2020, respectively). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).
P.N.M. acknowledges FTC for financial support (CEECIND/00509/2017 and PTDC/QUI-QIN/0252/2021).

References

1. Halcrow M. A.; Spin-Crossover Materials: Properties and Applications (John Wiley & Sons Ltd, 2013).
2. Vicente, A. I.; Ferreira, L. P.; Carvalho, M. D.; Rodrigues, V. H. N.; Dîrtu, M.; Garcia, Y.; Calhorda, M. J.; Martinho, P. N. Dalton Trans. 48 (2018) 4239–4247.
3. Vicente, A. I.; Joseph, A.; Ferreira, L. P.; Carvalho, M. D.; Rodrigues, V. H. N.; Duttine, M.; Diogo, H. P.; Minas Da Piedade, M. E.; Calhorda, M. J.; Martinho, P. N. Chem. Sci. 7 (2016) 4251–4258.
4. Martins, F. F.; Joseph, A.; Diogo, H. P.; Minas da Piedade, M. E.; Ferreira, L. P.; Carvalho, M. D.; Barroso, S.; Romão, M. J.; Calhorda, M. J.; Martinho, P. N. Eur. J. Inorg. Chem. 2018 (2018) 2976–2983.
5. Vicente, A. I.; Wu, X.; Ortin, Y.; Ferreira, L. P.; Carvalho, M. D.; Realista, S.; Barker, A.; Morgan, G. G.; Galamba, N.; Costa, P. J.; Calhorda, M. J.; Martinho, P. N. Dalton Trans. 48 (2019) 4239–4247.

Design and synthesis of 1,2-diarylazaindoles for thermally-activated delayed fluorescence

Joana R. M. Ferreira[1,2,*], Bruna F. L. Guerreiro[2], Jaime A. S. Coelho[3], M. Manuel B. Marques[2], Samuel Guieu[1,4]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal; [2]LAQV-REQUIMTE, Department of Chemistry, School of Science and Technology, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal; [3]Centro de Química Estrutural–Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Lisboa 1749-016, Portugal; [4]CICECO-Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal
**joanarmf@ua.pt*

Azaindole presents four regioisomers and has found diverse applications from biological drugs[1,2] to materials such as in organic light-emitting diode (OLED) devices.[3,4] Azaindole derivatives have already been described as fluorescent molecules.[5] That way, our main goal is to design azaindoles to exhibit Thermally-Activated Delayed Fluorescence (TADF) properties for further application in OLED. In order to achieve TADF properties they should present a small singlet-triplet energy splitting as well as a small overlap between the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO).[6]
Here, azaindole derivatives were designed (Figure 1), employing computer-assisted modeling. Subsequently, these derivatives were synthesized following a one-pot catalyzed strategy developed by our group in 2017,[7] and their photophysical properties were experimentally characterized, including the evaluation of their singlet-triplet energy splitting and fluorescence emission lifetime decay. The comparison of the TD-DFT calculations with the experimental photophysical properties demonstrated that some chromophores are promising for application in luminescent devices.

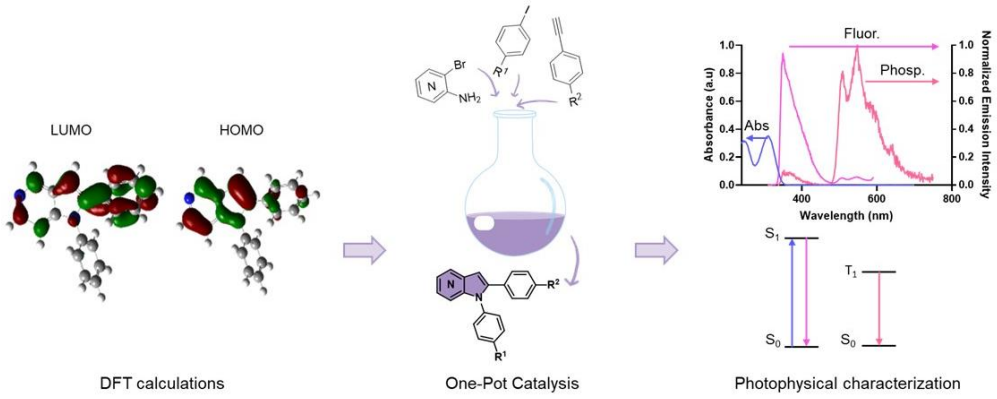


Figure 1: Computational modeling, general structure and photophysical properties of the azaindole derivatives.

Acknowledgements
Thanks are due to University of Aveiro, FCT/MEC, Centro 2020 and Portugal2020, the COMPETE program, and the European Union (FEDER program) for the financial support to the LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), to the CICECO-Aveiro Institute of Materials (UID/CTM/50011/2019, UIDB/50011/2020 & UIDP/50011/2020), financed by national funds through the FCT/MCTES, to the Portuguese NMR Network. SG is supported by national funds (OE), through FCT, I.P., in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. JRMF thanks FCT and ESF (European Social Fund) through POCH (Programa Operacional Capital Humano) for her PhD grant (UI/BD/151272/2021). The authors thank FCT for the project funding (PTDC/QUI-QOR/0712/2020).The authors also thank the Coimbra Chemistry Centre for the collaboration in the measurement of the photophysical properties.

References
1. S. Kumar and Ritika, *Futur J Pharm Sci*, 2020, **6**, 121.
2. D. R. Motati, R. Amaradhi and T. Ganesh, *Bioorg Med Chem*, 2020, **28**, 115830.
3. C. Martin, C. Borreguero, K. Kennes, M. Van der Auweraer, J. Hofkens, G. de Miguel and E. M. García-Frutos, *J Mater Chem C Mater*, 2019, **7**, 1222–1227.
4. S. Tongsuk, R. Malatong, T. Unjarern, C. Wongkaew, P. Surawatanawong, T. Sudyoadsuk, V. Promarak and N. Ruangsupapichat, *J Lumin*, 2021, **238**, 118287.
5. S.-B. Zhao and S. Wang, *Chem Soc Rev*, 2010, **39**, 3142.
6. H. Nakanotani, Y. Tsuchiya and C. Adachi, *Chem Lett*, 2021, **50**, 938–948.
7. S. I. Purificação, M. J. D. Pires, R. Rippel, A. S. Santos and M. M. B. Marques, *Org Lett*, 2017, **19**, 5118–5121.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of sustainable catalytic processes towards polymeric materials *versus* fine chemicals via CO_2 addition to epoxides

Andreia C. S. Gonzalez*, Rafael T. Aroso, Rui M. B. Carrilho, Mariette M. Pereira

CQC, Departamento de Química Universidade de Coimbra, Rua Larga, 3004-535 Coimbra (Portugal)
**andreacsgonzalez@gmail.com*

Carbon dioxide (CO_2) is an abundant greenhouse gas, considered as one of the main causes of climate changes, which bring us serious social, health and economic burden in the present and near future. Due to the high chemical inertness of CO_2 molecule, chemical reactions involving CO_2 activation usually face large energy barriers and require the development of highly effective catalysts.[1-3] We highlight the reaction of CO_2 addition to epoxides, from which it is possible to selectively obtain two types of products: cyclic carbonates and polycarbonates, both with relevant applications, such as green solvents and in plastic engineering, respectively.[1,4] These reactions have been mainly accomplished through the use of metal catalysts, such as complexes of salens, β-diiminates, aminotriphenolates, porphyrins and metallophthalocyanines, as well as supported metal salts and metal organic frameworks. Most of metal catalysts are known to act as Lewis acids that activate the epoxide, and a nucleophile is usually required, as co-catalyst, to promote the epoxide ring opening. The co-catalyst can be added to the reaction (e.g. imidazole, DMAP, quaternary ammonium or phosphonium salts, such as PPNCl), or it can be part of the catalyst molecule, forming a bifunctional catalytic system.[5] In this communication, we describe an efficient and sustainable synthetic methodology to prepare bifunctional cationic imidazolyl-based Al(III) phthalocyanines and a neutral tert-butylphenoxy Al(III) phthalocyanine. Their application as selective catalysts in CO_2 addition reactions to epoxides, towards polycarbonates *versus* cyclic carbonates, is presented and the effect of the phthalocyanine structure in the catalytic activity and selectivity is described and discussed.

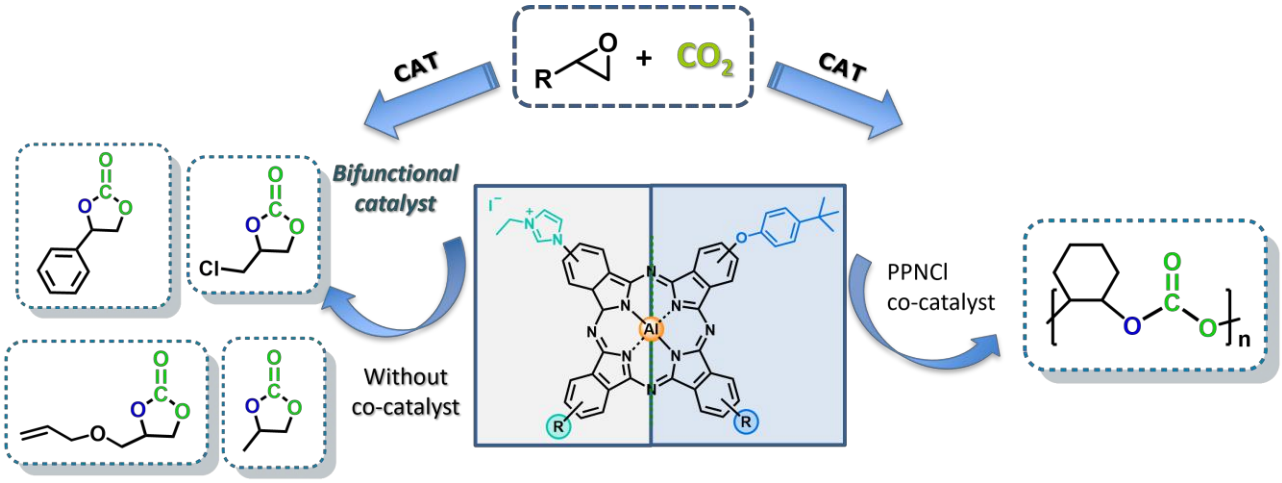


Figure 1: Catalyst modulation for control of selectivity in catalytic CO_2 addition reactions to epoxides.

Acknowledgements
The authors thank FCT (Fundação para a Ciência e Tecnologia), QREN/FEDER (COMPETE Programa Operacional Factores de Competitividade) for funding through projects UIDB/00070/2020, UIDP/00070/2020, UIDB/00313/2020, UIDP/00313/2020 and UIDB/00285/2020, and PRR - Recovery and Resilience Plan and the European Union (EU) Next Generation Funds, for funding through Project Nº 6979 - PRODUTECH R3 [Recuperação-Resiliência-Reindustrialização] following NOTICE N.º 02/C05-i01/2022, Component 5 – Capitalization and Business Innovation - Mobilizing Agendas for Business Innovation. A.C.S. Gonzalez thanks FCT for PhD grant UI/BD/150804/2020.

References

1. Kamphuis, A. J., Picchioni, F. and Pescarmona, P. P., Green Chemistry, 2019, 21(3): 406-448.
2. Huang, J., Worch, J. C., Dove, A. P. and Coulembier, O., ChemSusChem, 2020, 13(3): 469-487.
3. Dias L. D., Carrilho R. M. B., Henriques C. A., Calvete M. J. F., Masdeu-Bultó A. M., Claver C., Rossi L. M., Pereira, M. M., ChemCatChem, 2018, 10, 2792.
4. Carrilho R. M. B, Dias L. D., Rivas R., Pereira M. M., Claver C., Masdeu-Bultó A. M., Catalysts, 2017, 7, 210.
5. Gonzalez A.C.S., Felgueiras A.P., Aroso R.T., Carrilho R.M.B and Pereira M.M., Journal of Organometallic Chemistry, 2021, 950: 121979.

Gelatin hydrogel-based bioinks reinforced with nanofibrillated cellulose for 3D bioprinting of hepatocellular carcinoma models

Nicole S. Lameirinhas[1,*], Maria C. Teixeira[1], João P. F. Carvalho[1], Bruno F. A. Valente[1], Jorge L. Luís[2], Liliana Pires[2], Ricardo J. B. Pinto[1], Helena Oliveira[3], José M. Oliveira[2], Armando J. D. Silvestre[1], Carla Vilela[1], Carmen S. R. Freire[1]

[1] *CICECO -Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2] *School of Design, Management and Production Technologies Northern Aveiro, ESAN, Portugal*
[3] *CESAM – Centre for Environment and Marine Studies, Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal*
**nicoleslameirinhas@ua.pt*

The use of *in vitro* tumor models to study cancer and investigate different treatment approaches is an important strategy in cancer research. However, the use of two-dimensional (2D) cell cultures faces some difficulties as it fails to mimic the complexity of the *in vivo* tumor tissues, since cells may change their protein and gene expression. Therefore, three-dimensional (3D) bioprinting emerges as an attractive technique for 3D-tumor-model-design for cancer research. 3D bioprinting consists of the deposition of bioinks (biomaterials and cells) in a previously defined pattern following a layer-by-layer approach.[2] Hydrogels are the most commonly used type of bioinks and can be formulated with diverse synthetic and natural polymeric materials.[3] But, several hydrogel-based bioinks lack adequate long-term mechanical properties. One solution to overcome this drawback is to create nanocomposite hydrogel-based bioinks using reinforcing agents, such as nanofibrillated cellulose (NFC).[4] Herein, a gelatin (Gel)-hydrogel was reinforced with NFC yielding formulations with different Gel/NFC mass proportions (90:10, 80:20, 70:30 and 60:40) and crosslinked with genipin. The formulated nanocomposite hydrogels were characterized in terms of their rheological behavior, and the fully crosslinked hydrogels were evaluated regarding their rheological and mechanical properties, as well as in terms of their stability in two media (Dulbecco's Modified Eagle's Medium (DMEM) and Phosphate Buffer Saline (PBS)), morphology, and cytotoxicity towards hepatocellular carcinoma cells (HEPG2). As expected, NFC improved the rheological (seen by the enhancement of both storage (G') and loss (G'') moduli) and mechanical properties (perceived by the increase of Young's modulus from 4729 ± 869 kPa for the formulation 90:10, to 9554 ± 1705 kPa for the 60:40 one) of the Gel-based hydrogels. NFC also contributed to an increase of the stability of the fully crosslinked hydrogels in DMEM and PBS. Additionally, the fully crosslinked hydrogels are non-cytotoxic towards the HEPG2 cells (viabilities higher than 80% for all hydrogels up to 48 h). The hydrogel with the Gel/NFC mass proportion of 70:30 was selected to be loaded with the HEPG2 cell line (2×10^6 cells mL^{-1}) and bioprinted. The cell viability was evaluated until 14 days post bioprinting and it remained considerably high (90 ± 4 %) up to day 14. These results highlighted that the combination of NFC with Gel is a promising strategy for developing novel hydrogel-based bioinks for 3D bioprinting of HEPG2 cell line envisioning the biofabrication of hepatocellular carcinoma models.

Acknowledgements
This work was developed within the scope of the project CICECO – Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC) and the research project I&D NANOBIOINKS, CENTRO-01-0145-FEDER-031289-funded by the Operational Program of the Center Region, in its FEDER/FNR component, and by national funds (OE), through FCT/MCTES. The research contract of R.J.B. Pinto was funded by national funds (OE), through FCT in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. FCT is also acknowledged for the PhD grant to N.L. (SFRH/BD/140229/2018), and the research contracts under Scientific Employment Stimulus to C.V. (CEECIND/00263/2018 and 2021.01571.CEECIND) and C.S.R.F. (CEECIND/00464/2017).

References
1. E. L. S. Fong, D. A. Harrington, M. C. Farach-Carson and H. Yu, *Biomaterials*, 2016, **108**, 197–213.
2. S. V. Murphy and A. Atala, *Nat. Biotechnol.*, 2014, **32**, 773–785.
3. P. S. Gungor-Ozkerim, I. Inci, Y. S. Zhang, A. Khademhosseini and M. R. Dokmeci, *Biomater. Sci.*, 2018, **6**, 915–946.
4. G. Chinga-Carrasco, *Biomacromolecules*, 2018, **19**, 701–711.

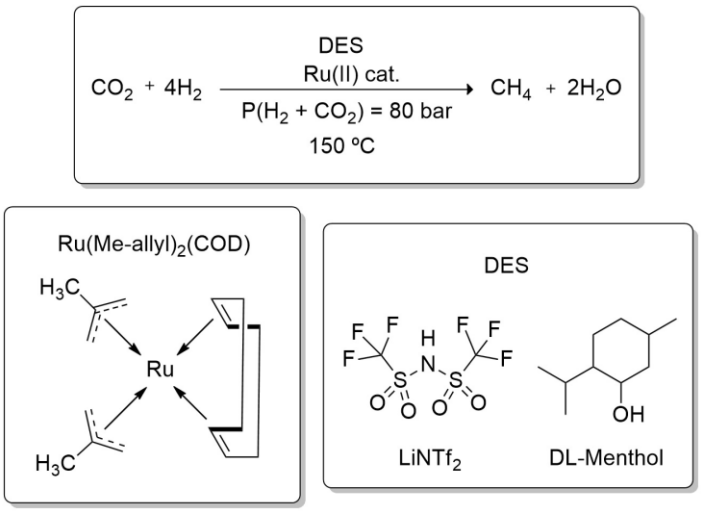
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Ruthenium-catalyzed CO_2 hydrogenation to methane in deep eutectic solvents

V. Paz*, C. I. Melo, L. C. Branco*

LAQV-REQUIMTE, NOVA School of Science and Technology, 2829-516 Caparica, Portugal
**v.paz@fct.unl.pt, l.branco@fct.unl.pt*

Several researchers have expressed growing concerns about the need to reduce CO_2 emissions due to rising extreme climate events caused by the greenhouse effect. The production of methane by the CO_2 Hydrogenation process emerged as a promising technology for CCU (Carbon Capture and Utilization). This approach seems to be possible by homogeneous or heterogeneous catalysis contributing to reducing carbon emissions and promoting carbon neutrality.[1] Ruthenium is widely used in CO_2 transformation, and it is very efficient for hydrogenation reactions compared to other metal catalysts.[1]
Deep eutectic solvents (DES) are defined as a mixture of two or more components composed of hydrogen bond donors (HBD) and acceptors (HBA) which at a particular composition present a eutectic point and become liquids at room temperature. DES have emerged as a greener and cheaper alternative to ionic liquids.[2]
In this study, we investigated the use of DES for the hydrogenation of CO_2 to methane via the Sabatier reaction. Previously, our group reported the efficient hydrogenation of CO_2 to methane using fluorinated ionic liquids as reaction media and Ru(Me-allyl)$_2$(COD) as the catalyst.[3,4] The formation of Ru nanoparticles in situ and further stabilization in ionic liquid media are crucial to achieving high yields. In our current work, we selected similar reaction conditions (pressure, temperature, reaction time) replacing the ionic liquids with DES as the reaction medium. Our best result was achieved using lithium bis(trifluoromethanesulfonyl)imide (LiNTf2)/DL-Menthol (1:8) DES in optimized reaction conditions. These preliminary results showed an interest to explore DES as alternative media for CO_2 hydrogenation reactions.



Scheme 1

Acknowledgements: We acknowledge project Cat4GtL (POCI-01-0247-FEDER-069953), co-funded by ERDF through COMPETE 2020 under PORTUGAL 2020. This work was also supported by FCT/MCTES through projects MIT-EXPL/CS/0052/2021, projects UIDB/50006/2020, LA/P/0008/2020 and UIDP/50006/2020 of the Associate Laboratory for Green Chemistry – LAQV. NMR spectrometers are part of The National NMR Facility, supported by FCT (ROTEIRO/0031/2013-PINFRA/22161/2016) (co-financed by FEDER through COMPETE 2020, POCI, and PORL and FCT through PIDDAC). Victoria Paz thanks to doctoral grant SFRH/BD/150660/2020.

References

1. X. Yang, F. Tan, D. Wang, Q. Feng, D. Qiu, D. Dang and X. Wang, Ceram. Int., 2021, 47, 27316-27323.
2. A. Paiva, R. Craveiro, I. Aroso, M. Martins, R. L. Reis, A. R. C. Duarte, ACS Sustainable Chem. Eng., 2014, 2, 1063-1071.
3. C. I. Melo, A. Szczepanska, E. Bogel-Lukasik, M. N. Ponte, L. C. Branco, ChemSusChem, 2016, 9, 1081-1084.
4. C. I. Melo, D. Rente, M. N. Ponte, E. Bogel-Lukasik, L. C. Branco, ACS Sustainable Chem. Eng., 2019, 7, 11963-11969.

Active polymeric filtration membranes with siderophore for iron(III) removal from aqueous systems

Ricardo A. L. S. Santos[1,*], Diana C. G. A. Pinto[1], Célia M. P. G. Amorim[2]

[1]LAQV-REQUIMTE, Chemistry Department, University of Aveiro, Campus Universitário de Santiago 3810-193 Aveiro, Portugal;
[2]LAQV-REQUIMTE, Faculty of Pharmacy, University of Porto, R. Jorge de Viterbo Ferreira 228, 4050-313 Porto, Portugal.
**ricardossantos@ua.pt*

The excess of iron(III) in industrial effluents and in the blood is an issue. Not only the iron catalyzes the oxidation of organic compounds from living beings but also forms highly insoluble precipitates of iron(III) oxyhydroxides.[1] Then, that solid's deposits interfere with the fluidic systems' normal flow. One way to solve this problem is to dop filtration membranes with active agents such as siderophores to enable the chemisorption of the iron(III) present in the samples during filtration. It was chosen compounds of the hydroxamic acid family, with long alkyl chains for that purpose. They are known to have very high complex formation constants.[2] The addition of an alkyl chain to the hydroxamic acid was the strategy found to improve the lipophilicity of the siderophore, avoiding its leaching from the polymeric membrane structure during the nonsolvent-induced phase inversion process. Those membranes, with the siderophore included, were prepared by spin-coating. They were then characterized with respect to their siderophore contents, porosities, and maxima water flow. Their specific iron(III) absorptions were analyzed in static and dynamic conditions. The results suggest an excellent inclusion of the siderophore in the membrane structure. Under batch conditions, the iron(III) absorption was superior to the 1:1 iron/ligand proportion.

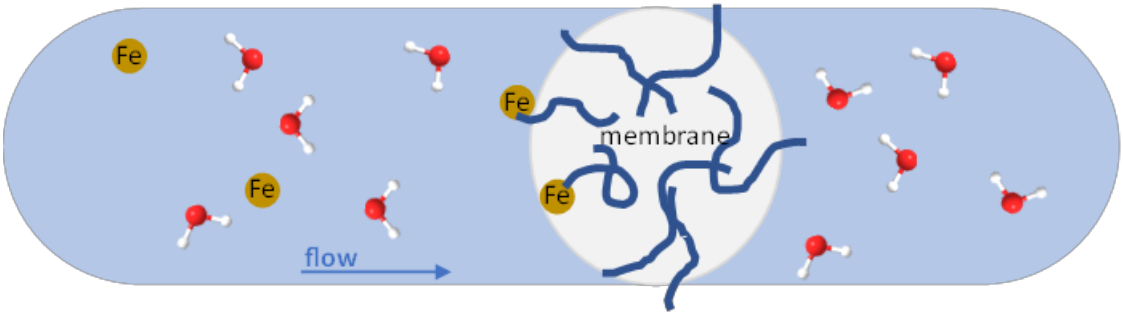


Figure 1: Graphical Abstract – the iron(III) capture by the hydroxamic acid functional groups included in the membrane.

Acknowledgments
Thanks are due to the University of Aveiro and Portuguese National Funds, through FCT (Fundação para a Ciência e Tecnologia), and as applicable co-financed by FEDER within the PT2020 Partnership agreement by funding the LAQV-REQUIMTE (UIDB/50006/2020+UIDP/50006/2020). RALS Santos thanks FCT for his PhD grant (UI/BD/151268/2021).

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020

References

1. A. Stefánsson, Environmental Science & Technology, 41 (2007) 6117, 10.1021/es070174h.
2. R. Hider, X. Kong, Natural Product Reports, 27 (2010) 637, 10.1039/B906679A.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Novel therapeutic avenues: Dual inhibition of 20S proteasome and CRM1 in multiple myeloma explored through computational methods

Pedro M. P. Fernandes[1,2,*], Rita C. Guedes[1], Jorge A. R. Salvador[2]

[1]Research Institute for Medicines (iMed.ULisboa), Faculdade de Farmácia, Universidade de Lisboa, 1649-003 Lisboa, Portugal
[2]Laboratory of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Coimbra, 3000-548 Coimbra, Portugal and Center for Innovative Biomedicine and Biotechnology (CIBB), Center for Neuroscience and Cell Biology (CNC), University of Coimbra, 3004-504 Coimbra, Portugal
**pfernandes@cnc.uc.pt*

Multiple myeloma (MM) poses a significant burden on public health, accounting for a considerable portion of new cancer cases and cancer-related deaths.[1] With a growing number of patients experiencing relapse and developing resistance to current treatment options, there is a pressing need for novel therapeutic strategies. Recent studies have highlighted the development of resistance to proteasome inhibitors, such as bortezomib, due to various mechanisms, including mutations in the proteasome complex, up-regulation of transporter channels and cytochrome components, and induction of alternative compensatory pathways.[2] Furthermore, elevated expression levels of CRM1 were reported in MM patients and plasma cell leukemia cells. Importantly, increased CRM1 expression was found in patient cells that exhibited resistance to bortezomib treatment.[3] This emphasises the therapeutic potential of targeting CRM1 as a novel approach to bypass drug resistance and improve patient outcomes. Targeting both the proteasome and CRM1, a crucial nuclear export protein, offers a promising avenue to overcome drug resistance and improve treatment outcomes. In this study, we present a comprehensive computational investigation aimed at identifying potential dual inhibitors of the 20S proteasome and CRM1, key proteins implicated in the progression of MM and drug resistance.

Using a computational approach, we employed molecular docking, pharmacophore modelling, molecular dynamics simulations, and free energy calculations to screen a diverse chemical library and identify potential dual inhibitors. Our study focused on the identification of compounds that can simultaneously inhibit the activity of the 20S proteasome and CRM1, thus disrupting multiple pathways involved in the pathogenesis of MM.

The computational insights gained from this study provide a solid foundation for the design and development of novel molecules with dual inhibitory activity against the 20S proteasome and CRM1. The identification of potential dual inhibitors holds great promise to enhance the effectiveness of current treatments and combat drug resistance in multiple myeloma.

Overall, this research highlights the power of computational methods to accelerate the discovery of novel therapeutic options. By targeting both 20S proteasome and CRM1, we aim to address the challenges posed by drug resistance and improve the treatment of multiple myeloma, ultimately benefiting the lives of patients affected by this devastating disease.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for financial support PD/BD/143158/2019, PTDC/QEQ-MED/7042/2014, UIDB/04138/2020, UIDP/04138/2020 and SAICTPAC/0019/2015.

References

1. National Cancer Institute, SEER Cancer Stat Facts, https://seer.cancer.gov/statfacts/html/mulmy.html.
2. G. P. Soriano, L. Besse, N. Li, M. Kraus, A. Besse, N. Meeuwenoord, J. Bader, B. Everts, H. den Dulk, H. S. Overkleeft, B. I. Florea and C. Driessen, *Leukemia*, 2016, **30**, 2198–2207.
3. Y.-T. Tai, Y. Landesman, C. Acharya, Y. Calle, M. Y. Zhong, M. Cea, D. Tannenbaum, A. Cagnetta, M. Reagan, A. A. Munshi, W. Senapedis, J.-R. Saint-Martin, T. Kashyap, S. Shacham, M. Kauffman, Y. Gu, L. Wu, I. Ghobrial, F. Zhan, A. L. Kung, S. A. Schey, P. Richardson, N. C. Munshi and K. C. Anderson, *Leukemia*, 2014, **28**, 155–165.

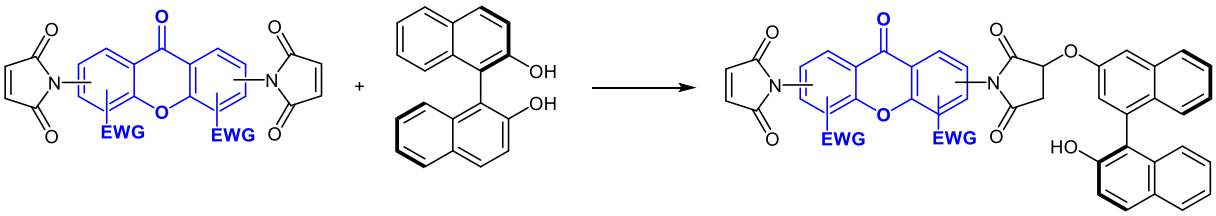
Development of a xanthone-BINOL conjugate as a chemosensor for the detection of chiral amino acids

M. Margarida P. Borges[1], Virgínia M. F. Gonçalves[1,2], Carlos J. A. Ribeiro[1,3], Marcela A. Segundo[4], Maria Elizabeth Tiritan[1,5,6], Eduarda M. P. Silva[1,4,*]

[1]1H-TOXRUN - One Health Toxicology Research Unit, University Institute of Health Sciences, CESPU, 4585-116 Gandra, Portugal; [2]UNIPRO - Oral Pathology and Rehabilitation Research Unit, University Institute of Health Sciences, CESPU, 4585-116 Gandra, Portugal; [3]Canneurox Portugal, SA a subsidiary of Avextra AG. Quinta da Parreira, Azinheira dos Barros e São Mamede do Sádão, 7570-003 Grândola, Portugal; [4]LAQV, REQUIMTE, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Rua de Jorge Viterbo Ferreira 228, 4050-313 Porto, Portugal [5]Laboratory of Organic and Pharmaceutical Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Rua de Jorge Vierbo Ferreira, 228, 4050-313 Porto, Portugal; [6]CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Novo Edifício do Terminal de Cruzeiros do Porto de Leixões, Avenida General Norton de Matos, S/N, 4450-208 Matosinhos, Portugal
*eduarda.silva@iucs.cespu.pt

Alzheimer's disease (AD) is a neurological disorder, and it is classified as a leading cause of dementia. It is a very common illness in our society that creates serious disabilities and progressively hinders the quality of life of patients. Several mechanisms thought to be involved in the pathogenesis of AD have been discussed among researchers. The amyloid hypothesis, for example, depicts the neuronal dysfunction by the abnormal buildup of proteins called amyloid plaques and tangles around the brain cells.[1] The dysregulation of glutamate neurotransmission has also been associated with AD.[2] Furthermore, higher levels of D-serine were found in the cerebrospinal fluid of plausible AD patients than in control subjects.[3] Hence, knowledge related with the detection and quantification of D-aa and D/L aa ratios can be of upmost importance in early AD diagnoses and disease progression. Accordingly, we are investigating the enantioselective fluorescent recognition and quantification of D-aa and D/L amino acids ratios for AD diagnosis using a chiral xanthone derivative-based fluorophore and BINOL as chiral moiety.

To develop the new xanthone-based chiral derivatives, we firstly synthesized a xanthone containing a maleimide moiety (MX) obtained from a previously derivatized aminoxanthone (AX).[4,5] The MX could then act as Michael acceptor for the reaction with 1,1'-bi-2-naphthol (BINOL), the chiral moiety that will allow the enantioselective interactions with aa. All the compounds were structurally characterized, and spectroscopic studies are in progress to reveal the potential use of the new molecule as a fluorescence probe for detection and quantification of D-aa and D/L aa ratios.



Scheme 1: Xanthone chiral based chemosensor (EWG = electron withdrawing group).

Acknowledgements
This work was supported by CESPU – Cooperativa de Ensino Superior Politécnico e Universitário, under the grant XANTAAL_GI2-CESPU_2022.

References

1. C. Depp, et al. Myelin Dysfunction Drives Amyloid-β Deposition in Models of Alzheimer's Disease. *Nature* 2023, **618**, 349-357.
2. J. M. Seckler and S. J. Lewis, Advances in D-Amino Acids in Neurological Research, *Int. J. Mol. Sci.* 2020, **21**, 7325.
3. C. H. Lin, H. T. Yang, C. C. Chiu, et al. Blood Levels of D-Amino Acid Oxidase vs. D-Amino Acids in Reflecting Cognitive Aging. *Sci. Rep.* 2017, **7**, 14849.
4. A. Grzelakowska, et al. Novel Fluorescent Probes for L-Cysteine Based on the Xanthone Skeleton, *J. Photochem. Photobiol. A: Chem.* 2020, **387**, 112153.
5. T. C. S Pace, et al. Photophysics of Aminoxanthone Derivatives and their Application as Binding Probes for DNA. *Photochem. Photobiol.* 2006, **82**, 78-87.

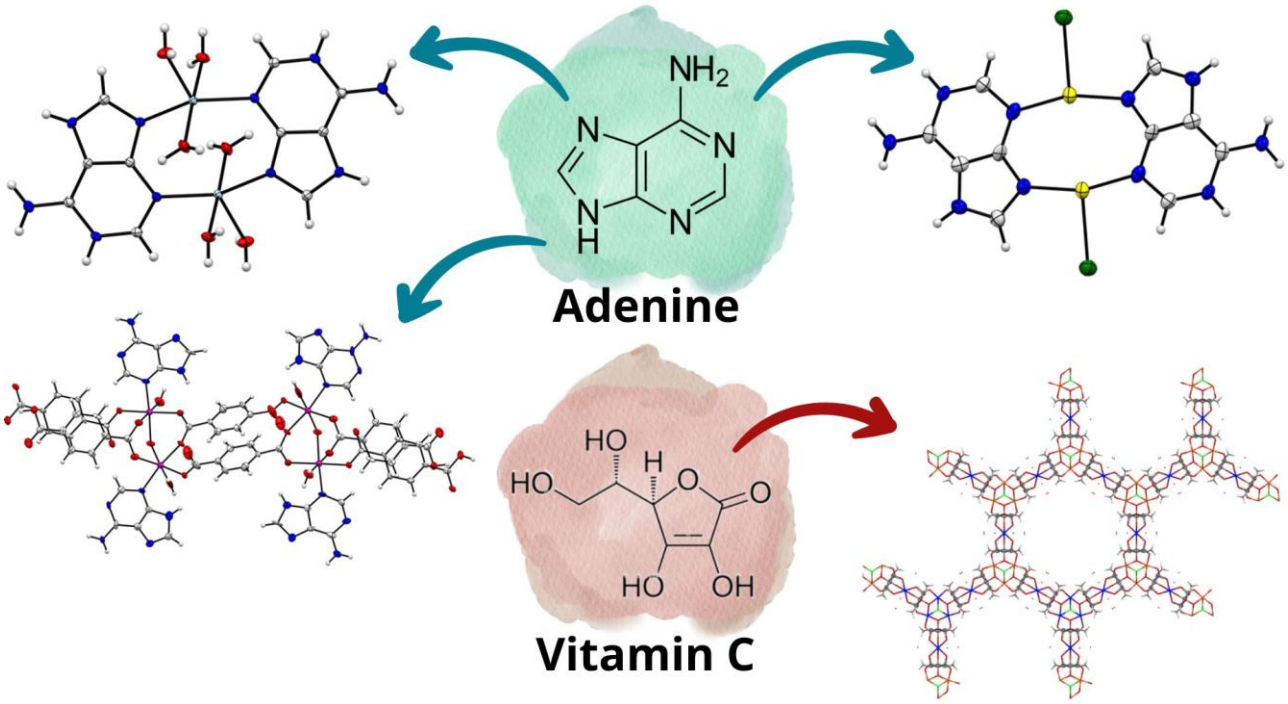
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Bioactive vitamins-metal complexes: Design, synthesis, structure, and their biological application

P. Brandão*, E. Batata, I. Moreira., J. Pacheco, S. Guieu

University of Aveiro, Department of Chemistry/CICECO-Aveiro Institute of Materials, Aveiro 3810-193, Portugal
**pbrandao@ua.pt*

Vitamins contain a wide variety of binding modes, making them an attractive class of building blocks for the construction of metal complexes and extended MOF compounds,[1] which can result in diverse topologies showing excellent properties. Vitamins themselves are active molecules in different biological processes, and the combination with metals might be of both scientific and pharmacological interest. In addition, vitamins are naturally abundant and easy to produce, allowing industrial low costs. Because of all these characteristics, the use of vitamins could be a great challenge to develop new biologically active and environmentally friendly metallo-drugs[2] and Bio-MOFs.[2,3] In an attempt to emphasize the structure and biological activity of such vitamins metal complexes as well as vitamin-MOFs, we explore the synthesis of different vitamins (mainly B1, B3, B4, B6, B9, C) metal (mainly Fe, Cu, Co, Ni, Mg, Ca, Zn) compounds and their application in cancer therapy as well as NO delivery systems.



Scheme 1: Copper(I), Copper (II) and Co(II) adenine complexes and copper (II) vitamin C derivative 3D framework.

Acknowledgements
We thank for the financial support of this work by the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC).”

References

1. P. Brandão and S. Guieu, in *Molecular Nutrition: Vitamins*, Elsevier, 2019, pp. 33–49.
2. P. Brandão, S. Guieu, A. Correia-Branco, C. Silva and F. Martel, *Inorg. Chim. Acta*, 2019, **487**, 287–294.
3. R. V. Pinto, F. Antunes, J. Pires, V. Graça, P. Brandão and M. L. Pinto, *Acta Biomater*, 2017, **51**, 66–74.

Removal of copper ions from aqueous solution by using reduced chitosan

J. F. M. Sousa*, P. Matias, E. Bernardino, D. Murtinho, A. J. M. Valente, P. E.Abreu, J. M. C. Marques

University of Coimbra, CQC-IMS, Department of Chemistry, Rua Larga, 3004-535 Coimbra, Portugal
**uc2011141774@student.uc.pt*

The presence of heavy metals in wastewater has been increasing with the rapid industrial development. Wastewater contaminated with heavy metals finds its way into the environment, they are the main pollutant in Europe and are present in dangerous concentrations in many sites across the globe. Copper is a heavy metal that in trace quantities is essential to human life and health however, in excess causes various diseases. Thus, removing copper from the wastewater is urgent.[1] Different methods have been used to remove heavy metal ions from various wastewater sources. Among them, adsorption has been the most viable, economical, and high effective. Adsorbents such as chitosan has been used in adsorption studies by several authors, either by chitosan with different deacetylation degrees and molecular weights[2,3] or by chemically modified chitosan.[4] Chitosan is a polysaccharide very abundant, non-toxic, low cost, biodegradable and have many free hydroxyl and amino groups, making it a good adsorbent.

In this work, four different reduced chitosan derivatives (RChi1 – RChi4) to adsorb Cu(II) from aqueous solution were synthesized by chitosan modification with salicylaldehyde, followed by imine reduction. The results show that (RChi) have a better adsorption capacity than chitosan. With a adsorption capacity of 80% at pH 4.0, the reduced chitosan (RChi3) with a moderate percentage of modification (i.e., 43%) and a higher imine reduction percentage (i.e., 98%) proved to be more efficient than the other reduced forms. RChi3 adsorption data were better described with the Langmuir-Freundlich isotherms and pseudo-second order kinetic model, which means that a physio-chemical adsorption process was involved during the adsorption. Molecular dynamics (MD) simulations were performed to obtain detailed insights into the interaction between Cu(II) and chitosan or reduced chitosan derivative. The data analysis revealed that the functionalization of chitosan (RChi3) favors the capture of Cu(II) in water (Figure 1). Cu(II) have a greater interaction with the oxygen of the glucosamine ring and the neighboring hydroxyl groups. As a conclusion, we may say that (RChi3) is an efficient and low-cost adsorbent, which can be employed to remove Cu(II) from wastewater.

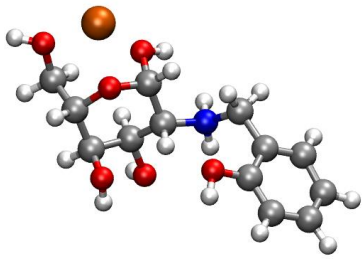


Figure 3: Capture of Cu(II) by reduced chitosan derivative (RChi3).

Acknowledgements
This work was funded by the Coimbra Chemistry Centre, which is supported by the Fundação para a Ciência e a Tecnologia (FCT) through the programmes UID/QUI/00313/2020 and COMPETE, and PhD grant (SFR/BD/146358/2019), and also by the project “BIOSHELL”, Ref. BLUEBIO/0003/2019, financed by FCT within program ERA-NET Cofund on Blue Bioeconomy (BlueBio). J.F.M. Sousa and P.M.C. Matias thank the Fundação para a Ciência e Tecnologia (FCT), Portugal, for the PhD grants UI/BD/150803/2020 and 2022.12425.BD, respectively.

References

1. 1. J. P. Vareda, A. J. M. Valente, L. Durães, *J. Environ. Manage.,* 2019, **246**, 101–118.
2. 2. G. Z. Kyzas, M. Kostoglou, N. K. Lazaridis, *Chem. Eng. J.,* 2009, **152**, 440–448.
3. 3. M. Mende, D. Schwarz, C. Steinbach, R. Boldt, S. Schwarz, *Colloids Surfaces A Physicochem. Eng. Asp.* 2016, **510**, 275–282.
4. 4. J. P. Vareda, A. J. M. Valente, L. Durães, *Adv. Colloid Interface Sci.* 2021, **289**.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Polymersomes targeting glioblastoma cells for a chalcone delivery

A. Alves[1,2,*], A. Silva[3], J. Moreira[2,4] , C. Nunes[5], S. Reis[5], M. Pinto[2,4], H. Cidade[2,4], F. Rodrigues[3], D. Ferreira[1], P. Costa[1], M. Correia-da-Silva[2,4]

[1]UCIBIO – Applied Molecular Biosciences Unit, MedTech-Laboratory of Pharmaceutical Technology, Faculty of Pharmacy, University of Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal and Associate Laboratory i4HB - Institute for Health and Bioeconomy, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal; [2]LQOF/FFUP -Laboratory of Organic and Pharmaceutical Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal; [3]REQUIMTE/LAQV, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida 431, 4200-072 Porto, Portugal; [4]CIIMAR - Interdisciplinary Center of Marine and Environment Research, University of Porto, Terminal dos Cruzeiros do Porto de Leixões, Avenida General Norton de Matos 4450-208 Matosinhos, Portugal; [5]LAQV/REQUIMTE, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal
**anadaniela92@hotmail.com*

Glioblastoma (GBM) is a primary malignant tumor of the Central Nervous System responsible for most deaths among patients with primary brain tumors.[1] Current therapies are not effective, with the average survival of GBM patients after diagnosis being limited to few months. Chemotherapy is difficult due to the heterogeneity of GBM and the great efficacy of Blood–Brain-Barrier (BBB) making drug absorption into brain very difficult.[2] Polymersomes (PMs) are an attractive new type of nanoparticles for drug administration, due to their high stability, enhance circulation time, biodegradability, and drug sustained release.[3]
The main purpose of this study was to develop a targeted delivery system based on di-block polymersomes (PEG- ε-caprolactone (PCL)) able to cross the BBB to deliver a chalcone synthesized by LQOF/FFUP with proven antitumor activity, at the site of the tumor[3]. Two 3',4',3,4,5-trimethoxychalcone (MB) formulations PEG2000-PCL and PEG5000-PCL, were synthesized, characterized, and studied regarding 14 days stability, *in vitro* anti-growth activity and release studies. The amphiphilic PEG2000-PCL and PEG5000-PCL diblock copolymers were obtained by ring opening polymerization (ROP) method. The catalyst used was stannous octoate (Sn(Oct)2). The macroinitiator, methoxy polyethylene glycol (methoxyPEG), was dried at 120 °C with microwave irradiation and PCL was used for the formation of PMs. PMs with and without MB were prepared by the film rehydration method. PEG5000-PCL and PEG2000-PCL showing a mean diameter about 200 nm approximately. The stability of empty PEG5000-PCL PMs showed no significant changes in the properties of the PMs after 1, 7, and 14 days, in contrast to PEG2000-PCL PMs which showed some significant changes. Both formulations produced spherical particles with uniform morphology and similar size according to DLS and confirmed by TEM technique. The encapsulation efficacy (EE) was tested, and both formulations showed an EE of approximately 90%. In GBM cell line, U-87 MG, the particles with and without MB, did not present any toxicity, in contrast to MB. A release study of MB from PMs at pH 7.4 and 6.3 is on-going.

Acknowledgements
This research was funded by national funds from FCT - Fundação para a Ciência e a Tecnologia, I.P., in the scope of the project UIDP/04378/2020 and UIDB/04378/2020 (Marine Natural Products and Medicinal Chemistry Group_CIIMAR), of the Research Unit on Applied Molecular Biosciences - UCIBIO and the project LA/P/0140/2020 of the Associate Laboratory Institute for Health and Bioeconomy - i4HB. A.A acknowledges FCT for the PhD scholarship (grant number SFRH/BD/144607/2019.

References
1. Omuro, A. and L.M. DeAngelis, 2013. 310(17): p. 1842-50.
2. Daneman, R. and A. Prat, Cold Spring Harb Perspect Biol, 2015. 7(1): p. a020412.
3. Chandrawati, R. and F. Caruso, 2012. 28(39): p. 13798-807.

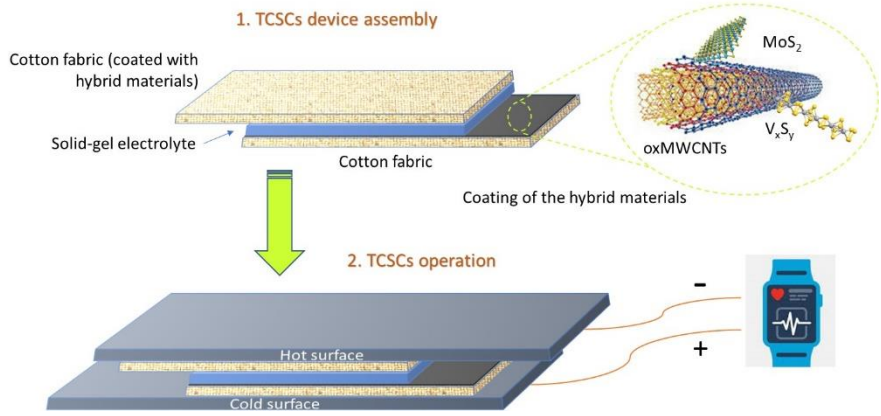
New hybrid carbon/metal sulfide nanomaterials for the development of smart textiles with energy storage and harvesting properties

M. S. Nunes[1,*], J. S. Teixeira[1,2], A. R. Sousa[1,2], A. M. Pereira[2], C. R. Pereira[1]

[1]REQUIMTE/LAQV, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal; [2]IFIMUP, Instituto de Física de Materiais Avançados, Nanotecnologia e Fotónica, Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4160-007 Porto, Portugal
**marta.nunes@fc.up.pt*

The current expansion of the Internet of Things market has driven the development of smart textiles with energy storage and harvesting properties.[1] Textile-based supercapacitors are an energy storage technology, able to power low-consumption devices to be used in healthcare, sports and military applications. This technology should combine the high energy density of batteries with the long-life cycle, high power density and quick charging of conventional capacitors, to improve the efficiency of the electrical energy storage.[2] All-in-one thermally chargeable supercapacitors (TCSCs) are innovative multifunctional devices that combine the functions of supercapacitive energy storage with thermal energy harvesting, namely using the human residual heat.[1]

This work is focused on the preparation of textile-based TCSCs on cotton fabrics, using hybrid nanomaterials composed of carbon nanotubes and metal sulfides as electrode materials (Scheme 1). The hybrids were prepared through the *in situ* functionalization of oxidized multiwalled carbon nanotubes (oxMWCNTs) with molybdenum and vanadium sulfides. Mono- and bimetallic hybrids were prepared using different molybdenum/vanadium molar ratios. The hydrothermal reaction time, temperature and type of sulfur precursor were optimized to obtain high purity metal sulfide phases. The morphology, structure and chemical composition of the as-prepared materials were characterized by X-ray diffraction, scanning electron microscopy, energy-dispersive X-ray spectroscopy, and Raman spectroscopy. At a later stage, the oxMWCNTs and the hybrids were coated onto cotton fabrics. Then, two textile electrodes were stacked with a solid-gel electrolyte between them to create asymmetric TCSCs devices with a sandwich-type configuration. The energy harvesting and storage performance of the assembled devices was investigated, demonstrating their ability to produce and store energy.



Scheme 1: Schematic representation of TCSCs devices assembly and operation.

Funding
This work was financially supported with funding from FCT/MCTES (UIDP/50006/2020) through national funds.

Acknowledgements
The authors thank the projects PTDC/CTM-TEX/4126/2021, UIDB/04968/2020 and UIDP/04968/2020 financed by Portuguese funds through FCT/MCTES. MSN acknowledges FCT/MCTES for the work contract through the project PTDC/CTM-TEX/4126/2021. JST and CRP thank FCT for funding through PhD scholarship (SFRH/BD/145513/2019) and Individual Call to Scientific Employment Stimulus (2021.04120.CEECIND/CP1662/CT0008), respectively.

References
1. J. S. Teixeira, R. S. Costa, A. L. Pires, A. M. Pereira and C. Pereira, *Dalton Trans.*, 2021, **50**, 9983.
2. M. F. Iqbal, M. N. Ashiq and M. Zhang, *Energy Technol.*, 2021, **9**, 2000987.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Evaluation of the absorption properties of rainwater in Estarreja

H. Santos, G. Santos, P. Santos*

CESAM & Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal
** E-mail: patricia.santos@ua.pt*

The Estarreja town, located in the north coast of Portugal, has a large industrial area with a great chemical complex, but also has a large area dedicated to agricultural activities, being this region strongly affected by anthropogenic activities. These activities can emit pollutants to the atmosphere, being them then removed from the atmosphere in part by precipitation. Since rainwater is a way of availability of freshwater with impacts for the environment and human beings, becomes important to evaluate its characteristics, namely in what concerns to the presence of chromophoric dissolved organic matter (CDOM)[1,2], which may be used as an indicator of the presence of organic pollutants.
The present work aimed to assess the effect of the industrial area for the CDOM content in Estarreja rainwater. Thus, rainwater samples were collected simultaneously in three sites at the industrial area and in a background site of Estarreja, in different seasons. The CDOM content of samples was explored by UV–Visible spectroscopy. The absorption properties of the rainwater samples were important to understand the sources of CDOM in the industrial area of Estarreja, as well as its space-time changes.

Acknowledgements
Thanks are due for the financial support provided by CNRS-INEE LabEx DRIIHM, AND and are due to FCT/MCTES for the financial support to CESAM (UIDB/50017/2020 AND UIDP/50017/2020) through national funds. Gabriela Santos thanks FCT by the PhD fellowship (SFRH/BD/137755/2018). Patrícia Santos thanks support by the FCT Scientific Employment Stimulus - Individual 2017 (CEECIND/01835/2017).

References
1. P. S. M. Santos, R. M.B. O. Duarte and A. C. Duarte, *J. Atmos. Chem.*, 2009, **62**, 45–57.
2. P. S. M. Santos, E. B. H. Santos and A. C. Duarte., *Sci. Pollut. Res.*, 2013, **20**, 227-237.

Analyzing the impact of structural changes on the spin crossover phenomenon in iron(III) complexes

Tiago Gomes[1], Liliana P. Ferreira[2,3], Clara S. B. Gomes[4], Paulo N. Martinho[1], Nuno Xavier[1]

[1]Centro de Química Estrutural - Institute of Molecular Sciences, Faculdade de Ciências, Universidade de Lisboa; [2]Biosystems and Integrative Sciences Institute (BioISI), Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Lisboa; [3]Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal; [4]LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal
**tpereiragomes@hotmail.com*

Iron complexes serve as a great example of how impactful the spin crossover effect can be, not only on how the transition between spin states occurs (Figure 1), but also on the electronic and structural properties of the complexes, especially affecting the bonds between the metal center and the ligands.[1] In addition, potential modifications to the structure of the ligand, complementary to a potential anionic counterion metathesis, affect the pattern of the magnetic profile obtained for these complexes – e.g., the presence of halogen atoms in the structure of N-ethyl-N-(2-aminoethyl)salicylaldiminate (SalEen) influence said behaviour in Fe(III) complexes[2]. Another interesting detail is that, by changing the solvent used in the crystallisation process for these iron complexes or by controlling the evaporation rate of said solvent, we can obtain different polymorphs for the same compound.[3,4] With all these principles in mind, we focus on the optimization of previously studied Fe(III) complexes and the synthesis of newer ones, to extend the library of compounds under study – while also trying to obtain differing complexes, by varying the solvent of the crystallisation process – and the study of the magnetic behaviour for all synthesised Fe(III) complexes.

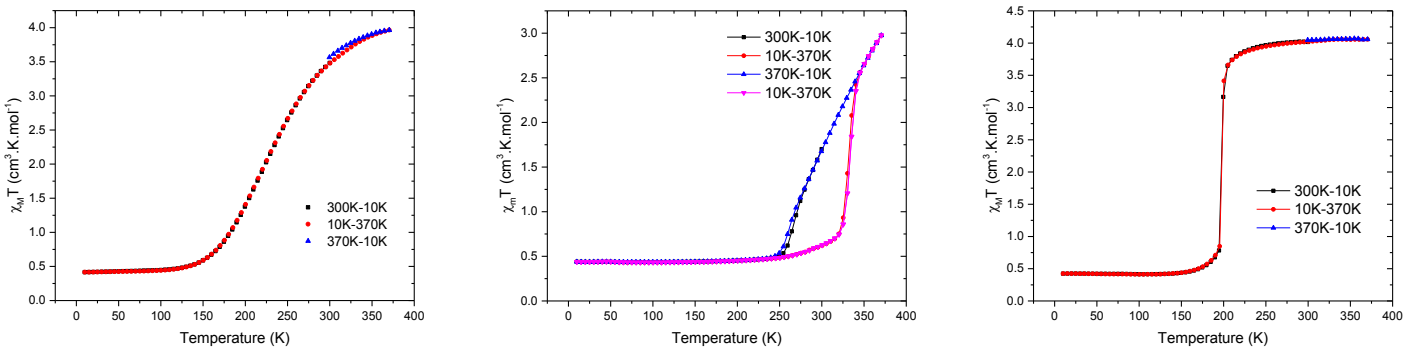


Figure 1: Magnetic profiles for a family of Fe(III) complexes synthesised during the project.

Acknowledgements
We are grateful to Fundação da Ciência e a Tecnologia, FCT, for Project PTDC/QUI-QIN/0252/2021. Centro de Química Estrutural (CQE) and Institute of Molecular Sciences (IMS) acknowledge the financial support of Fundação para a Ciência e Tecnologia (Projects UIDB/00100/2020, UIDP/00100/2020, and LA/P/0056/2020, respectively). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).
P.N.M. acknowledges FTC for financial support (CEECIND/00509/2017).

References
1. M. Nihei, T. Shiga, Y. Maeda and H. Oshio, *Coord. Chem. Rev.*, 2007, **251**, 2606–2621
2. R.T. Marques, F.F. Martins, D.F. Beki, A.I. Vicente, L.P. Ferreira, C.S.B. Gomes, S. Barroso, V. Kumar, Y. Garcia, N.A.G. Bandeira, M.J. Calhorda and Paulo N. Martinho, *Magnetochemistry*, 2022, **8**, 162-174
3. T.Boonprab, P. Harding, K.S. Murray, W. Phonsri, S.G. Telfer, A. Alkas, R. Ketkaew, Y. Tantirungrotechai, G.N.L. Jameson and D.J. Harding, *Dalton Trans.*, 2018, **47**, 12449–12458
4. A.I. Vicente, L.P. Ferreira, M. Carvalho, V.H.N. Rodrigues, M.M. Dirtu, Y. Garcia, M.J. Calhorda and P.N. Martinho, Dalton Trans, 2018, **47**, 7013–7019

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Biophysical characterization of methyl-β-cyclodextrin-membrane interaction for application in drug and gene delivery

Cristiana V. Ramos[1,2*], Margarida M. Cordeiro[1,2], Jaime Samelo[1,2], Maria João Moreno[1,2]

[1]*Coimbra Chemistry Center, Institute of Molecular Sciences (CQC-IMS), University of Coimbra, 3004-535 Coimbra, Portugal;*
[2]*Department of Chemistry, Faculty of Sciences and Technology, University of Coimbra, 3004-535 Coimbra, Portugal*
**cristianavramos95@gmail.com*

For the past few decades, cyclodextrins (CDs) and their derivatives have shown interesting applications in the large field of drug and gene delivery.[1,2] This is attributed to their excellent biocompatibility, functionalization capabilities, and their capacity to securely encapsulate hydrophobic molecules within their internal cavity.[2] In addition to the increase in drug solubility, at high concentrations CDs can improve drug delivery due to their interaction with membrane components, perturbing the lipid bilayer and thus influencing drug permeability.[3] Despite the importance of these applications, there is still little knowledge regarding the CDs interaction with phospholipid membranes. It is critical to understand the interaction between cyclodextrins and cell membranes to optimize this novel strategy of drug delivery. Previous studies have demonstrated that the interaction between CDs and membranes may occur through the formation of inclusion complexes with the membrane lipids.[3] Extraction of cholesterol by □-CDs is well characterized, being used as a methodology to decrease the level of cholesterol in the membrane, although at high concentrations CDs cause irreversible damage to the cell's structure.[4] A deep understanding of cyclodextrin's interaction with biomimetic systems, such as liposomes and biological membranes, is crucial in pharmacology for controlling CD-mediated drug delivery and release without causing membrane disruption.

The main objective of this work is to focus on the characterization of the interactions between Methyl-β-CD (MβCD) and lipid membranes under conditions where the membrane is not destroyed. These results will provide information about the physicochemical parameters and the mechanism of interaction between MβCD and the model membrane, being very relevant for predicting the behavior of cyclodextrins for biomedical applications. The methylated cyclodextrin was selected due to its wide use given its larger solubility in aqueous media when compared with unmodified β-cyclodextrin.[5]

The interaction of MβCD with biomimetic membranes was investigated using biophysical tools, including effects on membrane permeability, polarity, and fluidity. The results demonstrate that the MβCD effect on membranes is mediated by several factors, including membrane structure and composition, as well as cyclodextrin concentration. Our outcomes suggest that the disruption of phospholipid membranes may be minimized if the MβCD concentration is kept below about 5 mM, which is adequate for many applications. Addition of MβCD to membranes containing the non-polar fluorescent probe diphenylhexatriene (DPH) leads to a very significant decrease in fluorescence, indicating a more polar environment around DPH. The effect of M□CD on the membrane gel-fluid phase transition temperature (Tm) was evaluated through DPH fluorescence anisotropy and differential scanning calorimetry (DSC), showing an increase in Tm at low cyclodextrin concentrations, and a decrease at high concentrations. This behavior can be explained by a preferential interaction of M□CD with the gel phase, and saturation of this phase at relatively low CD concentrations. Higher MβCD concentrations would lead favor interactions with the fluid phase that may accommodate higher amounts of CD. The effect of M□CD on membrane permeability was evaluated through carboxyfluorescein efflux and phospholipid translocation, indicating little effect at CD concentrations below 1 mM.

Acknowledgements
This work was supported through research grants from the POCTI program of the Fundação para a Ciência e a Tecnologia (FCT) of the Portuguese Ministry for Higher Education and Scientific Research through project PT2020_PTDC_DTP_FTO_2784_2014, co-funded by COMPETE2020-UE, and CENTRO-01-0145-FEDER-000014 through "Programa Operacional Regional do Centro" CENTRO2020. The authors are grateful to FCT for funding of the Coimbra Chemistry Centre through projects UIDB/00313/2020 and UIDP/00313/2020, and CVR thanks FCT for the Ph.D. grant 2020.04545.BD.

References

1. M. Jug, Nanomaterials for Clinical Applications, 2020, 29–69.
2. R. M. Haley, R. Gottardi, R. Langer and M. J. Mitchell, Drug Delivery and Translational Research, 2020, 10, 661–677.
3. Z. Hammoud, N. Khreich, L. Auezova, S. Fourmentin, A. Elaissari and H. Greige-Gerges, International Journal of Pharmaceutics, 2019, 564, 59–76.
4. Á. Haimhoffer, Á. Rusznyák, K. Réti-Nagy, G. Vasvári, J. Váradi, M. Vecsernyés, I. Bácskay, P. Fehér, Z. Ujhelyi and F. Fenyvesi, Scientia Pharmaceutica, 2019, 87, 33.
5. P. Saokham, C. Muankaew, P. Jansook and T. Loftsson, Molecules, 2018, 23, 1161.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

P101

Targeting amyloid aggregation with steroidal compounds

Hélio M. T. Albuquerque[1,*], Raquel Nunes da Silva[1,2], Sandra I. Vieira[2], Artur M. S. Silva[1]

[1]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal*
[2]*Department of Medical Sciences and Institute of Biomedicine, IBiMED, University of Aveiro, 3810-193 Aveiro, Portugal*
**helio.albuquerque@ua.pt*

Amyloid-β (Aβ) and tau aggregation resulting in amyloid plaques and neurofibrillary tangles are detected in 70–80% of people diagnosed Alzheimer's disease (AD).[1] The clinical success of the antibody Lecanemab slowing cognitive decline in people with early-stage AD, was the first treatment for this disease to unequivocally pass its clinical trials. This was simultaneously a breakthrough because it's the first AD drug to show any measurable cognitive improvement among trial participants; and a disappointment because the effects were only modest. However, Lecanemab left an important legacy since it had a crucial role in clarifying a possible druggable pathway. As so, researchers are revisiting small molecules that target this same pathway, which, unlike bulky biologics, are structurally less complex, generally cheaper, and compatible with at-home oral consumption, making it feasible for people to start their drug regimen early and stay on it longer. In this context, we develop hybrid compounds through framework combination between cholesterol and quinoline moieties, capable to inhibit and reverse Aβ self-aggregation *in vitro* and in cell models (Figure 1).[2] The hybrid compounds were prepared by oxidation of cholesterol precursor followed by Friedlander annulation, setting up a library of eight non-toxic and stable compounds (Figure 1).[2]

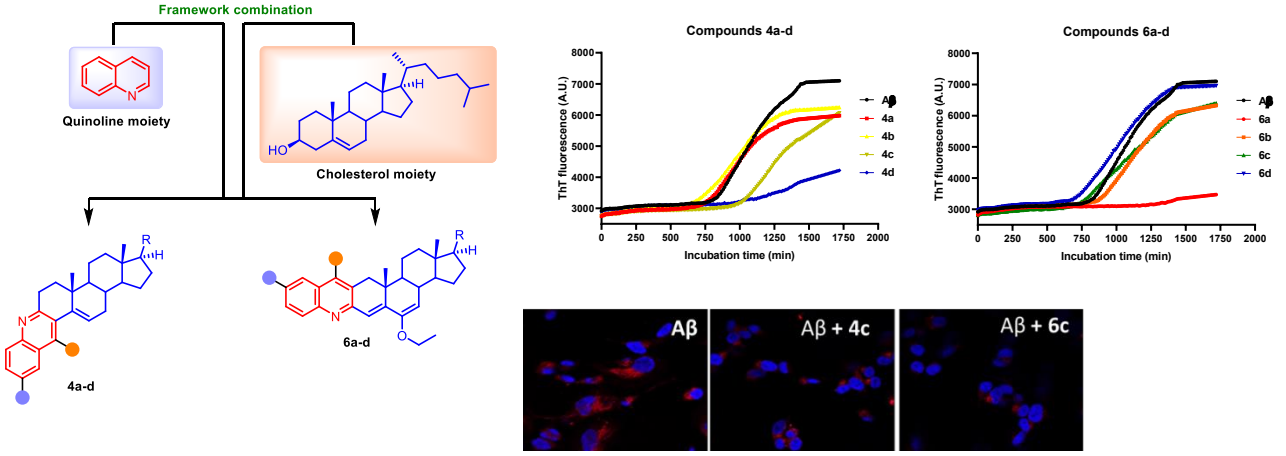


Figure 1: Cholesterol-quinoline hybrid compounds targeting Aβ aggregation.

Acknowledgements and funding
This work received financial support from PT national funds (OE) through FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) within the projects: LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), and MuTaTher-AD—"Multi-target theranostics for Alzheimer's disease" (2022.06064.PTDC). Hélio Albuquerque gratefully acknowledges MuTaTher-AD for his researcher contract. Microphotographs were acquired in the LiM facility of iBiMED/UA, a member of the Portuguese Platform of BioImaging (PPBI) (POCI-01-0145-FEDER-022122).

References

1. D. Malafaia, H. M. T. Albuquerque, A. M. S. Silva, *Eur. J. Med. Chem.* **2021,** *214*, 113209
2. H. M. T. Albuquerque, R. N. Silva, M. Pereira, A. Maia, S. Guieu, A. R. Soares, C. M. M. Santos, S. I. Vieira, A. M. S. Silva, ACS *Med. Chem. Lett*. **2022**, *13*, 443−448

P102

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Manganese compounds as efficient catalysts for the reductive depolymerization of plastic waste

Daniel L. Lourenço, Daniela F. Oliveira, Ana C. Fernandes*

Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
**anacristinafernandes@tecnico.ulisboa.pt*

Nowadays, one of the biggest pollution concerns is related to the huge amount of plastic waste that is generated around the world. Plastic waste represents not only a global pollution problem, but also a carbon-rich, low-cost, globally available feedstock. In this context, the conversion of plastic waste into value-added compounds is an extremely important research area.

The development of methodologies for the reductive depolymerization of plastic waste using inexpensive catalysts based on an earth-abundant metal would be an important advancement in achieving the requirements of an ecologically and economically benign process.

Manganese, as the third richest transition metal in the Earth's crust, is cheap and less toxic, has been applied as a catalyst in a variety of organic reduction, including reduction of aldehydes and ketones, CO_2, esters, imines, sulfoxides. However, these methodologies are promoted by bidentate or pincer-type ligand-manganese catalysts, which can be a disadvantage in scaling up reactions, making the processes more expensive.

In continuation of our work,[1-5] in this communication we report the reductive depolymerization of a variety of polyester and polycarbonate plastic waste catalyzed by commercially available homogeneous and heterogeneous manganese catalysts using boranes as the reducing agents with good to excellent yields and high reusability (Figure 1). Another important advantage of this methodology is the use of catalysts without containing complex ligands, which is very important from a scale-up point of view.

Figure 1: Reductive depolymerization of plastic waste catalyzed by manganese compounds.

Acknowledgements
This research was supported by Fundação para a Ciência e Tecnologia (FCT) through projects PTDC/QUI-QOR/0490/2020, UIDB/00100/2020, UIDP/00100/2020 and LA/P/0056/2020. DLL thanks to FCT for the grant.

References
1. A. C. Fernandes, *Green Chem*. **2021**, *23*, 7330-7360.
2. B. F. S. Nunes, M. C. Oliveira, A. C. Fernandes, *Green Chem.* **2020**, *22*, 2419-2425.
3. A. C. Fernandes, *ChemSusChem* **2021**, *14*, 4228-4233.
4. D. L. Lourenço, A. C. Fernandes, *Catalysts* **2022**, *12*, 381. 5.
5. D. L. Lourenço, A. C. Fernandes, *Molecular Catal.* **2023**, *542, 113128.*

Effect of hyperbaric storage at room temperature on the development of the Maillard reaction in sugar-aminoacid model systems

F. Basso[1,*], L. Manzocco[1], C. A. Pinto[2], M. C. Nicoli[1], J. A. Saraiva[2]

[1]Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Via Sondrio 2/A, 33100 Udine, Italy
[2]LAQV-REQUIMTE, Department of Chemistry, Campus Universitário de Santiago, University of Aveiro, 3810-193 Aveiro, Portugal
**federico.basso@uniud.it*

Hyperbaric storage (HS) is developing, non-thermal food storage approach based on the application of moderate hydrostatic pressure (up to 250 MPa) for up to one year[1]. The technology is highly sustainable when no temperature control system is applied, as no energy is required for the maintenance of storage conditions[2]. Although HS has been proven capable to induce substantial microbial inactivation, and to steer enzyme activity and protein techno-funcitonality[3–5], only limited evidence is available about the effect of the technology on chemical reactions in food. According to the Le Chatelier principle and to the Transition State theory, pressure affects chemical reactions kinetics by favouring the events associated to a negative volume change and vice-versa[6]. In agreement with these universally recognized laws, HS was shown to boost and hamper the development of volume-reducing (*e.g.*, fish lipid peroxidation) and volume-expanding reactions (*e.g.*, meat volatile production), respectively[1]. Despite its relevance in food storage, nothing is however known regarding the effect of HS on the Maillard reaction[7]. The Maillard reaction is a complex scheme of interdependent chemical events originating from the condensation of an amino- and a carbonyl-compound (e.g., proteins and polysaccharides, respectively)[7]. Besides being hampered by pressure due to its inherent volume expansion[6], Maillard browning is influenced by several factors, with particular reference to temperature[7]. It is in fact well-known that the rate of Maillard browning exponentially decreases and increases with temperature and pressure, according to the Eyring and the Arrhenius equations, respectively[6]. In the HS context, characterized by prolonged storage times, even minimal changes in temperature and pressure could result in dramatic changes in food browning.

The aim of this work was to study the effect of HS on the kinetics of the Maillard reaction. To this aim, the effect of temperature (43, 53, 63 °C) and pressure (0.1, 15, 50 and 100 MPa) on the formation rate (k) of Maillard intermediates (absorbance at 294 nm) and melanoidins (absorbance at 420 nm) was studied during HS of aqueous solutions containing glucose (1.71 M) and glycine (2.05 M) at pH 6.

The increase in storage temperature caused a prompt increase in the formation rate of both intermediates and melanoidins, according to the Arrhenius equation with activation energy approaching 85 kJ mol^{-1}. Increasing storage pressure, a decrease in k was detected as estimated by the Eyring equation with activation volume about 11 mL mol^{-1}. No significant influence of storage pressure was observed on the reaction activation energy, suggesting HS not to affect the mechanism of Maillard browning but exerting primarily a kinetic effect on the phenomenon. A combined model based on the Arrhenius and Eyring equations was thus fitted to the experimental data ($R^2 > 0.97$) in order to predict the effect of concomitant changes in temperature and pressure on the rate of Maillard reaction. The model was validated ($r = 0.94$) at temperature and pressure conditions (20-25 °C, 20-200 MPa) within and outside its building range.

Results demonstrate the capability of HS to limit Maillard browning in food as well as the possibility to apply temperature-accelerated protocols to predict the shelf life of food stored under HS conditions.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCT for the financial support to the LAQV-REQUIMTE research Unit (UIDB/50006/2020 & UIDP/50006/2020) through national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement, and for financing the PhD grant of Carlos A. Pinto (SFRH/BD/137036/2018 and COVID/BD/153220/2023).

References

1. M. D. Santos, L. G. Fidalgo, C. A. Pinto, R. V Duarte, Á. T. Lemos, I. Delgadillo and J. A. Saraiva, *Crit Rev Food Sci Nutr*, 2021, **61**, 2078–2089.
2. A. Bermejo-Prada, A. Colmant, L. Otero and B. Guignon, *J Food Eng*, 2017, **193**, 76–85.
3. F. Basso, M. Maifreni, N. Innocente, L. Manzocco and M. Cristina Nicoli, *Food Research International*, 2022, **156**, Article 111090.
4. C. A. Pinto, S. A. Moreira, L. G. Fidalgo, M. D. Santos, M. Vidal, I. Delgadillo and J. A. Saraiva, *Food Research International*, 2017, **99**, 123–132.
5. L. Manzocco, F. Basso and M. C. Nicoli, *Food Bioproc Tech*, 2023, DOI:10.1007/s11947-023-03025-0.
6. S. I. Martinez-Monteagudo and M. D. A. Saldaña, *Food Engineering Reviews*, 2014, **6**, 105–127.
7. M. A. J. S. Van Boekel, *Compr Rev Food Sci Food Saf*, 2008, **7**, 144–158.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Tailoring the guest-host $PW_{11}Co$@ZIF-67 nanocomposite ORR/OER electrochemical bifunctionality through carbonization

V. K. Abdelkader-Fernández[1], D. M. Fernandes[2,*], S. S. Balula[2], L. Cunha-Silva[2], M. J. Pérez-Mendoza[1], C. Freire[2]

[1]Departamento de Química Inorgánica, Facultad de Ciencias, Universidad de Granada (UGR), Avenida de Fuente Nueva, s/n, 18071 Granada, España; [2]REQUIMTE/LAQV, Departamento de Química e Bioquímica, Faculdade de Ciências da Universidade de Porto, Rua do Campo Alegre, 4169-007 Porto, Portugal
**diana.fernandes@fc.up.pt*

The electrochemical oxygen reduction and evolution reactions (ORR and OER) are crucial energy-related processes that take place in fuel cell and electrolyzer systems. For this reason, regarding the real implementation of these devices, efficient electrocatalysis of these processes is required, stimulating the quest for new, non-expensive, and active electrocatalysts during the last years. In this context, polyoxometalates (POMs), metal-organic frameworks (MOFs), and MOF-derived nanocarbons have received a lot of attention due to their remarkable and complementary structural and electrochemical properties[1,2]. In this work, we present a study focused on the carbonization of a POM@MOF nanocomposite in which the POM units ($PW_{11}Co$) are individually confined inside the MOF (ZIF-67) cavities. To obtain different nanostructured hybrids with diverse compositions, carbonization degrees, metal oxidation states, textural features, that results in distinct electrocatalytic ORR/OER performances, several carbonization temperatures were explored: 200, 400, 500, 600 and 950°C. Then, the compositional/structural changes were characterized using XPS, ICP-OES, CHNS analysis, PXRD, ATR-IR, Raman (Figure 1a), gas adsorption, and TEM, while their electrocatalytic behaviors were assessed via cyclic and linear sweep voltammetry (CV, LSV – Figure 1b), and chronoamperometry (CA) measurements.

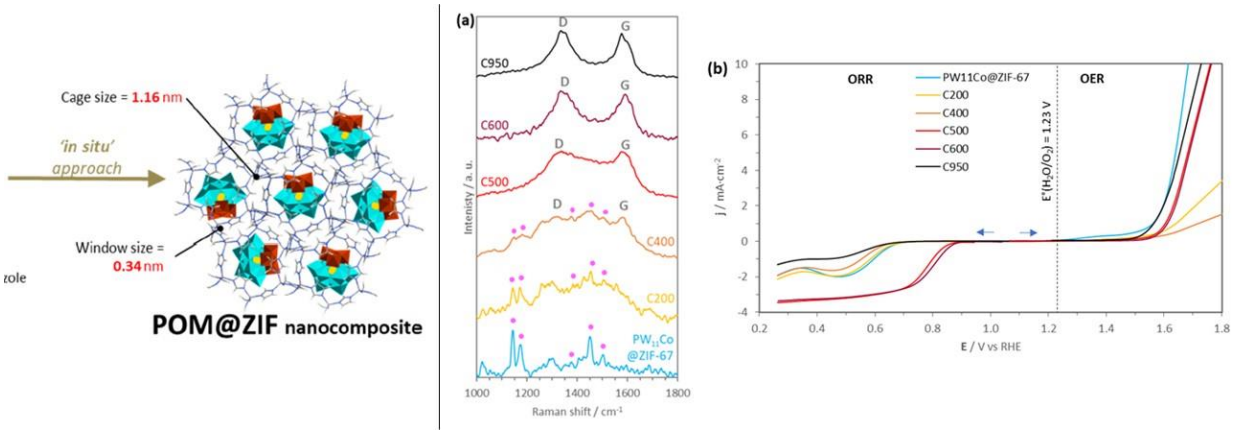


Figure 1: POM@ZIF nanocomposite: (a) Raman spectra initial nanocomposite, C200, C400, C500, C600 and C950 and (b) ORR and OER LSV curves.

Funding
This work was financial supported with funding from FCT/MCTES (UIDP/50006/2020 and UIDB/50006/2020) through national funds.

Acknowledgements
D.M.F. also thanks Fundação para a Ciência e a Tecnologia for funding through the Individual Call to Scientific Employment Stimulus (Refs. 2021.00771.CEECIND/CP1662/CT0007). V. K. Abdelkader Fernández thanks Junta de Andalucía (Regional government of Spain) for his Postdoctoral research contract within the framework of "Programa de Contratación de Jóvenes Doctores 2020".

References
1. C. Freire, D. M. Fernandes, M. Nunes and V. K. Abdelkader, *ChemCatChem*, 2018, **10**, 1703-1730.
2. V. K. Abdelkader, D. M. Fernandes, S. S. Balula, L. Cunha-Silva and C. Freire, *J. Mater. Chem. A*, 2020, **8**, 13509-13521.

Recycling spent frying oil in acidogenic fermentation by microbial mixed cultures

André Oliveira[1,2,*], Sílvia Petronilho[2,3], Luísa S. Serafim[1]

[1]*CICECO, Aveiro Institute of Materials, Chemistry Department, University of Aveiro, Aveiro, Portugal*
[2]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, Aveiro, Portugal*
[3]*Chemistry Research Centre-Vila Real, Department of Chemistry, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal*
**andreoliveira98@ua.pt*

Waste reduction through the manufacture of added value products has attracted attention worldwide in recent years. Household and food industry waste is estimated to correspond to ca. 23% of the 50.3 million tons of waste produced annually in the EU[1]. Spent frying oil (SFO) is one of the wastes that is produced at high volumes, despite part of it being used in biodiesel production. The recalcitrant compounds of SFO difficults its treatment in wastewater treatment plants (WWTPs). In this work, the possibility of producing short-chain organic acids (SCOAs) using SFO as substrate for acidogenic fermentation (AF), one of the steps of anaerobic digestion, was assessed. Firstly, SFO was characterized as fatty acid methyl esters (FAME) after alkaline-catalyzed transesterification, which revealed that oleic acid (ca. 81%) was the main fatty acid, followed by palmitic (ca. 11%), linoleic (ca. 6%), and stearic (ca. 2%) acids. Three inocula were studied to determine the most suitable for AF of SFO, which included the anaerobic (AnMS) and aerobic (AeMS) sludges from a municipal WWTPs and an aerobic sludge (AeBS) from a WWTP of biodiesel production. Starting with a food to microorganism ratio (F/M) of 1:1 in a carbon oxidation demand (COD) basis, AnMS was the inoculum that produced the highest SCOAs concentration (1.60 g COD/L). However, this inoculum mostly produced acetic acid with a low amount of butyric acid. The most diverse profile of SCOAs was obtained with the inoculum AeMS with 48:17:9:13:13% in a molar basis for acetic, propionic, butyric, iso-butyric, and valeric acids, respectively. Fourier-Transform Infrared Spectroscopy (FTIR) confirmed the production of SCOAs and the consumption of lipids in SFO at the end of the AF experiments. F/M ratios of 2:1 and 1:2 (gCOD/gCOD) were also studied but using AeMS and AeBS. Both ratios led to lower acidification degree than F/M ratio of 1:1 that resulted in an acidification degree of 39.33% for the SFO assay with AeBS as inoculum, and a 55.67% acidification degree for the OL assay with AeBS as inoculum. Despite this, assays with AeMS as inoculum resulted in higher concentrations and diversity of SCOAs. Due to lack of studies using lipid-based substrates for SCOAs production with mixed microbial cultures, this work can be considered as a starting point for future studies to reduce SFO waste and pollution, while following circular economy concepts.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCTES for the financial support of CICECO-Aveiro Institute of Materials (FCT Ref. UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) and LAQV-REQUIMTE (UIDB/50006/2020) research units and CQ-VR at UTAD Vila Real (UIDP/00616/2020), through PT national funds, and when applicable, co-financed by FEDER, within the PT2020 Partnership Agreement and Compete 2020. The authors also thank to "A Saloinha, Lda." for providing potato byproducts to recover the spent frying oil. FCT is also thanked for the post-doc grant SFRH/BPD/117213/2016 (SP). This work is also supported by NORTE 2020, under the PT 2020 Partnership Agreement, through the ERDF and FSE.

References

1. F. Battista, G. Strazzera, F. Valentino, M. Gottardo, M. Villano, M. Matos, F. Silva, Maria. A. M. Reis, J. Mata-Alvarez, S. Astals, J. Dosta, R. J. Jones, J. Massanet-Nicolau, A. Guwy, P. Pavan, D. Bolzonella and M. Majone, *J Environ Chem Eng*, 2022, **10**, 108319.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Molecular design of a metal–nitrosyl ferroelectric with reversible photoisomerization

L. Verissimo[1], W.-J. Xu[1,*], M.-F. Li[2], A. R. Garcia[3], K. Romanyuk[4], J. M. G. Martinho[3], P. Zelenovskii[4], A. Tselev[4], W.-X. Zhang[2], X.-M. Chen[2], A. Kholkin[4], J. Rocha[1]

[1]Department of Chemistry & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal; [2]MOE Key Laboratory of Bioinorganic and Synthetic Chemistry, School of Chemistry, Sun Yat-Sen University, Guangzhou 510275, China; [3]Centro de Química Estrutural, Institute of Molecular Sciences and Department of Chemical Engineering, Instituto Superior Técnico, University of Lisbon, 1049-001 Lisbon, Portugal; [4]Department of Physics & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal
**weijxu@ua.pt*

The development of photo-responsive ferroelectrics, capable of remotely controlling polarization through optical means, holds significant importance for both fundamental research and technological applications. In this study, we present the design and synthesis of a novel metal-nitrosyl ferroelectric crystal, (DMA)(PIP)[Fe(CN)$_5$(NO)] (**1**) (DMA = dimethylammonium, PIP = piperidinium), with potential phototunable polarization via a dual-organic-cations molecular design strategy (Figure 1).[1] In comparison to the parent non-ferroelectric material (MA)$_2$[Fe(CN)$_5$(NO)] (MA = methylammonium), which exhibits a phase transition at 207 K, the introduction of larger dual organic cations in compound **1** lowers crystal symmetry, resulting in robust ferroelectricity. Additionally, this modification increases the energy barrier for molecular motions, leading to a significantly enhanced polarization of up to 7.6 μC cm^{-2} and a high Curie temperature (T_c) of 316 K. Infrared spectroscopy shows that the reversible photoisomerization of the nitrosyl ligand is accomplished by light irradiation. Specifically, the ground state with the N-bound nitrosyl ligand conformation can be reversibly switched to both, the metastable state I (MSI) with isonitrosyl conformation, and the metastable state II (MSII) with side-on nitrosyl conformation. Quantum chemistry calculations suggest that the photoisomerization changes significantly the dipole moment of [Fe(CN)$_5$(NO)]$^{2-}$ anion, thus leading to three ferroelectric states with different values of macroscopic polarization. Such optical accessibility and controllability of different ferroelectric states via photoinduced nitrosyl linkage isomerization open up a new and attractive route to optically-controllable macroscopic polarization.

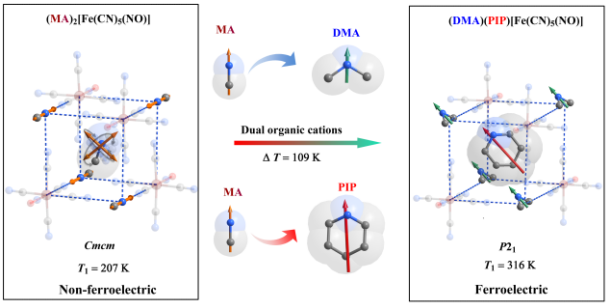


Figure 1: Design concept and strategy of nitroprusside-based ferroelectric (DMA)(PIP)[Fe(CN)$_5$NO].

Acknowledgements
This work was supported by NSFC (22071273 and 21821003), Local Innovative and Research Teams Project of Guangdong Pearl River Talents Program (2017BT01C161). This work (including the grant of W.-J. X.) was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020 & UIDP/50011/2020, financed by national funds through the FCT/MEC and when appropriate co-financed by FEDER under the PT2020 Partnership Agreement. It is also funded by national funds (OE), through FCT − Fundação para a Ciência e a Tecnologia, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19. We thank FCT for funding the project PTDC/CTM-CTM/4044/2020. AT acknowledges individual support by the 2021.03599.CEECIND through national funds provided by FCT – Fundação para a Ciência e a Tecnologia. LV would like to thank FCT UI/BD/151050/2021. J. M. G. M. and A. R. G. thank FCT and COMPETE (FEDER) within projects UIDB/00100/2020, UIDP/00100/2020 and LA/ P/0056/2020. We thank Dr. Alexander Tkach, Prof. Paula M. Vilarinho for the *P-E* loop measurements.

References

1. W.-J. Xu, M.-F. Li, A. R. Garcia, K. Romanyuk, J. M. G. Martinho, P. Zelenovskii, A. Tselev, L. Verissimo, W.-X. Zhang, X.-M. Chen, A. Kholkin, and J. Rocha, *J. Am. Chem. Soc.,* 2023, DOI: 10.1021/jacs.3c01530.

Tailored solutions for plastic recycling: Evaluating eutectic solvents for selective polymer dissolution by COSMO-RS

João T. S. Martins[1], Simão Vidinha Pandeirada[1], Mariana I. S. Aguiar[1], Andreia F. Sousa[1,2], João A. P. Coutinho[1], José Pedro Wojeicchowsk[1], Ana M. Ferreira[1,*]

[1]*CICECO, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal.*
[2]*Centre for Mechanical Engineering, Materials and Processes, Department of Chemical Engineering, University of Coimbra, 3030-790, Coimbra, Portugal.*
**ana.conceicao@ua.pt*

The widespread use of plastics has played a major role in driving the economic progress worldwide in recent years, with an annual production exceeding 350 million tons. These flexible synthetic polymers possess lightweight and versatile characteristics, making them indispensable in various applications, including packaging, biomedicine, and electronics. Nevertheless, only a small portion undergoes recycling due to the deterioration of recycled materials' physical properties, which limits their usage to lower-quality applications.[1] Among various recycling methods, precipitation-dissolution stands out as a promising approach, although organic solvents remain the preferred choice.[2] Recently, novel solvents, including bio-based ones, have showcased their ability to selectively dissolve and precipitate polyethylene.[3] Eutectic solvents (ES) present a promising option for dissolving polymers and promoting effective recycling. Nevertheless, choosing the suitable ES can be challenging due to the wide array of optimal combinations involving hydrogen bond donors (HBD) and hydrogen bond acceptors (HBA).

In this study, the COSMO-RS (COnductor-like Screening MOdel for Real Solvents) thermodynamic model, based on quantum chemistry, was utilized to identify the most promising ES for dissolving the most used fossil-based polymers that represent plastic waste, namely polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), and polyvinylchloride (PVC), but also two of the most important bio-based polymers, the polyethylene 2,5-furanoate (PEF) and the polylactic acid (PLA).[4,5] It was screened a total of 2360 ES for each polymer using the total combinations between 59 hydrogen bond donors (HBD) and 40 hydrogen bond acceptors (HBA) at a molar ratio of 1:1. The affinity of these ES for the polymers was evaluated by predicting the logarithmic activity coefficient in silico of the respective plastic wastes at a temperature of 373.15 K. Additionally, to ensure accuracy of COSMO-RS predictions, a series of solubilization tests were conducted using the ES that were computationally selected as the top candidates for each polymer.

The finding results indicated that hydrophobic ES, particularly those containing long-chain alcohols as HBD, proved to be the most appropriate solvents for dissolving PE, PP, and PVC. In the case of PET and the bio-based polymers PLA and PEF, ES with phenolic monoterpenes as HBA, such as carvacrol and thymol, exhibited excellent dissolution capabilities. Promising results were further confirmed through laboratory validation, which demonstrated the effectiveness of the ES thymol:formic acid (1:1) in dissolving PET while not promptly dissolving the other tested fossil-based polymers. Those results imply the potential for separating mixed waste containing different polymers using different ES compositions. The work outcomes suggest that selecting the appropriate ES can lead to a more sustainable and selective dissolution process, representing a significant advancement for the recycling of multilayer plastic packaging and mixed polymer waste.

Acknowledgments
This work was partly developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). AFS and AMF acknowledge FCT for the research contracts CEECIND/02322/2020 and CEECIND/00361/2022, respectively. This publication is supported by COST Action FUR4Sustain- European network of FURan based chemicals and materials FOR a Sustainable development, CA18220, supported by COST (European Cooperation in Science and Technology).

References
1. C. Sonnendecker, J. Oeser, P. K. Richter, P. Hille, Z. Zhao, C. Fischer, H. Lippold, P. Blázquez-Sánchez, F. Engelberger, C. A. Ramírez-Sarmiento, T. Oeser, Y. Lihanova, R. Frank, H.-G. Jahnke, S. Billig, B. Abel, N. Sträter, J. Matysik, W. Zimmermann, *ChemSusChem.*, 2022, **15**, e202200696.
2. T. W. Walker, N. Frelka, Z.Shen, A. K. Chew, J. Banick, S. Grey, M. S. Kim, J. A. Dumesic, R. C. V. Lehn, G. W. Hube., *Sci. Adv.*, 2020, **47**, eaba7599.
3. A. M. Ferreira, I. Sucena, V. Otero, E. M. Angelin, M. J. Melo, J. A. P. Coutinho, *Mol.*, 2022, **27**, 98.
4. R. Geyer, J. R. Jambeck, K. L. Law, *Sci. Adv.*, 2017, **3**, 3-8.
5. A. F. Sousa, R. Patrício, Z. Terzopoulou, D. N. Bikiaris, T. Stern, J. Wenger, K. Loos, N. Lotti, V. Siracusa, A. Szymczyk, S. Paszkiewicz, K. S. Triantafyllidis, A. Zamboulis, M.S. Nikolic, P. Spasojevic, S. Thiyagarajan, D. S. v. Es, N. Guigo, *Green Chem.*, 2021, **23**, 8795-8820.

P108

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Peptide conjugates for the topical treatment of infected wounds

Ana Gomes[1,*], Iva Fernandes[1], Lucinda Bessa[1,2], Mariana Ferreira[1], Joana Maciel[1], Alexandra Plácido[1], Cátia Teixeira[1,3], Ermelindo Leal[4], Ricardo Ferraz[1,5], Paula Gameiro[1], Eugénia Carvalho,[5] Paula Gomes[1]

[1]LAQV-REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, Portugal
[2]current affiliation: CIIEM, Egas Moniz - Cooperativa de Ensino Superior, Almada, Portugal
[3]current affiliation: Gyros Protein Technologies, Tucson, AZ 85714, United States of America
[4]Centro de Neurociências e Biologia Celular (CNC), Universidade de Coimbra (UC), Portugal
[5]CQBM, Escola Superior de Saúde, Politécnico do Porto, Portugal
**agomes@fc.up.pt*

Due to widespread multidrug-resistant (MDR) microbes, efficient treatments for infected wounds are being exhausted.[1] The symptoms of wound infection are consistent with local polymicrobial biofilms, which are difficult to eliminate and delay the healing process. The current standard of care requires oral antibiotics and other measures, often complex and distressing (e.g., amputations). A perfect treatment should promote both antimicrobial protection and fast tissue regeneration, to improve the inefficient healing in elderly people affected with, e.g., diabetes or venous/arterial insufficiency. [2]

Considering the above, we advance peptide conjugates as potential active pharmaceutical ingredients for topical formulations to tackle skin infections. Such conjugates are anticipated to concomitantly display antimicrobial and anti-biofilm action along with fast healing through, e.g., collagenesis-inducing effects. Promising results were obtained with chimeric peptides combining a *de novo* designed antimicrobial peptide sequence [3] with a cosmetic peptide, used as anti-aging, with ability to induce collagen production.[4] The best constructs exhibited: (i) antibacterial and anti-biofilm activity against Gram-positive and Gram-negative bacteria, including MDR clinical isolates; (iii) improved action against *S. aureus* (prevalent pathogen in chronically-infected wounds) in simulated wound fluid; and (v) antifungal activity. [5] The replacement of the antimicrobial peptide by an ionic liquid afforded a new conjugate, a peptide-ionic liquid construct, with broad-spectrum antibacterial activity, antifungal action, and collagen-inducing effect. These results will be shown alongside the most recent findings that provide deeper insight into the mode of action of the best conjugates.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for supporting LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) and for Ana Gomes Researcher contract (2022.08044.CEECIND/CP1724/CT0004).

Funding
This work was financed by FCT-Fundação para a Ciência e a Tecnologia/Ministério da Ciência, Tecnologia e Inovação through the financing support to LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020).

References

1. V. Puca, R. Z. Marulli, R. Grande, I. Vitale, A. Niro, G. Molinaro, S. Prezioso, R. Muraro and P. Di Giovanni, *Antibiotics (Basel)*, 2021, **10**.
2. E. Makrantonaki, M. Wlaschek and K. Scharffetter-Kochanek, *J Dtsch Dermatol Ges*, 2017, **15**, 255-275.
3. S. J. Kang, H. S. Won, W. S. Choi and B. J. Lee, *J Pept Sci*, 2009, **15**, 583-588.
4. H. Park, E. An and A. R. Cho Lee, *Tissue Eng Regen Med*, 2017, **14**, 73-80.
5. A. Gomes, L. J. Bessa, I. Fernandes, R. Ferraz, C. Monteiro, M. C. L. Martins, N. Mateus, P. Gameiro, C. Teixeira and P. Gomes, *Pharmaceutics*, 2021, **13**, 1962.

Tricarbonyl-pyrazine-molybdenum(0) metal−organic frameworks for the storage and delivery of biologically active carbon monoxide

A. C. Gomes*, A. F. Silva, I. B. Calhau, A. A. Valente, I. S. Gonçalves, M. Pillinger

CICECO – Aveiro Institute of Materials, University of Aveiro, Department of Chemistry, Aveiro, Portugal
**agomes1@ua.pt*

Metal−organic frameworks (MOFs) have been demonstrated to be promising scaffolds for storing and delivering therapeutic gasotransmitters or gas-releasing molecules. The current study investigates the viability of tricarbonyl-pyrazine-molybdenum(0) MOFs as carbon monoxide-releasing materials (CORMAs). A former investigation found that the reaction of excess pyrazine (pyz) with $Mo(CO)_6$ in a sealed ampoule gave a mixture comprising a major triclinic phase with pyz-occupied hexagonal channels, formulated as *fac*-$Mo(CO)_3(pyz)_{3/2}\cdot 1/2pyz$ (Mo-hex), and a minor dense cubic phase, formulated as *fac*-$Mo(CO)_3(pyz)_{3/2}$ (Mo-cub). In the present work, an open reflux method in toluene afforded the pure Mo-cub phase (Figure 1). The crystalline solids Mo-hex and Mo-cub were characterized by powder X-ray diffraction, scanning electron microscopy, thermogravimetric analysis, FT-IR and FT-Raman spectroscopies, and $^{13}C\{^1H\}$ cross-polarization magic-angle spinning NMR spectroscopy. The suitability of these materials to behave as CORMAs was assessed by the deoxymyoglobin/carbonmonoxy-myoglobin UV−vis assay. Mo-hex and Mo-cub release CO upon contact with a physiological buffer (PBS) in the dark, delivering 0.35 and 0.22 equiv (based on Mo), respectively, after 24 h, with half-lives of 3−4 h. These materials are attractive as potential CORMAs due to the slow release of a high CO payload. In the solid-state and under open air, Mo-cub underwent almost complete decarbonylation over a period of 4 days, corresponding to a theoretical CO release of 10 mmol per gram of material.[1]

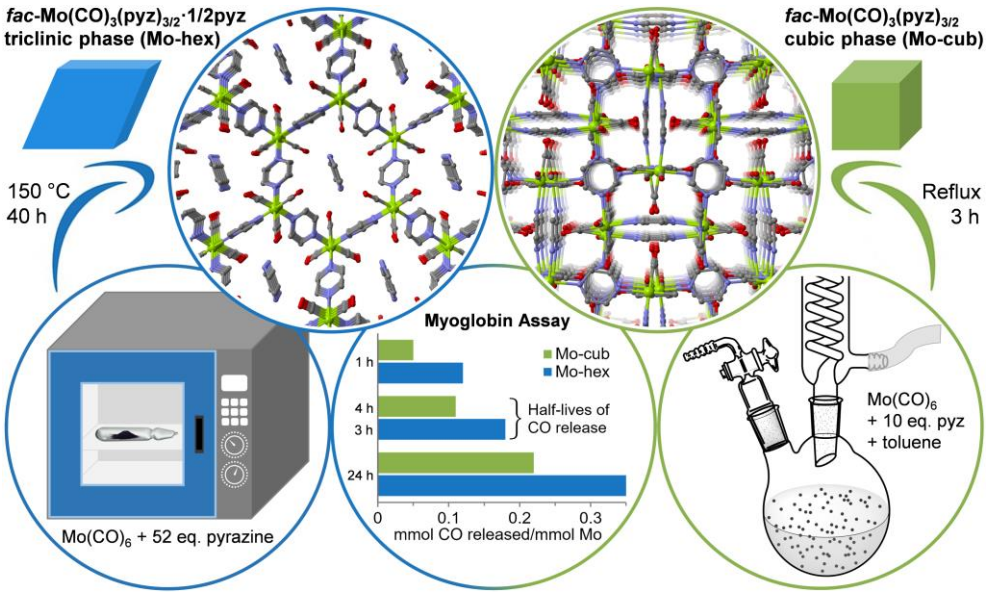


Figure 1: Synthetic approaches used for the preparation of Mo-cub and Mo-hex, and corresponding CO release profiles.

Acknowledgements
We thank funding provided by CICECO (UIDB/50011/2020, UIDP/50011/2020 &LA/P/0006/2020), CENTRO 2020 (project CENTRO-01-0145-FEDER-028031 and PTDC/QUI-QOR/28031/2017) and COMPETE 2020, financed by FCT/MEC (PIDDAC) and ERDF. The NMR spectrometers are part of National NMR network (PTNMR) and partially supported by Infrastructure project no. 022161. I.B.C. is grateful to the FCT for a PhD studentship (2021.05953.BD). A.C.G. thanks the FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus (CEECIND/02128/2017).

References

1. A.F. Silva, I.B. Calhau, A.C. Gomes, A.A. Valente, I.S. Gonçalves, M. Pillinger, ACS Biomater. Sci. Eng. 2023, 9, 1909−1918

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

From bulk catalysts to membranes: Designing a new route to scale-up sustainable fuel desulfurization

R. G. Faria[1,*], L. A. Neves[2], S. S. Balula[1], L. Cunha-Silva[1]

[1]*REQUIMTE/LAQV, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Portugal*
[2]*LAQV@REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal*
**rui_faria_619@hotmail.com*

A recent report from the U.S. Energy Information Administration predicts that fossil fuels will continue to dominate global energy production, still accounting for 70% by 2050. This reliance on traditional energy sources is driven by increasing fuel consumption, particularly in growing Asian markets.[1] The combustion of fossil fuels leads to environmentally harmful emissions, including sulfur oxides that contribute to acid rain formation. While hydrodesulfurization (HDS) technologies have successfully addressed the desulfurization of road fuels, the treatment of heavy fuels requires the development of alternative desulfurization processes. This presents an opportunity to minimize waste in petroleum refineries.

Oxidative Desulfurization (ODS) has emerged as an efficient method for removing sulfur from fuels at significantly lower temperatures and pressures than HDS.[2] Achieving the sustainability of ODS relies on exploring innovative catalysts such as polyoxometalates (POM), metal-organic frameworks (MOF), and their combination (POM@MOF). These catalysts have demonstrated exceptional efficiency in facilitating ODS reactions[3]. However, one challenge has been their powdered nature, impacting handling and recyclability. To overcome this limitation, we have developed a distinctive membrane configuration using POM and [POM@MOF] catalysts immobilized in Polyvinylidene Fluoride (PVDF) membranes.

This work focuses on using these catalytic membranes to achieve complete desulfurization of model fuels. The introduction of these novel membranes not only enhances catalyst stability but also prolongs their lifespan by minimizing mass loss. Remarkably, this approach demonstrates minimal compromise in performance compared to conventional bulk catalysts, highlighting the significant potential of catalytic membranes. This research paves the way for advancing ODS towards industrial-scale implementation and offers promising possibilities for cleaner and more efficient fuel desulfurization processes.

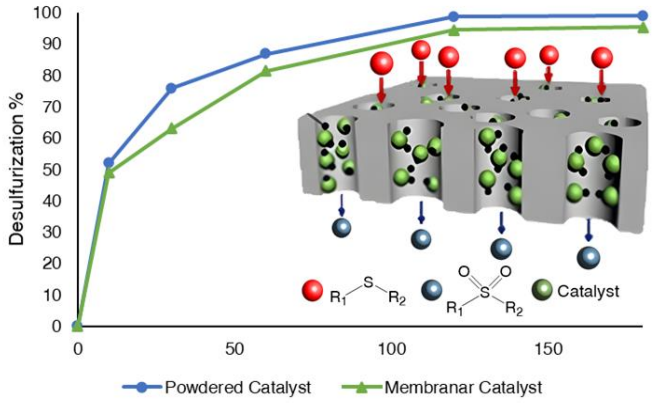


Figure 1: Comparison of ODS Profiles: Powdered Catalyst vs. Membrane Configuration. Illustration of the ODS reaction occurring within a porous catalytic membrane (inset).

Acknowledgments
This work received financial support from Portuguese national funds (FCT/MCTES) through the strategic project UIDB/50006/2020 and UIDP/50006/2020 (for LAQV-REQUIMTE) and was also funded by the European Union (FEDER funds through COMPETE POCI-01-0145-FEDER-031983). LCS and SSB thank FCT/MCTES for funding the Individual Call to Scientific Employment Stimulus (CEECIND/00793/2018 and EECIND/03877/2018, respectively). RGF thanks REQUIMTE and FCT/MCTES for the PhD grant (BD/151277/2021). LAN acknowledges FCT)/MCTES for the assistant researcher contract under Scientific Employment Stimulus (2022.00689.CEECIND).

References

1. United States Energy Information Administration, International Energy Outlook 2021.
2. A. M. Viana, D. Julião, F. Mirante, R. G. Faria, B. de Castro, S. S. Balula and L. Cunha-Silva, Cat. Today, 2021, **362**, 28-34.
3. S. C. Fernandes, A. M. Viana, B. de Castro, L. Cunha-Silva and S. S. Balula, Sustain. Energ. Fuels, 2021, **5**, 4032-4040.

Fluorescent sensors for metal cations based on coumarin-3-carboxamide derivatives

Liliana J. Gomes[1,*], C. S. B. Gomes[1,2], Augusto C. Tomé[3], Artur J. Moro[1]

[1]LAQV-REQUIMTE, Department of Chemistry, Nova School of Science and Technology / FCT-NOVA, NOVA University Lisbon, 2829-516 Caparica, Portugal; [2]UCIBIO, Department of Chemistry, Nova School of Science and Technology / FCT-NOVA, NOVA University Lisbon, 2829-516 Caparica, Portugal and i4HB, Nova School of Science and Technology / FCT-NOVA, NOVA University Lisbon, 2829-516 Caparica, Portugal; [3]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**lj.gomes@campus.fct.unl.pt*

The scientific community is strongly motivated to develop effective methods for the detection and accurate quantification of metals. Indeed, several industries require new detection methods for raw materials (e.g. heavy metals detection in the mining industry), while simultaneously monitoring the surrounding water and soil deposits. Additionally, since some of these metals are highly toxic, it is vital to test biological samples for controlling *in vivo* levels of these toxic metals. Nowadays, methods like Atomic Absorption Spectroscopy (AAS) or Inductively Coupled Plasma Optical Emission Spectrometry (ICP-AES) are considered expensive and require a complex sample preparation and analysis.[2] In this regard, fluorescent chemosensors have emerged as a promising solution since they can produce a distinct signal when exposed to an analyte, even at low concentrations.[3]

To address this need, a new family of coumarin-3-carboxamide derivatives is herein presented as potential fluorescent chemosensors for metal ions. The new derivatives have two distinct moieties, being the coumarin structure the signaling moiety, and the aza-crown (morpholine, 1-aza-12-crown-4, aza-15-crown-5 and others) The receptor/recognition moiety.

To investigate the photophysical characteristics of these compounds, UV-Vis and fluorescence titrations were carried out with several ions (Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+} and Pb^{2+}). The results of these experiments demonstrated the selective properties of some of the synthesized coumarin-3-carboxamides towards lead, calcium and copper.

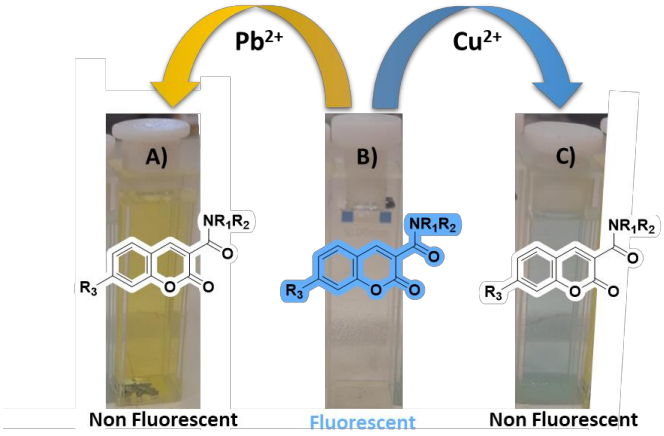


Figure 1: Selectivity from one of the synthesized coumarin-3-carboxamides towards Pb^{2+} and Cu^{2+}. **A)** coumarin-3-carboxamide complexed with Pb^{2+} - yellow solution with no fluorescence. B) coumarin-3-carboxamide – transparent solution with blue fluorescence. **C)** coumarin-3-carboxamide complexed with Cu^{2+} - blue solution with no fluorescence.

Acknowledgements
L. J. G. acknowledges FCT/MCTES for a Ph. D. grant (UI/BD/153617/2022).

Funding
The work was supported by the Associate Laboratory for Green Chemistry - LAQV through projects UIDB/50006/2020 | UIDP/50006/2020 and LA/P/0008/2020, funded by FCT/MCTES through national funds.

References
1. J. Zhao *et al*. *Coordination Chemistry Reviews* 378, **2019**, 415–444.
2. M. N. Sweilam et al., ACS Sens. **2018**, 3, 1802.
3. T. Sakamoto, A. Ojida e I. Hamachi. *Chemical Communications*. **2009**, 141–152.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Combining natural bile acids with old basic drugs affords new triple stage antimalarial surface-active ionic liquids

Ana Teresa Silva[1,*], Isabel Oliveira[2], Denise Duarte[3], Diana Moita[4], Miguel Prudêncio[4], Fátima Nogueira[3], Ricardo Ferraz[1,5], Eduardo F. Marques[2], Paula Gomes[1]

[1]LAQV-REQUIMTE, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, P-4169-007 Porto, Portugal; [2]CIQUP, IMS (Institute of Molecular Sciences), Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto, P-4169-007 Porto, Portugal; [3]Global Health and Tropical Medicine, Instituto de Higiene e Medicina Tropical, Universidade Nova de Lisboa, P-1349-008 Lisboa, Portugal; [4]Instituto de Medicina Molecular, Faculdade de Medicina Universidade de Lisboa, P-1649 028 Lisboa, Portugal; [5]Center for Translational Health and Medical Biotechnology Research (TBIO), School of Health (ESS), Polytechnic of Porto, Rua Dr. António Bernardino de Almeida, 400, 4200-072 Porto, Portugal.
**up201303026@edu.fc.up.pt*

Ionic liquids (ILs) are special organic salts that have been gaining momentum in medicinal chemistry. Despite their simple and cost-effective synthesis, ILs offer an easy access to structures of biological interest by combining bioactive molecules with opposite polarities, e.g., via simple ionic pairing of an acid with a base. [1] This makes ILs of special interest for treating malaria. Since this disease is prevalent mainly in low-to-middle income countries, novel chemotherapeutic strategies must be kept affordable. Malaria is caused by *Plasmodium* parasites, whose complex life cycle includes three developmental stages in the host: the blood stage, the liver stage, and the gametocyte stage. This complexity turns the development of new effective drugs quite difficult, which is aggravated by the fast emergence of drug-resistant strains. This fact has often led to the disuse of several antimalarials, driving the need to find new ones with multiple-stage action. In this context, we have been working on new antimalarial ILs by mixing antimalarial aminoquinolines—chloroquine and primaquine—with natural lipids. [2-3] Two new families of salts derived from those antimalarial drugs and naturally-occurring bile acids were now produced by acid-base neutralization, and evaluated for their antiplasmodial action. The chloroquine-derived bile salts were found active against all the three stages of parasite development in the host. Their behavior as surface-active ionic liquids (SAILs), i.e. their interfacial and self-aggregation properties, were also investigated, as they may contribute critically to their delivery and therapeutic action.

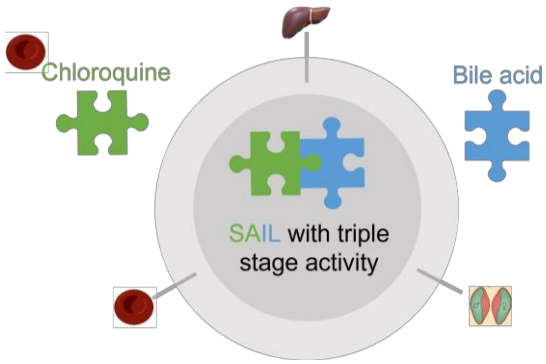


Figure 1: Synthesis of ionic liquid by a simple neutralization reaction.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through projects UIDB/50006/2020 and UIDB/00081/2020.

Acknowledgements
ATS thanks FCT/MCTES and Sociedade Portuguesa de Química for her doctoral grant SFRH/BD/150649/2020.

References

1. R. Ferraz, J. Noronha, F. Murtinheira, F. Nogueira, M. Machado, M. Prudencio, S. Parapini, S. D'Alessandro, C. Teixeira, A. Gomes, C. Prudêncio, P. Gomes, RSC Advances, 6 (2016) 56134.
2. A. T. Silva, L. Lobo, I. S. Oliveira, J. Gomes, C. Teixeira, F. Nogueira, E. F. Marques, R. Ferraz, P. Gomes, International Journal of Molecular Sciences, 21 (2020) 5334.
3. A. T. Silva, I. S. Oliveira, J. Gomes, L. Aguiar, D. Fontinha, D. Duarte, F. Nogueira, M. Prudêncio, E. F. Marques, C. Teixeira, ChemMedChem, 17 (2022) e202100650.

Light-activated sulfonamides for antimicrobial photodynamic therapy

Sofia N. Sarabando[1,2,*], Carlos J. P. Monteiro[2], Emília Sousa[1,3], Andreia Palmeira[1,3], M. Amparo F. Faustino[2]

[1]Laboratory of Organic and Pharmaceutical Chemistry, Chemical Sciences Department, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal; [2]LAQV-Requimte and Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal; [3]CIIMAR – Interdisciplinary Center of Marine and Environmental Research, 4450-208 Porto, Portugal
**sofia.sarabando@ua.pt*

Sulfonamides are the oldest class of conventional antimicrobials used to combat infections. Sulpha drugs are dihydropteroate synthase (DHPS) competitive inhibitors, *p*-aminobenzoic acid antimetabolites, and consequently inhibit tetrahydrofolic acid synthesis, which is essential to the formation of nucleic acids precursors in bacteria.[1] Photoactivated drugs, in particular porphyrin sulfonamides have emerged as a promising class of compounds with potential for antimicrobial applications.[2,3] These molecules are capable of producing reactive oxygen species (ROS) upon irradiation with light, which can damage the cell wall and other cellular components of bacteria.[4] This makes them a potential alternative to traditional antibiotics, which are facing increasing resistance from microbial populations. Once the combination of different therapeutic approaches may improve biological activity, the aim of this work was to combine a porphyrin with a sulpha moiety with an amide bond that could be cleaved by amidases naturally present in bacteria.[5] Thus, the present work describes the synthetic access and strategy used for preparing porphyrin-sulfonamide bioconjugates containing enzymatically cleavable amide groups. The synthetic route and structure elucidation of the synthetic intermediates and the final conjugate were achieved by spectroscopic methods and docking studies against DHPS and other bacterial targets and photodynamic action results will also be presented.

Acknowledgements
The authors thank the University of Aveiro and FCT/MCT for the financial support provided to LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), Group of Marine Natural Products and Medicinal Chemistry CIIMAR (UIDB/04423/2020, UIDP/04423/2020), through national funds (OE), and where applicable, co-financed by the FEDER-Operational Thematic Program for Competitiveness and Internationalization-COMPETE 2020, within the PT2020 Partnership Agreement.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 + UIDP/50006/2020 and UIDB/04423/2020 + UIDP/04423/2020.

References
1. G. Patrick, *An Introduction to Medicinal Chemistry*, Oxford University Press; 6th edition, **2017**.
2. S. N. Sarabando, C. J. Dias, C. Vieira, M. Bartolomeu, M. G. P. M. S. Neves, A. Almeida, C. J. P. Monteiro, M. A. F. Faustino, *Molecules*, **2023**, 28 (5), 2067.
3. S. N. Sarabando, A. Palmeira, M. E. Sousa, M. A. F., Faustino, C. J. P. Monteiro, *Pharmaceuticals*, **2023**, 16, 682.
4. M. Q. Mesquita, C. J. Dias, M. G. P. M. S. Neves, A. Almeida, M. A. F. Faustino, *Molecules,* **2018**, 23, 2424.
5. Z. Wu, C. Liu, Z. Zhang, R. Zheng, Y. Zheng, *Biotechnol. Adv.,* **2020**, 43, 107574.

P114

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Physicochemical and pharmacokinetic profiles of African natural products: A computational approach

Silvestre Isidoro[1,2,*], Natalia Aniceto[1], Olga Silva[1], Elsa T. Gomes[3], Rita C. Guedes[1]

[1]*Research Institute for Medicines (iMed.Ulisboa), Faculty of Pharmacy, Universiade de Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisbon, Portugal;* [2]*Faculty of Health Sciences, Universidade Lúrio, Bairro de Marrere, R. nr. 4250. Km 2.3- Nampula, Mozambique;* [3]*Faculty of Pharmacy, Universidade de Lisboa, Lisbon, Portugal*
**sisidoro@edu.ulisboa.pt*

Background. Natural products (NPs) still contribute to the discovery of new drugs. About 35% of available drugs are NPs or NP-inspired drugs. Medicinal plants play an important role in African Traditional Medicine (ATM) and about 80% of the African population relay on ATM care. This could be attributed to several factors, such as, availability, accessibility and culture. The ratio of traditional medicine practitioners (TMPs) and medical doctors to African population is 1:500 and 1:40,000, respectively. Therefore, validating the use of African plants for medicinal applications may improve evidence-based therapy, awareness of their preservation and also access to medical care. **Objective and methods.** In this study we aim to analyse physicochemical and pharmacokinetic profiles of African and Mozambican NPs from the NPASS database using a range of techniques and algorithms, such as, SwissADME web tool, RDKit library, QikProp package and t-distributed stochastic neighbor embedding (t-SNE). **Result**. About 99.0% of NPs scaffolds were unique when compared to drugs approved in major jurisdictions database. They have also showed higher molecular weight, Log P, TPSA values. About 40% of NPs did not violate any of the drug-likeness filters (Ro3, Ro5, Ghose, and others). And 45% have not inhibited cytochrome major inhibitors. With respect to the Pan Assay Interference Compounds (PAINS) analysis, more than 88% of NPs did not present any PAINS substructure. **Conclusion**. African NPs provide unique chemical scaffolds and occupy relatively distinct chemical space in comparison to drugs approved in major jurisdictions. Most of the African NPs showed acceptable physicochemical, pharmacokinetic and toxicological properties. They cover a broad range of properties, from NPs that cannot permeate the skin to those that are active in the CNS. This explains its wide use in treating or preventing several illnesses. Most of them, also showed acceptable drug-likeness properties.

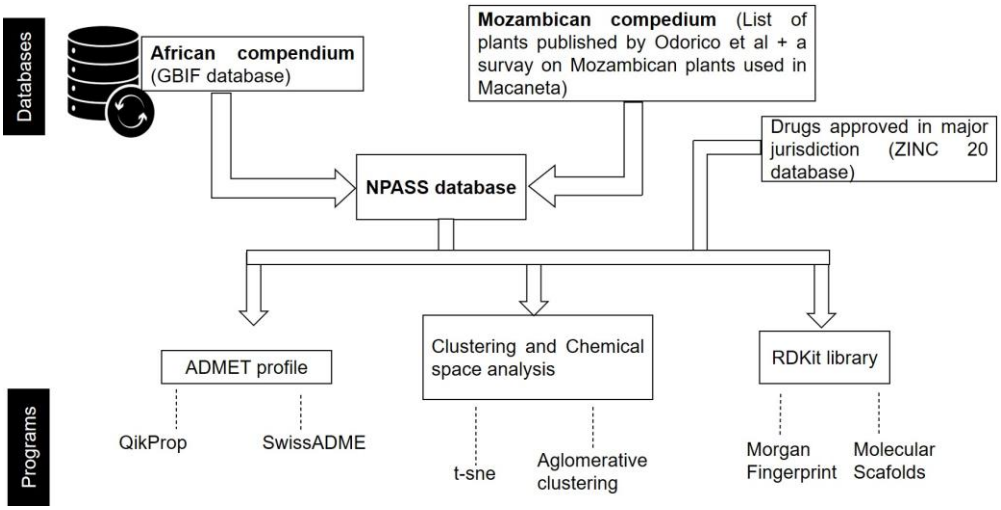


Figure 1: Workflow of the analysis performed for the NPs and drugs approved in major jurisdictions datasets.

Acknowledgements
The authors acknowledge Fundação para a Ciência e a Tecnologia (FCT) for financial support EXPL/QUI-OUT/1288/2021, 2022.03752.PTDC, CPCA/A2/6972/2020, UIDB/04138/2020, and UIDP/04138/2020 to iMed.ULisboa

References

1. T. Henkel, R. M. Brunne, H. Müller and F. Reichel, *Angew. Chem. Int. Ed*, DOI:10.1002/(SICI)1521-3773(19990301)38:5.
2. M. Sorokina, P. Merseburger, K. Rajan, M. A. Yirik and C. Steinbeck, *J Cheminform*, 2021, 1–13.
3. D. I. Osolodkin, E. v. Radchenko, A. A. Orlov, A. E. Voronkov, V. A. Palyulin and N. S. Zefirov, *http://dx.doi.org/10.1517/17460441.2015.1060216*, 2015, **10**, 959–973.

Exploring the bioavailability of phenolic compounds through *in vitro* simulated gastrointestinal digestion - INFOGEST

Adriana C. S. Pais[1,*], Ezequiel R. Coscueta[2], Maria Manuela Pintado[2], Armando J. D. Silvestre[1], Sónia A. O. Santos[1]

[1]CICECO-Aveiro Institute of Materials, Chemistry Department, University of Aveiro, 3810-193 Aveiro, Portugal
[2]Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina -Laboratório Associado, Escola Superior de Biotecnologia
**a.c.p.s@ua.pt*

Phenolic compounds, one of the most widely distributed and structurally diverse family of plant secondary metabolites, have been the focus of several studies due to their vast range of biological activities (such as antioxidant, anti-inflammatory and/or antiproliferative). Since they are commonly present in the human diet, phenolic compounds could be responsible for a wide range of human health beneficial effects.[1–4] Notwithstanding, these health effects strictly depend on their bioavailability, which consists of the amount of each ingested compound that reaches the target tissue where it can have its biological effect.[5] Therefore, the compound's structure, human digestive system enzymatic activity, and gut microbiota are some of the numerous factors that influence phenolic compounds' bioavailability and, consequently, their human health beneficial effects.[5]

In this vein, the bioavailability of ten phenolic compounds from different classes, mainly flavonols (quercetin and rutin), flavanones (naringenin and naringin), flavan-3-ols (epigallocatechin-gallate), flavones (apigenin), isoflavones (daidzein), dihydrochalcones (phloretin), one monomeric tannin compound (phloroglucinol), and a phenolic acid (ellagic acid) were evaluated in an *in vitro* simulated gastrointestinal digestion – INFOGEST ®, and further analyzed and quantified through ultra-high performance liquid chromatography with diode-array detection and coupled to electrospray ionization tandem mass spectrometry (UHPLC-DAD-MS^n). Intestinal absorption was determined through a dialysis system. Most of the compounds remained present along the gastrointestinal tract, and the bioaccessibility was generally higher than 50%, except for quercetin, epigallocatechin gallate, and ellagic acid. All compounds were highly absorbed in the intestine, with phloretin showing the lowest percentage at about 82%.

Thus, these results provide more information about bioavailability which could be a future remark to evaluate the human health effects of promising phenolic compounds combination or plant-based extracts with a similar composition or even extracts enriched with them.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). Thank the CBQF for its institutional support. Acknowledgements are also due to FCT/MCTES for the PhD grant to A.C.S.P. (SFRH/BD/143348/2019) and research contract under Scientific Employment Stimulus to S. Santos (2021.03348.CEECIND).

References

1. A. Durazzo, M. Lucarini, E. B. Souto, C. Cicala, E. Caiazzo, A. A. Izzo, E. Novellino and A. Santini, *Phyther. Res.*, 2019, **33**, 2221–2243.
2. A. Cortés-Martín, M. V. Selma, F. A. Tomás-Barberán, A. González-Sarrías and J. C. Espín, *Mol. Nutr. Food Res.*, 2020, **64**, 1900952.
3. G. R. Velderrain-Rodríguez, H. Palafox-Carlos, A. Wall-Medrano, J. F. Ayala-Zavala, C. Y. O. Chen, M. Robles-Sánchez, H. Astiazaran-García, E. Alvarez-Parrilla and G. A. González-Aguilar, *Food Funct.*, 2014, **5**, 189–197.
4. M. Veiga, E. M. Costa, S. Silva and M. Pintado, *Crit. Rev. Food Sci. Nutr.*, 2020, **60**, 873–886.
5. M. D'Archivio, C. Filesi, R. Varì, B. Scazzocchio and R. Masella, *Int. J. Mol. Sci.*, 2010, **11**, 1321–1342.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of a beneficial metformin drug delivery system using sustainable technologies

M. N. José*, C. Costa, D. Silva, T. Casimiro, L. C. Branco, A. Aguiar-Ricardo

LAQV-REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
**mn.jose@campus.fct.unl.pt*

Metformin is currently a first-line drug for the treatment of type 2 diabetes mellitus (T2DM) and a very promising drug to treat or prevent other types of pathologies.[1] However, the application of the drug in therapy is limited by the high polarity and basicity, being considered a Class III drug according to the Biopharmaceutical Classification System (BCS), which means that it has restrictions on how permeable it is. High doses are administered to balance this reduction of metformin activity, which unfortunately brings undesirable gastrointestinal effects and resistance problems associated with inadequate use of medication.[2]
To overcome these problems and potentiate metformin, some strategies have been implemented, namely the combination with other drugs, the administration of multiple doses, and the use of extended-release metformin (MXR) formulations. More recently, three studies have been published focusing on the design of more lipophilic formulations for metformin based on ionic liquid systems or organic salts as an alternative to hydrochloride salt, demonstrating the possibility to have significant progress in the bioavailability of metformin, by choosing correctly the lipophilic counter-anion.[3] In this context, we are exploring the activity of organic salts and ionic liquids (OSILs) prepared from metformin cation to improve the permeability and solubility of the drug in physiological media. Additionally, we made this research innovative by exploring the inhalation route with the new compounds, as an alternative to the oral route, which is currently the only one available and possesses some limitations.
Solubility in water and biological fluids, octanol-water partition coefficients and toxicity assays were studied for five produced metformin-OSILs. Even though all of the compounds showed positive results, only one was selected for the supercritical CO_2-assisted spray-drying (SASD) process of making dry powders because it stood out as being particularly promising. To improve the new system, numerous studies using different excipients were carried out, and they demonstrated excellent in vitro delivery efficiency.

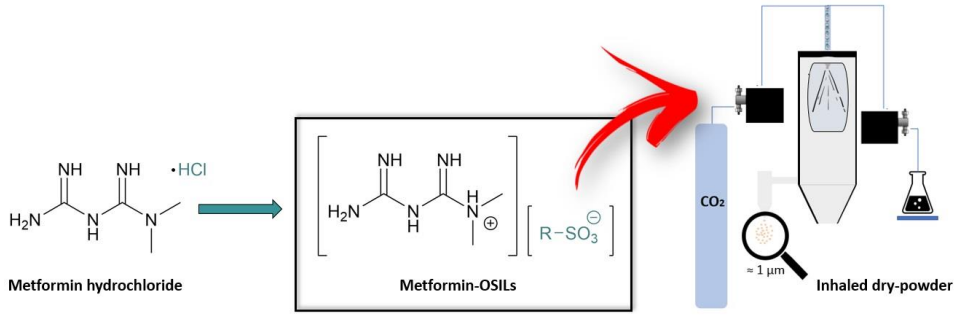


Figure 4: An overview of the work done focusing on the development of a beneficial metformin drug delivery system using sustainable technologies.

Acknowledgements
The authors are grateful for the financial support of the Associate Laboratory for Green Chemistry- LAQV, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Portugal, which is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). C. Costa thanks FCT (Fundação para a Ciência e Tecnologia) and ESF (European Social Fund) through POCH (Programa Operacional Capital Humano) for her PhD grant ref. PD/BD/142880/2018, COVID/BD/152744/2022 and Project PD/00184/2012-PDQS. M.N. José, C. Costa and A. Aguiar-Ricardo acknowledge also CA18224 GREENERING ("Green Chemical Engineering Network towards upscaling sustainable processes"). COST Actions are funded within the EU Horizon 2020 Programme. D. Silva also thanks for PhD grant (2020.09889.BD).

References
1. M. Markowicz-Piasecka, K. M. Huttunen, L. Mateusiak, E. Mikiciuk-Olasik and J. Sikora, *Current Pharmaceutical Design, 2017, **23**, 2532-2550* .
2. L. F. Diniz, P. S. Carvalho, J. E. Gonçalves, R. Diniz and C. Fernandes, New J. Chem., 2022, **46**, 13725–13737.
3. H. K. Saeed, Y. Sutar, P. Patel, R. Bhat, S. Mallick, A. E. Hatada, D.-L. T. Koomoa, I. Lange and A. A. Date, ACS Omega, 2021, **6**, 2626–2637.

Exploring dual-source thermal evaporation to create perovskite thin films for photovoltaic applications

Artur F. M. Farinha*, Luís M. N. B. F. Santos, José C. S. Costa

CIQUP, Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry, Faculty of Science, University of Porto, Portugal
**up201506214@fc.up.pt*

The use of dual-source vapor deposition by thermal evaporation is explored for the fabrication of perovskite thin films for solar cell applications. The vapor deposition technique employed in this study utilizes a thermal evaporation apparatus based on multiple Knudsen cells, each with independent temperature control[1,2]. This enables the sublimation of the two precursors of the perovskite (methylammonium iodide and lead iodide), which require different temperatures due to their distinct vapor pressures. Upon sublimation, both precursors deposit on the substrate under a perovskite structure (methylammonium lead iodide). This method allows for exceptional purity, crystallinity, and homogeneity in the resulting perovskite films[3–7]. The morphological, structural, and optical properties of the perovskite films were obtained by high-resolution scanning electron microscopy, X-ray powder diffraction, and UV-vis spectroscopy, respectively.
Additional experimental investigations involving the integration of a hole transport layer are presented. A pentacene thin film, deposited using the same vapor deposition by thermal evaporation equipment, improved the performance of the perovskite solar cell. Comparative analysis of the current-voltage (I-V) curves is presented, highlighting the performance disparities between the perovskite solar cell based solely on the perovskite film and the perovskite solar cell enhanced by the hole transport layer (pentacene). The vapor-deposited organic layer was also found to enhance the crystallinity and stability of the perovskite film.
Overall, this work demonstrates the potential of dual-source thermal vapor deposition as a versatile and efficient technique for fabricating perovskite solar cells, with the ability to enhance their performance through the incorporation of compatible functional layers, such as pentacene.

Acknowledgements
The authors thank the Portuguese Foundation for Science and Technology (FCT) for financial support to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), and IMS-Institute of Molecular Sciences (LA/P/0056/2020), Faculty of Science, University of Porto. A.F.M. Farinha also thanks the FCT for the award of a Ph.D. Research Grant (ref. 2022.11342.BD).

References
1. J. C. S. Costa, R. M. Rocha, I. C. M. Vaz, M. C. Torres, A. Mendes and L. M. N. B. F. Santos, *J Chem Eng Data*, 2015, **60**, 3776–3791.
2. J. C. S. Costa, A. F. S. M. G. Coelho, A. Mendes and L. M. N. B. F. Santos, *Appl Surf Sci*, 2018, **428**, 242–249.
3. A. F. M. Farinha, L. M. N. B. F. Santos and J. C. S. Costa, *U.Porto Journal of Engineering*, 2023, **9**, 151–167.
4. J. C. S. Costa, J. Azevedo, L. M. N. B. F. Santos and A. Mendes, *Journal of Physical Chemistry C*, 2017, **121**, 2080–2087.
5. J. C. S. Costa, J. Azevedo, J. P. Araújo, L. M. N. B. F. Santos and A. Mendes, *Thin Solid Films*, 2018, **664**, 12–18.
6. L. Gil-Escrig, I. Susic, İ. Doğan, V. Zardetto, M. Najafi, D. Zhang, S. Veenstra, S. Sedani, B. Arikan, S. Yerci, H. J. Bolink, M. Sessolo, L. Gil-Escrig, I. Susic, H. J. Bolink and M. Sessolo, *Adv Funct Mater*, 2023, 2214357.
7. H. Li, J. Zhou, L. Tan, M. Li, C. Jiang, S. Wang, X. Zhao, Y. Liu, Y. Zhang, Y. Ye, W. Tress and C. Yi, *Sci Adv*, 2022, **8**, 7422

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Repurposing of drugbank compounds for multitargeting of PD-L1 and TGF-β

Margarida M. Alves[1,3,*], Carlota Leonardo de Sousa[1,2], Ismael Rufino[1], Rita C. Acúrcio[2], Helena F. Florindo[2], J. N. Canongia Lopes[3], Rita C. Guedes[1]

[1]*Research Institute for Medicines (iMed.Ulisboa), Computational Medicinal Chemistry Lab, Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisboa, Portugal*
[2]*Research Institute for Medicines (iMed.Ulisboa), BioNanoSicences Lab, Faculdade De Farmácia, Universidade De Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisboa, Portugal*
[3]*Instituto Superior Técnico, Universidade De Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal*
**anamargaridaalves@tecnico.ulisboa.pt*

Cancer is a dangerous disease that affects millions of people every year. In 2021, an estimated 1.267.000 people died due to cancer in Europe. Currently, there are several treatments available to fight cancer, such as chemotherapy, radiotherapy, and surgical resection.[1] Another approach for treating cancer is immunotherapy, which involves boosting the immune system through immune checkpoint inhibitors or monoclonal antibodies, for example. However, there are some limitations due to the lack of knowledge about the mechanisms of these immune checkpoints, making it difficult to develop new and more effective inhibitors.[2] Repurposing of drugs consists of giving a new purpose, as the name indicated, to an FDA approved drug by testing it for new targets and diseases.[3] Because this drug is already studied (the toxicity is known, as well as the pharmacokinetics), the process of development is much more efficient and costs less.

The aim of this work is to apply strategies to increase tumor immunity by studying possible new multitargeting drugs. The focus was placed on two independent immune suppressive pathways: TGF-βR1 signaling and PD-L1 immune checkpoint, both involved in cancer cell growth and proliferation. In this work, a Computer-Aided Drug Design approach was implemented to increase drug discovery speed and efficiency.[4] Molecular docking, pharmacophore modeling, virtual screening, and molecular dynamics will be used in the design and screening of multitargeting drugs. To this end, 6 crystallographic structures, extracted from the Protein Data Bank for each target, were prepared, analyzed, and submitted to molecular docking. Those with the best results – 6R3K and 7VUN for PD-L1 and 5QIM, 5FRI, and 1RW8 for TGF-βR1– were used to screen the DrugBank database. In addition, the score cutoff as well as the interactions that the ligands establish with the protein were determined to filter screening results. Out of the 1568 compounds screened, 39 and 249 showed to be active for PD-L1 and TGF-βR1, respectively. The interactions that ended up being the most important are stablished with the residues ALA121, ILE54, MET155, TYR56, TYR123 for PD-L1 and ALA230, HIS283, LYS232, LEU260, LEU278, LEU340 for TGF-βR1. Pharmacophore models are also being built in order to filter even more the results. First the pockets of the different structures were studied to assess the similarity between them and then a pharmacophore based on the similar complexes was built.

The following step will be using molecular dynamics to study the behavior of the biological systems throughout time and evaluate modifications/derivatizations on hit structures that may improve pharmacodynamics/pharmacokinetics.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for supporting this work under the projects PD/BD/145161/2019, EXPL/QUI-OUT/1288/2021, EXPL/MED-QUI/1316/2021, UIDB/04138/2020, and UIDP/04138/2020.

References

1. Z. Cheng, M. Li, R. Dey, Y. Chen, Journal of Hematology and Oncology 2021, doi: 10.1186/s13045-021-01096-0
2. R. C. Acúrcio, S. Pozzi, B. Carreira, M. Pojo, N. Gómez-Cebrián, S. Casimiro, A. Fernandes, A. Barateiro, V. Farricha, J. Brito, A. P. Leandro, J. A. R. Salvador, L. Graça, L. Puchades-Carrasco, L. Costa, R. Satchi-Fainaro, R. C. Guedes, H. F. Florindo, Journal of ImmunoTherapy of Cancer 2022, doi: 10.1136/ jitc-2022-004695
3. N. Krishnamurthy, A. A. Grimshaw, S.A Axson, S. H. Choe, J. E. Miller, BMC Health Services Research 2022, doi: 10.1186/s12913-022-08272-z
4. D. Purohit, M. Makhija, P. Pandey, S. Kumar, S. Kumar, R. Dutt, D. Kaushik, P. Kumar, S. Kumar Journal of Medical Pharmaceutical and Applied Sciences 2022, **11**, 4794-4801.

Using binding pocket similarity to target unexplored proteins for the treatment of lung cancer

Filipe G. A. Estrada*, Natália Aniceto, Rita C. Guedes

Research Institute for Medicines (iMed.ULisboa), Faculdade de Farmácia, Universidade de Lisboa, 1649-003 Lisboa, Portugal
**filipe.estrada@campus.ul.pt*

Introduction: Lung cancer is a leading cause of death in both men and women worldwide. About 1.8 million people die of lung cancer each year and the overall 5-year survival rate is only 15%. Most lung cancers are detected at an advanced stage. While the patient is treated for one cancer, they may develop another one, including lung cancer. In patients with synchronous multiple primary lung cancer (MPLC) and contraindications to surgical treatment, the mean survival time is 31 months, and it is estimated that about 50.8–57.9% of MPLCs have similar histologies.[1]
Increased HIF-1α can initiate tumorigenesis in lung cancer, but by targeting HIF1AN can be downregulated. Therefore, HIF1AN can be considered a promising target in lung cancer treatment.[2]
Since HIF1AN is a target with no known potent active molecules, a combination of in silico methods will be employed. Active site similarity comparison can be used where a target with few-to-no active molecules and can be used as query to find new targets with similar pockets and use their ligands as new candidates for the first target. This sharing of molecules is possible due to the knowledge that, despite being structurally unrelated, targets can share many similarities in their pockets. And with similar pockets they are likely to interact with small molecules in similar ways, which provides important clues for drug discovery.[3] In this work, a similar strategy will be implemented.
Results and discussion: The evaluation of pocket similarities between the pockets of structures available in the PDB for HIF1AN was performed (Figure 1). Even though all structures correspond to the same protein, they can be relatively different, with pocket similarities across them ranging from very low values (0.24) up to perfect similarity (1) and showing varying pocket residues (between 16 and 31).
Conclusion: Even with structures from the same protein it is possible to have low similarity values. Despite that, these values are a good reference to decide which cutoff to apply when searching for similar well-known proteins.

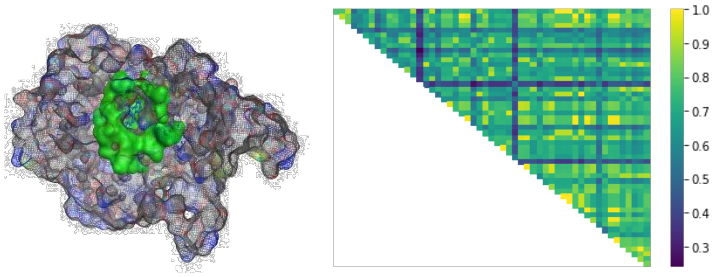


Figure 1: Example of a pocket detected in a PDB structure (green) and heatmap of similarities between the pockets detected in PDB structures of HIF1AN

Acknowledgements
This work was supported by Fundação para a Ciência e a Tecnologia, Portugal, through a PhD fellowship awarded 2022.13497.BD and FCT funding EXPL/QUI-OUT/1288/2021, CPCA/A2/6972/2020, UIDB/04138/2020, and UIDP/04138/2020

References
1. Romaszko AM, Doboszyńska A. Multiple primary lung cancer: A literature review. Adv Clin Exp Med. 2018 May;27(5):725-730. doi: 10.17219/acem/68631
2. Santos, R.M.; Moreno, C.; Zhang, W.C. Non-Coding RNAs in Lung Tumor Initiation and Progression. Int. J. Mol. Sci. 2020, 21, 2774, doi: 10.3390/ijms21082774
3. Miljković, Filip et al., Identifying relationships between unrelated pharmaceutical target proteins on the basis of shared active compounds, Future Science OA Volume 3, NO. 3, doi: 10.4155/fsoa-2017-0037.

P120

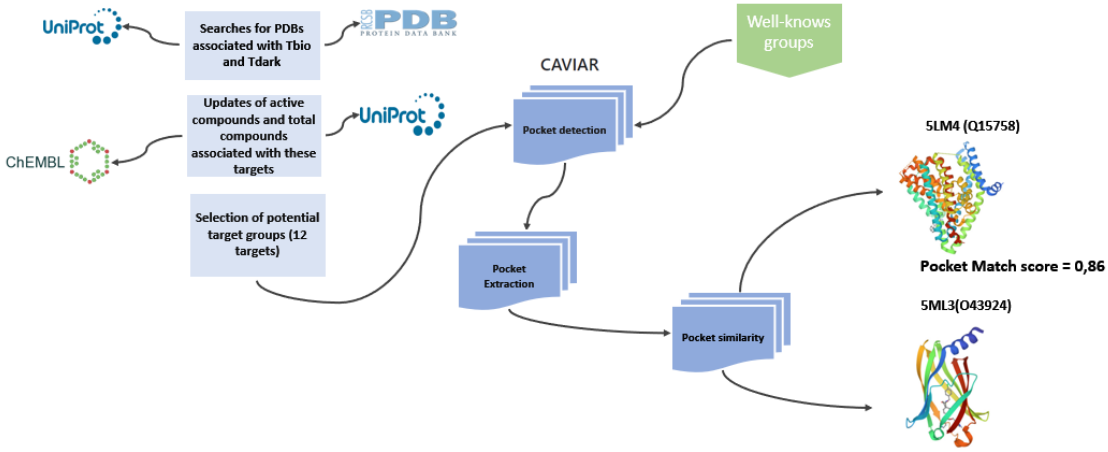
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Drugging the undruggable: Exploring news analyses of protein binding pockets to discover new interesting drug targets

I. Rufino*, B. F. Gomes, N. Aniceto, R. C. Guedes

Research Institute for Medicines (iMed.Ulisboa), Computational Medicinal Chemistry Lab, Faculdade de Farmácia, Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003, Lisboa, Portugal
**ismaelrc198@gmail.com*

Recurrent research in the discovery of new drugs is heavily focused on a small subset of the human proteome (15%). This often arises because researchers focus their efforts on a small set of genes to evade unexplored research paths. This leaves a gap concerning the validation process of new drugs. It is estimated that 85% of disease-associated targets have not yet been well exploited[1]. In this way this previous research performs a series of computational studies with a focus on detecting and analyzing protein binding sites with the aim of discovering new drug targets. To achieve these goals, this project creates three target groups of proteins based on the work by Oprea and collaborators, UniProt, ChEMBL, and Protein Data Bank (PDB) databases. One group contains targets already with approved drugs (or in clinical trials), here classified as Well-Known Targets (WKT). Another group contains targets that are difficult to model that we classify as Difficult to Obtain Pharmacological Effect (DOPE). Finally, the last group contains targets for which no active compounds were found, classified as yet not druggable targets (YNOTs). The analysis involved performing pocket detection for each PDB associated with protein targets. This was achieved using CAVIAR software, which allowed us to identify cavities in each protein, including binding sites[2]. Subsequently, we searched for similarities between the cavities of DOPE targets and the binding sites of targets in the Well-Knowns group using Pocket Match[3] (Scheme 1). The preliminary results using the created platform show that the cavity corresponding to the allosteric center of Excitatory amino acid transporter 1 (EAAT1) exhibited a good similarity score with phosphodiesterase 6 delta subunit (PDE6δ) and was considered the most suitable target candidate for further studies. The YNOTS group was performing in the same way as the DOPE group and for the first results we made a clustering analysis between YNOTS and Well-Knowns. Through these analyses, we intend to discover and propose additional targets and perform additional validation based on virtual screening to filter and identify the best potential compounds according to their affinities with the upcoming new targets.



Scheme 1: Representation of the analysis of DOPE targets

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia (FCT) for financial support EXPL/QUI-OUT/1288/2021, 2022.03752.PTDC, CPCA/A2/6972/2020, UIDB/04138/2020, and UIDP/04138/2020 to iMed.ULisbo

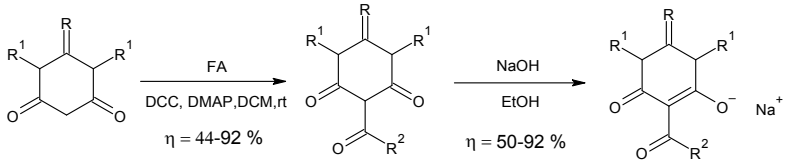
References
1. Oprea, T. I.; Bologa, C. G.; Brunak, S. et al., Nature 2018, 17, 317-332
2. Marchand J.-R., Pirard B., Ertl P. et al., Journal of Computer-Aided Molecular Design 2021, 6, 737-750
3. Yeteru K., Chandra N., BMC Bioinformatics 2001, 1, 1-17

(Thio)barbiturates and fatty acids hybrids against prostate cancer: Synthesis, antiproliferative activity and inhibition of fatty acids intake

S. Dinis[1,3], D. Ferreira[1,3], J. Serrano[1,3], C. Vaz[1], S. Socorro[1], S. Silvestre[1,2,3], P. Almeida[1,3,*]

[1]*CICS-UBI - Health Sciences Research Centre, University of Beira Interior, Covilhã, Portugal*
[2]*CNC - Center for Neuroscience and Cell Biology, University of Coimbra, Coimbra, Portugal*
[3]*Faculty of Sciences, University of Beira Interior, Covilhã, Portugal*
**paulo.almeida@ubi.pt*

Currently, prostate cancer is the third most predominant cancer in men, which motivates intense research on this pathology and on new therapeutic drugs. The deregulation of fatty acid (FA) metabolism has been recognized as a hallmark in carcinogenesis. The major contributor in cell FA uptake is the cluster of differentiation 36 (CD36), which was found overexpressed in several cancers. This motivated the research on the impact of its inhibition on tumoral cells viability.[1] Since both (thio)barbiturates and FA are recognized as two pharmacophoric groups with great versatility as anticancer agents[2], their hybridization has been explored by our research group aiming to develop new agents with potential interest in prostate cancer treatment. Two series of barbiturates were prepared through two different reactions of condensation, followed by a sodium enolate conversion, in good to excellent yields (Scheme 1). Thereafter, *in vitro* evaluation of their antiproliferative effects, caspase-3 activity, and FA uptake inhibition in 3 prostatic cell lines were performed. Moreover, an in-silico study involving molecular docking on CD36 and pharmacokinetics profile evaluation was also accomplished. The analysis of the antiproliferative activity points to 1,3-dimethylbarbituric acid and stearic acid, 1,3-dimethylthiobarbituric acid and stearic acid and 1,3-dimethylbarbituric acid and arachidonic acid as the most promising hybrids (half maximal inhibitory concentrations (IC_{50}) ranging from 1.43 to 43.43 μM for LNCaP, 11.69 to 43.43 μM for PC3 and 10.31 and 256.1 μM to PNT1A cells). To stress the results presented by the last derivative, namely the low-value IC_{50} to both tumoral cell lines (3.88 and 14.31 μM for LNCaP and PC3, respectively) and a selectivity index superior to 15 (PNT1A *versus* LNCaP and PC3 cells). The increase in caspase-3 activity was found especially relevant for the second one hybrid pair. Taking in mind a possible relation between the antiproliferative activity and the inhibition of FA influx effects, the evaluation of FA uptake by the cells was carried out. This study revealed that four hybrid pair derivatives had higher inhibitory activity than the sulfo-*N*-succinimidyl oleate, a very well-known CD36 inhibitor, used as a reference[33]. In fact, IC_{50} values from 4.96 to 17.00 μM were found to 1,3-dimethylbarbituric acid and 11-undecenoic, 1,3-dimethylbarbituric acid and palmitoleic acid and 1,3-dimethythiobarbituric acid and stearic acid. In addition, these three best results were in accordance with the molecular docking predictions. Finally, the in silico ADMET analysis revealed a good profile for these compounds. Regardless the apparent independence between antiproliferative and FA inhibition effects, these (thio)barbiturates and FA hybrids revealed to be very promising candidates to both biological activities.



R = S or O; R^1= H, Me, Et or Ph; R^2 = FACC

Scheme 1: General synthetic route and structures for hybridization of (thio) barbiturates with FA in study. DCC - dicyclohexylcarbodiimide; DMAP - 4-Dimethylaminopyridine; DCM-dichloromethane, FA – Fatty acid; FACC – Fatty acid carbon chain; rt- Room temperature

Acknowledgements
This work was developed within the scope of the CICS-UBI projects UIDB/00709/2020 and UIDP/00709/2020, financed by national funds through the Portuguese Foundation for Science and Technology/MCTES and ProMETAB project - Shaping prostate cell metabolism by extrinsic factors: insights into cancer prevention, diagnosis and treatment (POCI-01-0145-FEDER-029114). The NMR spectrometers are part of the Portuguese NMR Network (PTNMR) and are partially supported by the Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). S. Dinis acknowledges a doctoral fellowship grant, “bolsa de incentivo ao doutoramento” from the “programa plurianual UBI-SANTANDER”.

References

1. J. Wang and Y. Li, *Theranostics*, 2019, **9**, 4893–4908.
2. P. Prasher, M. Sharma, S. P. Singh and D. S. Rawat, *Drug Development Research*, 2021, **82**, 364-373.
3. O. Kuda, T. A. Pietka, Z. Demianova, E. Kudova, J. Cvacka, J. Kopecky and N. A. Abumrad, *Journal of Biological Chemistry*, 2013, **288**, 15547–15555.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

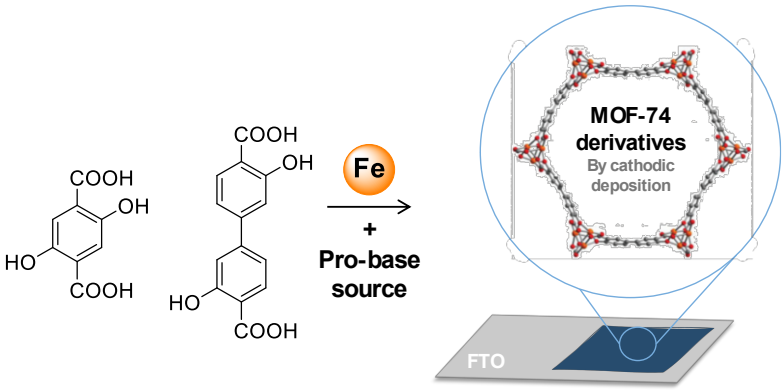
Electrosynthesis of iron-based metal-organic materials

S. Realista[1,*], A. R. Reis[1], V. Corregidor[2], L. C. Alves[2], S. Magalhães[3], A. M. Ferraria[4], A. M. Botelho do Rego[4], P. N. Martinho[1]

[1]*Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Ed. C8, 1749-016 Lisboa, Portugal.*
[2]*C2TN, DECN, E.N.10 (km 139.7), Instituto Superior Técnico, Universidade de Lisboa, 2695-066 Bobadela, Portugal*
[3]*IPFN, Instituto de Plasmas e Fusão Nuclear, Campus Tecnológico e Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Estrada Nacional 10, 2695-066 Bobadela LRS, Portugal*
[4]*BSIRG, iBB - Institute for Bioengineering and Biosciences, Associate Laboratory i4HB - Institute for Health and Bioeconomy, and Chemical Engineering Department at Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal*
**smrealista@ciencias.ulisboa.pt*

New functionalised surfaces are crucial for the development of materials science. Namely, the deposition of materials yielding thin films is urgently needed in all modern technologies.[1] This allows fine-tuning the properties of several common substrates (eg. carbon-based materials, metal oxides, bare metals, etc.) overcoming their intrinsic limitations. Many candidates have been used and among them, metal-organic materials (MOMs) started to attract attention.[2] MOMs, like coordination polymers or their subset metal-organic frameworks (MOFs), are built from the self-assembly of metal ions (nodes) and organic ligands (linkers) offering an infinite number of combinations and properties such as crystallinity, permanent porosity, high surface area and available active sites.[3] Recently, electrochemical techniques have emerged as alternatives for high-quality MOF film formation, with shorter synthesis times under milder conditions and the ability to fine-tune morphology as key advantages.[4]

Here we report the synthesis of two new metal-organic material-based films using the cathodic electrodeposition method using 2,5-dihydroxyterephthalic acid (**DOBDC**) and 3,3'-dihydroxybiphenyl-4,4'-dicarboxylic acid (**BPP**) as the organic linkers and iron(III) as the metal node. When compared with anodic dissolution this method gives the possibility of using non-metal electrode substrates and different metal ions. All the films were characterised by infrared spectroscopy (IR), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), particle-induced X-ray emission (PIXE), Rutherford backscattering spectrometry (RBS) and grazing-Incidence small-angle X-ray scattering (GISAXS). This study allowed us to boost our understanding of the molecular processes at interfaces, enhancing our knowledge to build new and improved functional interfaces.



Scheme 1: Electrosynthesis of the MOMs in this work using different organic linkers.

Acknowledgements
We are grateful to Fundação da Ciência e a Tecnologia, FCT, for Project PTDC/QUI-QIN/0252/2021. Centro de Química Estrutural (CQE) and Institute of Molecular Sciences (IMS) acknowledge the financial support of Fundação para a Ciência e Tecnologia (Projects UIDB/00100/2020, UIDP/00100/2020, and LA/P/0056/2020, respectively). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).
P.N.M. acknowledges FTC for financial support (CEECIND/00509/2017). S.R. acknowledges FTC for financial support (2020.02134.CEECIND).

References
1. T. Ma, J. Zhang, Q. Zhang, Z. Xu, Y. Xiong, Y. Ying, Y. Fe, *Adv. Colloid. Interfac.*, 2023, **311**, 102828.
2. Y. Zhang, C-H. Chang, Processes, 2020, **8**, 377.
3. 3 K. Biradha, A. Ramanan, J. J. Vittal, Cryst. *Growth Des.*, 2009, **9**, 2969.
4. H. Al-Kutubi, J. Gascon, E. J. R. Sudhölter and L. Rassaei, *ChemElectroChem*, 2015, **2**, 462–474.

Study of coffee soluble fibers cholesterol-lowering properties

Fernanda Machado[1,*], Irene Gómez[2], Raul Hurtado Ribeira[2], Diana Martin Garcia[2], María Dolores del Castillo[2], Manuel A. Coimbra[1], Filipe Coreta-Gomes[1,3]

[1]LAQV-REQUIMTE, Chemistry Department, University of Aveiro, 3810-193 Aveiro, Portugal
[2]Instituto de Investigacion en Ciencias de la Alimentacion, CSIC-UAM, Nicolas Cabrera 9, 28049 Madrid, Spain
[3]Coimbra Chemistry Centre - Institute of Molecular Sciences (CQC-IMS), Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal
**fernandamachado@ua.pt*

Cholesterol related diseases are responsible for high levels of death and impairment worldwide.[1] Coffee soluble dietary fibers (DF), mainly composed by polysaccharides (galactomannans and arabinogalactans) and melanoidins, have shown cholesterol-lowering properties. The hypocholesterolemic property associated with these high molecular weight compounds is thought to be due to: a) bile salt sequestration capacity, decreasing cholesterol solubilization and absorption[2,3], and b) the conversion of primary bile salts into secondary, a process that depends on the gut microbiota composition.[4] These secondary bile salts are more hydrophobic and prone to solubilize cholesterol.[5] Additionally, they exhibit enhanced enterohepatic recirculation due to their greater ability to permeate lipid membranes.[6] Given their increased hydrophobicity when compared to primary ones, secondary bile salts can establish a better interaction with coffee fibers, increasing their excretion.[7]
In this work, the impact of coffee and its DF (melanoidins and arabinogalactans) on cholesterol bioaccessibility was evaluated in an *in vitro* intestinal model. Microbial fermentation of these fibers was also addressed to gain insight on their effect on bile salt biotransformation.
Arabinogalactans and melanoidins decreased cholesterol bioaccessibility to about 50%. Regarding bile salts biotransformations, primary bile salt content decreased while secondary increased after 48h fermentation of these fibers, being significantly higher (p<0.05) in the arabinogalactans sample when compared to melanoidins. The diminished presence of secondary bile salts in the enterohepatic circulation due to the coffee fiber action, contribute to decrease micelles efficiency to solubilize cholesterol, supporting their hypocholesterolemic potential.
This study suggests that coffee soluble dietary fibers have cholesterol-lowering properties, acting through different mechanisms, and with potential to reduce the risk of chronic diseases associated to cholesterol.

Acknowledgements
To Fundação para a Ciência e a Tecnologia (FCT)/MCTES support to the research units LAQV-REQUIMTE (UIDB/50006/2020, UIDP/50006/2020), and by the project PTDC/QUI-OUT/29373/2017 through national funds (OE), including Filipe Coreta-Gomes research contract, being co-financed by the FEDER by the Operational Program of Competitiveness and Internationalization (POCI), within the PT2020 Partnership Agreement. Fernanda Machado acknowledges FCT for her PhD fellowship (2020.06768.BD). NMR data was collected at the UC-NMR facility supported in part by FEDER – European Regional Development Fund through the COMPETE Programme (Operational Programme for Competitiveness) and by National Funds through FCT through grants RECI/QEQ-QFI/0168/2012, CENTRO-07-CT62-FEDER-002012, and also through support to Rede Nacional de Ressonância Magnética Nuclear (RNRMN) and to Coimbra Chemistry Centre through grant UID/QUI/00313/2019. This work was also supported by the project COFFEE4BGA (PID2019-111510RB-I00).

References
1. Beltowski, J., Wojcicka, G. & Jamroz-Wisniewska, A. *Curr. Drug Saf.* 2009, 4, 209–228.
2. Coreta-Gomes, F. M. *et al*. *Nutrients* 2020, 12, 437.
3. Pires, C. L., Silva, I. M. V., Coimbra, M. A., Moreno, M. J. & Coreta-Gomes, F. *Foods* 2022, 11, 2935.
4. Sivamaruthi, B. S., Fern, L. A., Rashidah Pg Hj Ismail, D. S. N. & Chaiyasut, C. *Biomedicine and Pharmacotherapy* 2020, 128, 110310.
5. Coreta-Gomes, F. M., Vaz, W. L. C. C., Wasielewski, E., Geraldes, C. F. G. G. & Moreno, M. J. *Langmuir* 2016, 32, 4564–4574.
6. Coreta-Gomes, F. M. *et al. Langmuir* 2015, 31, 9097–9104.
7. Iaccarino, N. *et al*. *Food Funct.* 2020, 11, 514–523.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Impact of deposition rate on the morphology of pure and mixed ionic liquid films via thermal evaporation

Rita M. Carvalho[1,*], Soraia R. M. R. Silva[1], Cândida G. Neto[2], Luís M. N. B. F. Santos[1], Margarida Bastos[1], José C. S. Costa[1]

[1] *CIQUP, Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry, Faculty of Science, University of Porto, Portugal*
[2] *Faculty of Science, University of Porto, Porto, Portugal*
**201706341@edu.fc.up*

Ionic liquids (ILs) have garnered considerable interest within the scientific community due to their unique properties, in special their wetting behavior at the mesoscopic level, which holds great potential for impacting various scientific fields and technologies[1-4]. Notably, ILs exhibit distinct characteristics when exposed to vacuum conditions[4]. This research aims to investigate the influence of deposition rate on the nucleation and growth of IL films fabricated through vacuum thermal evaporation[5]. We examined four ILs comprised of an alkylimidazolium cation ($C_nC_1$im) paired with either bis(trifluoromethylsulfonyl)imide (NTf_2) or triflate (OTf) as the anion. The deposition was performed on indium tin oxide (ITO) and silver (Ag) surfaces. Additionally, the research focuses on the co-evaporation of two ILs, namely [C_2C_1im][OTf] and [C_8C_1im][OTf], with variations in the film composition and thickness. The ionic liquid mixture film was obtained through simultaneous evaporation of pure ILs using a customized physical vapor deposition (PVD) technique[6-7], based on the Knudsen effusion system, enabling precise control of the mass flow rate. Scanning electron microscopy (SEM) was utilized to analyze the morphology of the films.

Changes in the mass flow rate had a significant impact on the wettability of the investigated substrates by the pure ILs. In particular, the results demonstrate that an increase in the deposition rate resulted in a more pronounced droplet coalescence mechanism on the ITO surface, indicating enhanced surface diffusion of the ion pairs. Conversely, the influence of Ag surfaces was minimal due to the strong adhesion between ILs and metallic films. Long-chain ILs deposited on the ITO surface exhibited an intensified coalescence mechanism, regardless of the deposition rate[5]. Moving on to the ionic liquid mixtures, we investigated the adsorption, nucleation, and growth of films containing varying proportions of C_2C_1im and C_8C_1im. Our findings revealed that an enrichment of C_8C_1im in the mixture enhanced droplet coalescence mechanisms on ITO surfaces. These findings open up possibilities for targeted applications of ionic liquid films and present new avenues for fundamental scientific inquiries.

Acknowledgments
The authors thank the Fundação para a Ciência e a Tecnologia (FCT) for financial support to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), and IMS-Institute of Molecular Sciences (LA/P/0056/2020), Faculty of Science, University of Porto.

References

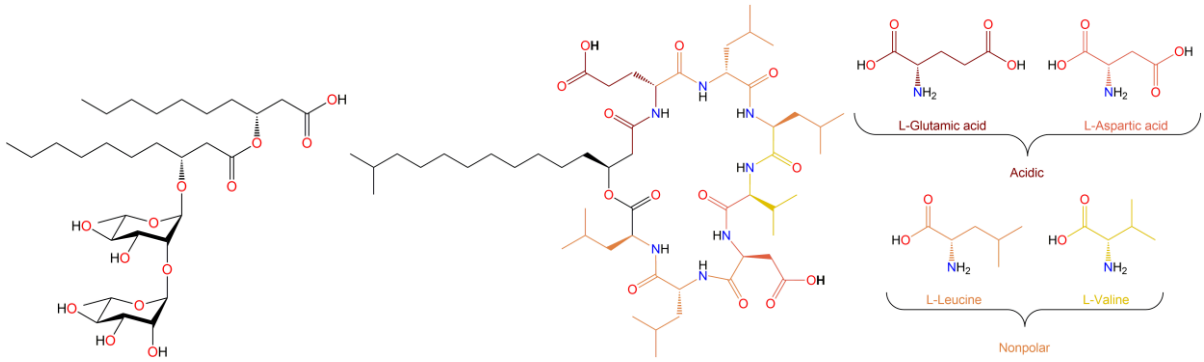
1. M. Lexow, F. Maier and H.-P. Steinrück, *Advances in Physics: X*, 2020, **5**, 1761266.
2. J. C. S. Costa, A. Alves, M. Bastos and L. M. N. B. F. Santos, *Physical Chemistry Chemical Physics*, 2022, **24**, 13343–13355.
3. M. S. M. Teixeira, L. M. N. B. F. Santos and J. C. S. Costa, *Colloids and Interfaces*, 2022, **6**, 46.
4. Y. Matsumoto, Molecules, 2023, **28**, 1991.
5. R. M. Carvalho, C. Neto, L. M. N. B. F. Santos, M. Bastos and J. C. S. Costa, *Fluids,* 2023, **8**, 105.
6. J. C. S. Costa, M. A. L. Lima, A. Mendes and L. M. N. B. F. Santos, *RSC Advances*, 2020, **10**, 11766–11776.
7. J. C. S. Costa, A. Mendes and L. M. N. B. F. Santos, *ChemPhysChem*, 2016, **17**, 2123–2127.

Ionic liquids and salts based on rhamnolipid and surfactin as biosurfactants

C. V. Esteves[1,2,*], Ž. Petrovski[1], D. M. G. Freire[3], L. C. Branco[1]

[1]*LAQV-REQUIMTE, Chemistry Department, NOVA School of Science and Technology, NOVA University of Lisbon, 2829-516 Caparica, Portugal*
[2]*Departamento de Engenharia Química e Biológica, Escola Superior de Tecnologia do Barreiro, Instituto Politécnico de Setúbal*
[3]*Department of Biochemistry, Universidade Federal do Rio de Janeiro, Rio de Janeiro 21941-909, Brazil*
**cav.esteves@fct.unl.pt*

Surfactants (**surf**ace **act**ive **a**ge**nts**) have dual characteristics of hydrophilicity and hydrophobicity which lead them to concentrate at interfaces as well as to aggregate into several supramolecular architectures rendering them unique properties.[1]
The possibility to explore the surfactant properties in combination with ionic liquids (ILs) has gained significant attention in recent years.[2]
ILs are organic salts with melting points below 100 ºC, which can be tailor-made and are factually both old and new, as the first was discovered in 1914, but have flourish in the last decades.[3]
Recent biosurfactants, produced by microbial strains, such as rhamnolipids (glycolipids with L-rhamnose and β-hydroxy fatty acids, Figure 1a)[4,5] and surfactins (cyclic lipopeptides, Figure 1b)[5], will be explored as potential ILs for enhanced solubility, catalysis, pharmaceutical and green chemistry approaches. In this communication, new biosurfactin based ILs have been prepared using sustainable processes and then characterized by different spectroscopic techniques in order to evaluate the expected chemical structure, cation-anion proportion as well as final purities.



a) b)

Figure 1: Chemical structures of a) rhamnolipid and b) surfactin.

Acknowledgements
The authors thank the support from FCT/MCTES (UIDB/50006/2020, LA/P/0008/2020 and UIDP/50006/2020 of the Associate Laboratory for Green Chemistry – LAQV) and the PRR INSECTERA Project funded by a Program-Contract of Financing of the Recovery and Resilience Plan (PRR). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by the Infrastructure Project N° 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). CVE thanks Researcher Development and Travel Grant from the Royal Society of Chemistry (application number D23-5488528708).

References
1. D. Möbius, R. Miller, V.B. Fainerman, Surfactants: Chemistry, Interfacial Properties, Applications, Elsevier Science, Amsterdam, 2001.
2. F. Faísca, L. Filipe, Ž. Petrovski, M.M. Santos, S. Gago and L.C. Branco, Surfaces, 2021, **4**, 169–190.
3. B.K. Paul, S.P. Moulik, Ionic Liquid-Based Surfactant Science: Formulation, Characterization, and Applications, John Wiley & Sons, New Jersey, 2015.
4. R.S. Reis, A.G. Pereira, B.C. Neves and D.M.G. Freire, Bioresour. Technol., 2011, **102**, 6377–6384.
5. L.V. de Araujo, C.R. Guimarães, R.L.S. Marquita, V.M.J. Santiago, M.P. de Souza, M. Nitschke and D.M.G. Freire, Food Control, 2016, **63**, 171–178.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Revisiting the nitrobenzene scaffold for cancer therapy

Ivo Cruz*, Hélio M. T. Albuquerque, Artur M. S. Silva, Joana L. C. Sousa

LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**ivo.silv@ua.pt*

Cancer therapy has been facing new approaches to minimize side effects in healthy cells and maximize the drugs efficiency. One of these approaches is epigenetic therapies and, among those, histone deacetylase inhibitors (HDACi) have been gathering more and more adepts, because of their oncosupressing potential. Despite of the recent advances in HDACi, they are still limited in terms of selectivity and diversity.[1,2] In that sense, this work aimed at developing novel HDACi, using nitro group-containing scaffolds, specifically nitrobenzene derivatives. The starting point was the nitrobenzene **1a**,[3] which has previously shown a considerable HDAC inhibitory potential. Afterwards, some structural alterations in this lead compound were done to establish a preliminary structure-activity relationship (SAR). Essentially, three points were evaluated (Figure 1): (i) the influence of the nitro group position (nitrobenzene **1b**), (ii) the flexibility of the linker side chain (chalcone **2**) and (iii) the effect of the hydroxy group in the complexation of Zn^{2+} (flavone **3**). The obtained SAR profile will be presented and discussed in this communication.

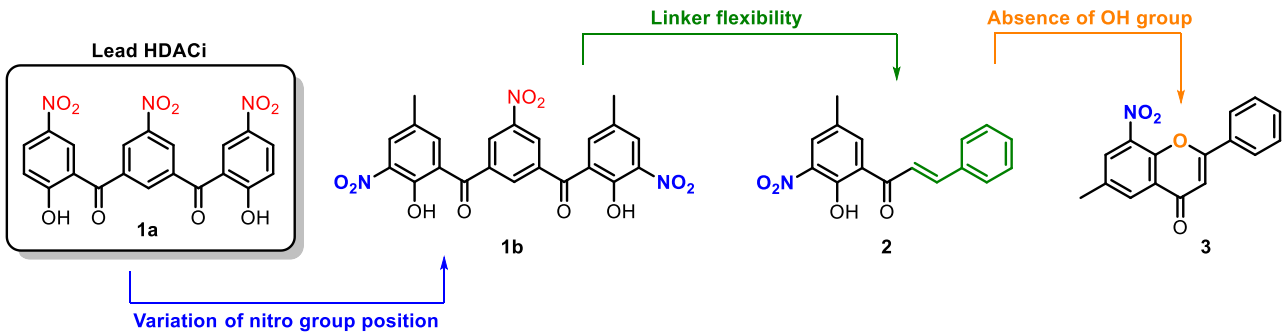


Figure 1: Chemical structures of the synthesized nitrobenzenes **1a,b**, chalcone **2** and flavone **3**, screened as HDACi.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), as well as the Portuguese NMR Network. Hélio Albuquerque gratefully acknowledges MuTaTher-AD project – "Multi-target theranostics for Alzheimer's disease" (2022.06064.PTDC) for his researcher contract. Joana Sousa gratefully acknowledges LAQV-REQUIMTE for her researcher contract.

References
1. T. C. S. Ho, A. H. Y. Chan and A. Ganesan, *J. Med. Chem.*, 2020, **63**, 12460−12484.
2. S. Geurs, D. Clarisse, K. De Bosscher and M. D'hooghe, *J. Med. Chem.*, 2023, DOI: 10.1021/acs.jmedchem.3c00226.
3. T. N. Francisco, J. L. C. Sousa, S. Guieu, A. M. S. Silva and H. M. T. Albuquerque, *Synlett*, 2022, **33**, 1505−1510.

Potential of bioactive natural compounds from *Pinus pinea* L. value chain for plant protection

Élia Fogeiro[1], Dulcineia F. Wessel[1,2,3], Susana M. Cardoso[1,*]

[1]*LAQV-REQUIMTE, Departamento de Química, Universidade de Aveiro, 3810-193 Aveiro, Portugal*
[2]*Escola Superior Agrária, Instituto Politécnico de Viseu, 3500-606 Viseu, Portugal*
[3]*CITAB, Universidade de Trás-os-Montes e Alto Douro, 5001-801 Vila Real, Portugal*
**susanacardoso@ua.pt*

Pinus pinea L. is one of the most relevant forest formations in the Mediterranean region, accounting for 960,000 hectares occupied in 2017[1]. The most important source of income provided by this species comes from its seeds, ie pine nuts, while other products - needles, bark, cones, nut shells and resin – are commonly used in low value applications such as energy production. These agroforestry by-products can be used as a cost-effective source of added-value compounds, once previous studies have shown their richness in terpenes, tannins, sterols and phenolic compounds.

In the scope of the United Nations Sustainable Development Goals and the European Green Deal, the European Commission has adopted a set of proposals aiming to restore damaged ecosystems and build more sustainable food production systems, including halving pesticide use by 2030[2]. With this issue in mind, the research in this field is moving towards focusing on the search for natural compounds and management methods as alternatives to conventional pesticides. Bioactive natural products have gained interest in recent years due to their potential target specificity, less harmful effects on non-target organisms and ease to disintegrate.

P. pinea value chain products have in their composition important compounds, namely phenolic compounds and mono-, di- and sesquiterpenes, particularly limonene, α- and β-pinene, germacrene-D and β-phellandrene, with demonstrated pesticidal properties[3]. Other minor constituents, such as myrcene, caryophyllene, and particularly, α-cadinol also exhibit very significant anti-fungal activities[3, 4]. Thus, it is pertinent to deepen the investigation in the potential of *P. pinea* extracts and essential oils to be used as alternative to traditional pesticides.

Acknowledgements
This work received support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020. The authors are grateful for funding from the Forest4Future project - PP21 - Valorization of pine and pine nuts in the Centro Region CENTRO-08-5864-FSE-000031. EF thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) for her PhD grant ref. 2021.08009.BD.

References

1. S. Mutke, C. Guadaño, S. Iglesias, D. Leon, S. Arribas, J. Gordo, L. Gil and G. Montero, in *Mediterranean pine nuts from forests and plantations*, eds. S. Mutke, I. Carrasquinho and A. C. Correia, Zaragoza : CIHEAM, 2017, vol. 122, pp. 71-75.
2. E. Commission, *Farm to Fork Strategy - For a fair, healthy and environmentally-friendly food system*, 2020.
3. I. Amri, S. Gargouri, L. Hamrouni, M. Hanana, T. Fezzani and B. Jamoussi, *Journal of Pest Science*, 2012, **85**, 199-207.
4. S.-S. Cheng, C.-L. Wu, H.-T. Chang, Y.-T. Kao and S.-T. Chang, *Journal of Chemical Ecology*, 2004, **30**, 1957-1967.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Fabrication of bifunctional flexible electrochromic supercapacitors based on electrically-conductive polymer and MWCNTs

Gabriela P. Queirós[1,*], André M. Pereira[2], Clara R. Pereira[1]

[1]*REQUIMTE/LAQV, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal*
[2]*IFIMUP – Institute of Physics for Advanced Materials, Nanotechnology and Photonics, Department of Physics and Astronomy, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal*
**up201304097@up.pt*

There is a growing concern about the excessive use of fossil fuels and the need for more environmentally-friendly energy alternatives. Supercapacitors are a promising energy storage solution due to their long cycle life, high power density and fast charging. A present challenge relies on the development of multifunctional supercapacitors with sensing properties for real-time monitoring of energy consumption. Electrochromic supercapacitors (ECSCs) are emerging versatile bifunctional devices that integrate the energy storage functionality with the ability to reversibly change color under an applied potential[1].
In this work, flexible ECSC devices were developed on a flexible plastic substrate (indium tin oxide on polyethylene terephthalate) using the electrically-conductive electrochromic polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) and multiwalled carbon nanotubes (MWCNTs) as electrode materials. The devices were assembled using a Li-based gel polymer electrolyte, which has high ionic conductivity, flexibility and enables reaching a wider potential window, making it suitable for flexible substrates, unlike liquid electrolytes that operate at smaller potential windows[2].
The electrochemical performance of the ECSCs was evaluated by electrochemical impedance spectroscopy, cyclic voltammetry and galvanostatic charge/discharge measurements and the electrochromic performance was evaluated by UV-Vis spectroelectrochemical measurements.
The flexible ECSC devices efficiently changed color from colorless to dark blue by application of -1.5/1.5 V potentials besides storing energy.
This research enabled the development of flexible devices with supercapacitive and electrochromic features, being a promising solution for wearable electronics applications, such as healthcare monitoring and flexible electronic displays[3].

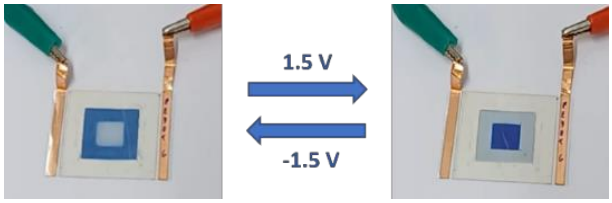


Figure 1: ECSC prepared with PEDOT:PSS as electrode material and gel polymer electrolyte.

Funding
This work was financially supported by Portuguese funds through Fundação para a Ciência e a Tecnologia (FCT)/MCTES in the framework of the projects UIDB/50006/2020, UIDP/50006/2020 and LA/P/0008/2020.

Acknowledgements
Work supported by Portuguese funds through FCT/MCTES in the framework of projects PTDC/CTM-TEX/4126/2021, UIDB/04968/2020 and UIDP/04968/2020. GQ thanks FCT for the PhD scholarship (UI/BD/151274/2021). CRP thanks FCT for funding through Individual Call to Scientific Employment Stimulus (2021.04120.CEECIND/CP1662/CT0008).

References
1. Z. Zhao, K. Xia, Y. Hou, Q. Zhang, Z. Ye and J. Lu, *Chemical Society Reviews*, 2021, **50**, 12702-12743.
2. M. Kotobuki, in *Polymer Electrolytes: Characterization Techniques and Energy Applications*, ed. A. K. A. TanWinie, and Sabu Thomas, by Wiley-VCH Verlag GmbH & Co. KGaA, 2020.
3. Z. Lu, X. Zhong, X. Liu, J. Wang and X. Diao, *Physical Chemistry Chemical Physics*, 2021, **23**, 14126-14145.

Antimicrobial and anti-inflammatory activity of an extract of *Arrabidaea brachypoda* containing dimeric flavonoids

I. Lopes[1,2*], C. Campos[2], R. Gil da Costa[2,3] C. da Rocha[4], H. Brito[4], F. Silva[5], E. Pinto[6], R. Medeiros[2,7], F. Cerqueira[2,7]

[1]School of Health Polytechnic Institute of Porto, Rua Dr. António Bernardino de Almeida, 400 4200 - 072, Porto, Portugal; [2]Molecular Oncology and Viral Pathology GRP—IC, Portuguese Institute of Oncology of Porto (IPO Porto), Rua António Bernardino de Almeida, 4200-072 Porto, Portugal; [3]Pos-Graduate Program in Adult Health, Federal University of Maranhão, São Luis 65080-805, MA, Brazil; [4]Chemistry Department, Federal University of Maranhão, São Luis 65080-805, MA, Brazil [5]Department of Pharmaceutical Technology, Faculty of Pharmacy of the University of Coimbra, University of Coimbra, Coimbra, Portugal; REQUIMTE/LAQV, Group of Pharmaceutical Technology, Faculty of Pharmacy of the University of Coimbra, University of Coimbra, Azinhaga de Santa Comba 3000-548, Coimbra, Portugal; [6]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), University of Porto, 4450-208 Matosinhos, Portugal and Laboratory of Microbiology, Biological Sciences Department, Faculty of Pharmacy of University of Porto, 4050-313 Porto, Portugal [7]FP-I3ID, FP-BHS, Universidade Fernando Pessoa, Praça 9 de Abril, 349, 4249-004 Porto, Portugal
**10170389@ess.ipp.pt*

Plants from *Arrabidaea* genus are used in folk medicine.[1] Previously, we reported the effect of dimeric flavonoids obtained from the roots of *Arrabidaea brachypoda* against protozoa from Trypanosomatidae family.[1,2] In this work the antifungal and antibacterial activity of an aqueous ethanol extract and its nonpolar fraction were tested. Neither the extract nor the nonpolar fraction was active against the yeasts (*Candida albicans* ATCC 10231, *C. krusei* ATCC 6258 and *Cryptococcus neoformans* CECT 1078) or Gram-negative bacteria (*Escherichia coli* ATCC 25922), even in the maximum concentration tested (1024μg/ml). However, both inhibited the growth of Gram-positive bacteria *Staphyloccocus aureus* ATCC 29213. The nonpolar fraction was more active than the extract (Minimal Inhibitory Concentration - MIC of 27 ± 5 and 128 ± 0 μg/ml, respectively) and, for MIC values, its effect seems to be bacteriostatic. Preliminary results showed that the nonpolar fraction of the extract, for concentrations near MIC values, inhibited RAW264.7 macrophages Nitric Oxide (NO) production (Griess Assay) and seems not significantly affect the viability (MTT assay) of the Primary Dermal Human Fibroblast (HDF) cell line. In conclusion, the nonpolar fraction of the hydroethanolic extract of *Arrabidaea brachypoda* containing dimeric flavonoids has antibacterial activity, as it inhibits the growth of *S. aureus* methicillin sensitive strain (MSS) ATCC 29213. Also, and based on preliminary results, by inhibiting NO production the fraction has potential anti-inflammatory activity without significant cytotoxicity against HDF cell line. All these results highlight the possible antimicrobial and anti-inflammatory activity of the fraction containing dimeric flavonoids, so the effect of isolated compounds should be tested.

Acknowledgements
We thank the: Faculty of Health Sciences of Fernando Pessoa University, Portuguese Institute of Oncology of Porto, CAPES - finance code 001; National funds through FCT within the scope of Base Funding UIDB/04423/2020 and UIDP/04423/2020 (Group of Marine Natural Products and Medicinal Chemistry - CIIMAR).

References

1. C.Q. da Rocha, E.F. Queiroz, C.S. Meira, D. R. Moreira, M. B. Soares, L. Marcourt, W. Vilegas and J.L. Wolfender. J Nat Prod. 2014, **77,** 1345-1350.
2. V.P.C. Rocha, C. Q. da Rocha, E. F. Queiroz, L. Marcourt, W. VilegasG.B. Grimaldi, P. Furrer, E. Allémann, J.L. Wolfender and M.B.P.Soares. Molecules, 2018, **24**:1. doi: 10.3390/molecules24010001.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

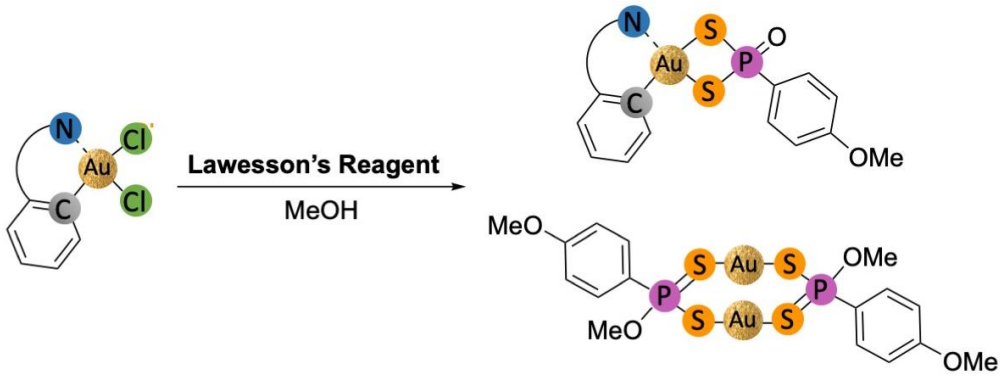
Reaction of (C^N)-cyclometallated gold(III) with Lawesson reagents: synthesis of dithiophosphonate gold(III) and gold(I) complexes.

Humberto Rodríguez-Solla*, Paula Pérez-Ramos, David Elorriaga, Raquel G. Soengas

Departamento de Química Orgánica e Inorgánica, Facultad de Química, Universidad de Oviedo, Julián Clavería 8, 33006 Oviedo, Spain
**hrsolla@uniovi.es*

Thiophosphorus ligands represent an important class of S-donor ligands that can exhibit a variety of coordination patterns. Metal complexes of organo-thiophosphorous ligands have been extensively investigated due to their industrial value as lubricants and additives and also for their biological properties.[1] Several examples have been reported showing that the formation of thiophosphorous metal complexes can be achieved by direct cleaving of dimeric structure of Lawesson's reagent (LR) with metal salts or complexes.[2] As an alternative, LR can be opened to the corresponding dithiophosphonate ligands, isolated as the corresponding ammonium salts. This strategy was explored for the synthesis of dithiophosphonate Au(I) complexes with interesting luminescent properties.[3] However, Au(III) remains elusive to this chemistry, probably due to its inherent character to undergo easy reduction to Au(0). In this regard, cyclometallated Au(III) complexes usually display enhanced stability in contrast to other classic ligands. On other hand, cyclometalated gold(III) complexes have a wide range of applications, including the development of opto-electronic devices and metal-based drugs.[4] Among them, cyclometallated (C^N)Au(III) complexes are particularly relevant due to their straightforward synthesis and the wide range of ancillary ligands tolerated.[5] Therefore, cyclometallated Au(III) containing organo-thiophosphorous ligands have potential wide-ranging applications.

Herein we report the direct reaction of a family of cyclometallated (C^N)Au(III) complexes with Lawesson's reagent (LR), to afford novel Au(III) and Au(I) dithiophosphonate complexes. To the best of our knowledge this is the first reported synthesis of gold(I) and gold(III) complexes from the direct cleavage of LR and provides a valuable addition to the few examples of gold complexes containing organo-thiophosphorous ligands (Scheme 1).



Scheme 1: Ring opening of Lawesson's reagent with (C^N)-cyclometallated Au(III) complexes

Acknowledgements
This work has received financial support from the Principado de Asturias (FICYT AYUD/2021/51542), MINECO (PID2019-109253RB-I00), Instituto de Salud Carlos III (PI22/00148) and the European Union (European Regional Development Fund-ERDF). Partial financial support by Arcelor Mittal (R&D-Principado de Asturias; FUO-22-130) is gratefully acknowledged. P.P.R. thanks Principado de Asturias for a predoctoral contract (Programa Investigo, AYUD/2022/9313).

References

1. S. Kumar, A. Syed, S. Andotra, R. Kaur and S. K. Pandey, J. Mol Struct., 2018, 1154, 165.
2. M. C. Aragoni, M. Arca, F. Demartin, F. A. Devillanova, C. Graiff, F. Isaia, V. Lippolis, A. Tiripicchio, G. Verani, Eur. J. Inorg. Chem., 2000, 2239.
3. W. E. van Zyl, J. M. López de Luzuriaga, A. A. Mohamed, R. J. Staples, J. P. Fackler, Inorg. Chem., 2002, 41, 4579
4. C. Ratia, R. G. Soengas, S. M. Soto, Front. Microbiol., 2022, 13, 846959.
5. M. R. M. Williams, B. Bertrand, D. L. Hughes, Z. A. E. Waller, C. Schmidt, I. Ott, M. O'Connell, M. Searcey, M. Bochmann, Metallomics, 2018, 10, 1655.

Fostering the combined anticancer/antibacterial activity of silver camphorimine composites

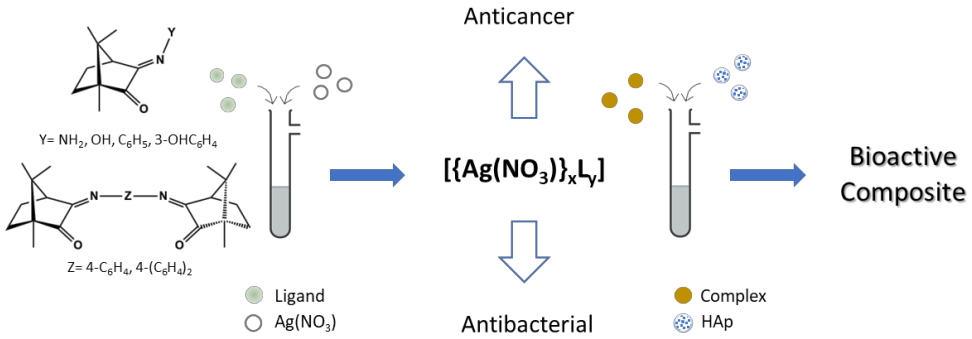
Joana P. Costa[1], Silvia A. Sousa[2], Jorge H. Leitão[2], Fernanda Marques[3], Marta M. Alves[1,*], M. Fernanda N. N. Carvalho[1,*]

*[1]Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa [2]Department of Bioengineering, IBB-Institute for Bioengineering and Biosciences, Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal and Associate Laboratory, i4HB-Institute for Health and Bioeconomy, Instituto Superior Técnico, University of Lisbon; [3]C2TN - Centro de Ciências e Tecnologias Nucleares, Instituto Superior Técnico, Universidade de Lisboa *fcarvalho@tecnico.ulisboa.pt and martamalves@tecnico.ulisboa.pt*

Osteosarcoma is one of the most common bone cancers whose treatment typically involves surgery and chemotherapy.[1] Although the mortality directly associated with osteosarcoma is not very high, chemotherapy resistance and pulmonary metastasis are responsible for a low survival rate.[2,3] Despite the clinical benefits of surgery and additional chemotherapy, the prognosis is often poor not only due to the resistance to chemotherapy and metastasis appearance but also because is compromised by opportunist infections taking advantage of the depleted immune system of oncologic patients.

Bone filling and/or bone revetement by bioactive materials with combined anticancer and antimicrobial activities could be highly beneficial to face such a threat. Focused on that purpose a survey on the anticancer and antibacterial properties of silver camphorimine complexes was conducted to prepare biocompatible, bioresorbable and/or biodegradable materials with combined anticancer and antibacterial properties.

The choice of coordination rather than organic compounds is based on their distinct properties and alternative mechanisms of action that might overcome some resistance mechanisms. With these in mind the biological activity of silver complexes ([{Ag(NO_3)}$_x$L$_z$]) based on camphor or bicamphor imine ligands were assessed. The complexes revealed high antimicrobial activity towards *Escherichia coli*, *Staphylococcus aureus*, *Burkholderia contaminans* and *Pseudomonas aeruginosa* strains.[4,5] The new data concerning their anticancer activity against human HOS osteosarcoma cells showed they combine both types of activities. A selection of the most promising anticancer/antibacterial complexes were used to prepare hydroxyapatite (HAp) composites. Some complexes are multifunctional, adding to their biological activity the ability for being used as binding agents. To optimize the range of composition at which the silver complex composites are effective different complex/HAp ratios were used. The results obtained until now show that the composites do not lose significantly activity compared with the precursor silver camphorimine complexes.



Scheme 1: Synthesis of complexes with combined activity using the represented camphor type ligands and Ag(NO_3). Synthesis of bioactive composite with the previous synthesized complexes and HAp.

Acknowledgements
We thank the Fundação para a Ciência e Tecnologia (FCT projects: UIDB/00100/2020, UIDP/00100/2020, UIDB/04565/2020, UIDP/04565/2020 and UID/Multi/04349/2019), Institute of Molecular Sciences (project LA/P/0056/2020), Institute for Bioengineering and Biosciences (LA/P/0140/2020) and the PhD Grant to Joana Costa (UI/BD/152244/2021).

References

1. K. Michalakis, A. Bakopoulou, E. Papachristou, D. Vasilaki, A. Tsouknidas, N. Michailidis, E. Johnstone, BioMed Research International, 2021, 5013065.
2. V.L. Tippett, L. Tattersall, N.B.A. Latif, K.M. Shah, M.A. Lawson, A. Gartland, 2022, Oncogene, 42:259-277.
3. A. Smrke, P.M. Anderson, A. Gulia, S. Gennatas, P.H. Huang, R.L. Jones, Cells, 2021, 10, 172
4. J.P. Costa, S.A. Sousa, A.M. Galvão, J.M. Mata, J.H. Leitão, M.F.N.N. Carvalho, Antibiotics, 2021, 10, 135.
5. J.M.S. Cardoso, S.I. Guerreiro, A. Lourenço, M.M. Alves, M.F. Montemor, N.P. Mira, PLoS ONE, 2017, 12(5):e0177355.

P132

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Green electrolytes for technological applications

S. Cerqueira[1,*], M. Mota[1], T. A. G. Duarte[2], M. M. Silva[1], V. de Zea Bermudez[2], R. F. P. Pereira[1]

[1]*Chemistry Center and Chemistry Department, University of Minho, Campus de Gualtar, 4710 - 057, Braga, Portugal*
[2]*Chemistry Department and CQ-VR, University of Trás-os-Montes e Alto Douro, Apartado 1013, 5001-801 Vila Real, Portugal*
**xana@quimica.uminho.pt*

Nowadays, it is the pursuit of the materials science community to implement sustainable materials in all fields of applications. It is expected that materials encompass properties like high abundance in nature; low cost; eco-friendliness; recyclability and suitable properties for the envisaged application.
In this sense, we propose herein the development of novel electrolytes for electrochemical devices, based on a natural polymer, the cellulose derivative hydroxypropylmethylcellulose (HPMC), doped with green ionic liquids (ILs), 1-Butyl-3-methylimidazolium chloride ([Bmim]Cl) and 1-Methyl-3-n-octylimidazolium Trifluoromethanesulfonate ([SBmim][Trif]). But why were these specific base materials selected?
HPMC is a water-soluble non-ionic cellulosic polymer, in which some of the hydroxyl groups were replaced by methyl (-CH_3) and hydroxypropyl (-$CH_2CH(OH)CH_3$) groups.[1] The degree of substitution (defined as the average number of etherified hydroxyl groups in a glucose unit) can be controlled to a certain extent, in order to obtain this cellulose derivative with a given solubility and viscosity in water solutions.[2] This cellulosic is a thermoreversible (gel point at 85.2 °C),[3,4] thermally stable (below 300 °C)[5], water-soluble, biodegradable, biocompatible and environment-friendly polymer,[2] thus an excellent candidate as the base polymer for electrochemical devices.
The imidazolium ILs chosen are energy-efficient green compounds, non-flammable, with high thermal stability, wide electrochemical window, and high electrical conductivity.[6] All these properties turn these ILs attractive into potential components in ionic conductive matrices.
Thus, the developed electrolytes were designated as HPMC:ILs (x%), where x stands for the percentual weight ratio between the polymeric matrix and the ILs mixture ([Bmim]Cl:[SBmim][Trif] (10:1, w:w)).
The HPMC:ILs (x%) electrolytes were extensively characterized in terms of optical (UV-Vis spectroscopy), structural (FTIR-ATR spectroscopy), thermal (differential scanning calorimetry (DSC)) and conducting properties (electrochemical impedance spectroscopy (EIS)). The electrolytes produced are highly transparent, presenting transmittance values in the visible region ranging from 93 to 89 %, for the HPMC matrix and for the highly doped electrolyte (HPMC:ILs (200%)), respectively. The FTIR-ATR studies evidenced that the incorporation of the ILs into the HPMC matrix did not induce significant changes in the polymer structure. The thermal studies highlighted the presence of water in all samples prepared (broad peaks between 45-80 °C) and a thermal stability up to approximately 320 °C. The highly doped electrolytes, HPMC:ILs (50-200%), displayed high ionic conductivities (e.g., HPMC:ILs (200%) exhibited a conductivity of 1.13×10^{-2} S cm^{-1} at 63 °C. The aforementioned results emphasize the huge potential of the developed green electrolytes in technological applications, as diverse as batteries and electrochromic windows.

Acknowledgements
We gratefully acknowledge Fundação para a Ciência e a Tecnologia, I.P. in the scope of the project SOLPOWINS-Solar-Powered Smart Windows for Sustainable Buildings (PTDC/CTM/4304/2020), and strategic projects UIDB/00686/2020, UIDP/00686/2020, UIDB/00616/2020 and UIDP/00616/2020. OBTAIN-Objective Sustainability (NORTE-01-0145-FEDER-000084), co-financed by the European Regional Development Fund (FEDER) through NORTE 2020 (Northern Regional Operational Programme 2014/2020). T.A.G.D. thanks OBTAIN for his postdoc grant (BIPD/UTAD/18/2021). S. M.P. C. and R.F.P.P. acknowledge FCT-UMinho for their contracts in the scope of Decreto-Lei 57/2016 57/2017.

References
1. P. Zarmpi, T. Flanagan, E. Meehan, J. Mann, N. Fotak, Eur J Pharm Biopharm., 2017, **111**, 1-15.
2. A. Sannino, C. Demitri, M. Madaghiele, *Materials*, 2009; **2**, 353-373.
3. S. C. Barros, A. A. da Silva, D.B. Costa, et al., Cellulose, 2014, **21**, 4531–4544.
4. S. C. Barros, M. M. Silva, Cellulose, 2018, **25**, 3163–3178.
5. S. C. Barros, A. A. da Silva, D.B. Costa, et al., Cellulose, 2015, **22**, 1911–1929.
6. S. A. Dharaskar, M. N. Varma, D. Z. Shende, C. K. Yoo, K. L. Wasewar. Sci. World J., 2013, 395274.

Natural exposure to lithium and suicide rate – data from human biomonitoring of urinary lithium levels

C. Gonçalves[1,2,*], R. Azevedo[1], C. Couto[1,3], M. Duro[1,4], A. Santos[1,2,5,6], L. Cainé[1,2,5], A. Almeida[1]

[1]LAQV/REQUIMTE, Laboratório de Química Aplicada, Departamento de Ciências Químicas, Faculdade de Farmácia da Universidade do Porto, Rua de Jorge Viterbo Ferreira 228, 4050-313 Porto, Portugal
[2]Faculdade de Medicina da Universidade do Porto, Alameda Prof. Hernâni Monteiro, 4200-319 Porto, Portugal
[3]TOXRUN – Toxicology Research Unit, Instituto Universitário de Ciências da Saúde, CESPU, Avenida Central de Gandra 1317, 4585-116 Gandra PRD, Portugal
[4]FP-ENAS – Fernando Pessoa Energy, Environment and Health Research Unit, Universidade Fernando Pessoa, Praça de 9 de Abril 349, 4249-004 Porto, Portugal and Laboratório de Análises Clínicas Dra. Matilde Sampaio, Reta de Vale da Madre, 5200-200 Mogadouro, Portugal & Laboratório de Análises Clínicas Vale do Sousa, Avenida José Júlio 281, 4560-547, Portugal
[5]Instituto Nacional de Medicina Legal e Ciências Forenses, Travessa do Carregal 3, 4050-202 Porto, Portugal
[6]Escola de Medicina da Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal
**carolina.isgoncalves4@gmail.com*

There is conflicting evidence about a possible inverse association between natural exposure to lithium and suicide rate in the general population.[1-4] Most studies have assessed lithium exposure simply by measuring the concentration in drinking water, which does not consider contributions from all sources. Our current study focuses on urinary levels, which may be a better approach to clarifying this issue.[5] In this context, we have been conducting comparative biomonitoring studies in regions with very different relative risk (RR) of suicide. In a pilot study, comparing the Porto metropolitan area (PMA; low RR) and the Trás-os-Montes region (TMR; high RR), with samples from individuals who resorted to Clinical Laboratories for routine laboratory analysis, no clear inverse association was found between urinary lithium levels and RR of suicide.[6] The median concentration was even lower in PMA (low RR): 22.6 µg/L (n=131) vs. 27.5 µg/L (n=51). However, there was also a significantly higher percentage of individuals with high urinary lithium levels (>80 µg/L): 15% (20/131) vs. only 6% (3/51). The reasons for this large inter-individual variability are being investigated in a larger study with healthy volunteers through a questionnaire on eating habits and determination of Li levels in drinking water and surface water in the referred regions. And a third region (Centre Region; CR) of intermediate RR, was included. This larger study with healthy volunteers generally confirms previous findings, not showing a clear inverse relationship between urinary Li levels and RR of suicide: PMA (low RR): 21.9 µg/L (n=91) vs. TM (high RR): 24.2 µg/L (n=90) vs. CR (intermediate RR): 19.0 µg/L (n=130). The details of the results will be presented here.

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.
This study was approved by the Ethics Committee of the Faculty of Pharmacy of the University of Porto (Report 04-02-2022). The authors would like to thank all the volunteers who agreed to participate in the study.

References

1. A. Memon, I. Rogers, S. Fitzsimmons, B. Carter, R. Strawbridge, D. Hidalgo-Mazzei and A. Young, *Br J Psychiatry.,* 2020, **217**, 667-678.
2. B. Eyre-Watt, E. Mahendran, S. Suetani, J. Firth, S. Kisely and D. Siskind, *Aust N Z J Psychiatry.,* 2021, **55**, 139-152.
3. P. Oliveira P, J. Zagalo, N. Madeira and O. Neves, Acta Med Port., 2019, **32**, 47-52.
4. N. N. Knudsen, J. Schullehner, B. Hansen, L. F. Jørgensen, S. M. Kristiansen, D. D. Voutchkova, T. A. Gerds TA, P. K. Andersen, K. Bihrmann, M. Grønbæk, L. V. Kessing and A. K. Ersbøll, *Int J Environ Res Public Health.,* 2017, **14**, 627.
5. F. Prazeres F., *Acta Med Port.,* 2019, **32**, 170-170.
6. M. Duro, C. Gonçalves, R. Azevedo, F. Costa, C. Couto, A. Santos, L. Cainé, A. Almeida, presented in part at Congrès International Vitamines, Oligoélements et Xénobiotiques Metalliques en Santé Humaine, Marraquexe, Marrocos, May, 2022.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Unraveling the photodynamic activity of cationic dibenzoporphyrin-based photosensitizers against *Escherichia coli*

Filipe M. P. Morais[1], Sofia Pedrosa[2], Cátia Vieira[2], Ana T. P. C. Gomes[3], M. Amparo F. Faustino[1], Adelaide Almeida[2], M. Graça P. M. S Neves[1], Nuno M. M. Moura[1]

[1]*LAQV-REQUINTE, University of Aveiro Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*CESAM, Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal*
[3]*Centre of Interdisciplinary Research in Health, Faculty of Dental Medicine (FMD), Universidade Católica Portuguesa, 3504-505 Viseu, Portugal*
**filipemorais@ua.pt*

antimicrobial Photodynamic Treatment (aPDT) is being pointed out as an efficient alternative to inactivate a broad spectrum of microorganisms, including those resistant to conventional antimicrobials. aPDT requires the activation of a non-toxic photosensitizer (PS) by visible light in the presence of dioxygen to produce highly cytotoxic reactive oxygen species (ROS), mainly singlet oxygen ($^1O_2$) responsible for the oxidation of vital microbial structures.[1–3] The multitarget action of the aPDT approach is particularly attractive considering the increase number of bacteria resistant to antimicrobial agents attributed to the incorrect prescription and/or over-prescription of antibiotics.[4]

Considering our interest in developing PS with adequate features to be used in aPDT, we report herein the synthesis, characterization and the photodynamic action of tetracationic dibenzoporphyrins against Gram-(-) bacteria. The cationization of the neutral dibenzoporphyrin derivative with iodomethane and 1-iodopentane allowed to evaluate the influence of alkyl chain size on the PS photoinactivation ability. The biological studies showing the photodynamic efficiency of these tetracationic dibenzoporphyrins (Figure 1) towards *Escherichia coli* will be presented and discussed.

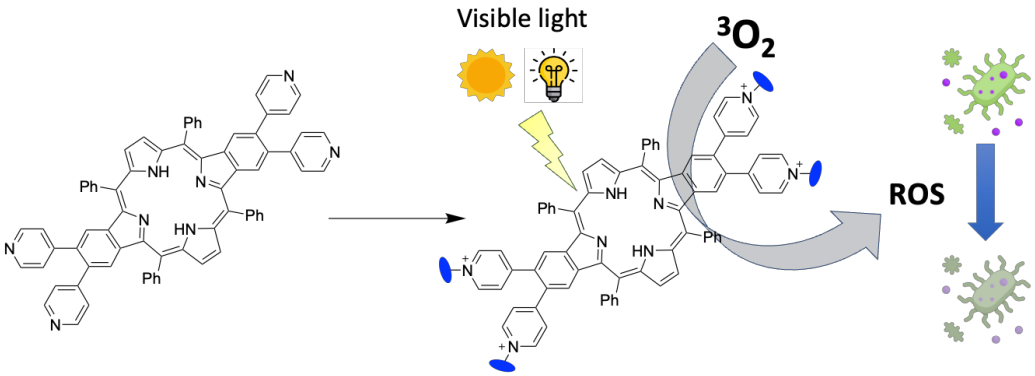


Figure 1: Schematic process of aPDT by using cationic dibenzoporphyrins as PS.

Acknowledgements
This work received support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) and CESAM (UID/AMB/50017/2019 and UIDB/50017/2020 + UIDP/50017/2020) through national funds, and to the Portuguese NMR Network. NMM Moura thanks FCT for funding through program DL 57/2016 – Norma transitória (CDL-CTTRI-048-88-ARH/2018).

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020 (LAQV-REQUIMTE) and UID/AMB/50017/2019 and UIDB/50017/2020 + UIDP/50017/2020 (CESAM), and the FCT project PORP2PS (EXPL/QUI-QOR/0586/2021). NMM Moura thanks FCT for his funding through program DL 57/2016 – Norma transitória (CDL-CTTRI-048-88-ARH/2018); F.M.P.M. and C.V. thank also FCT for their doctoral grants (UI/BD/154486/2022; SFRH/PD/150358/2019).

References

1. L. do Prado-Silva, G. T. P. Brancini, G. Ú. L. Braga, X. Liao, T. Ding and A. S. Sant'Ana, *Food Control*, 2022, **132**, 108527.
2. X. Moreira, P. Santos, M. A. F. Faustino, M. M. M. Raposo, S. P. G. Costa, N. M. M. Moura, A. T. P. C. Gomes, A. Almeida and M. G. P. M. S. Neves, *Dye. Pigment.*, 2020, **178**, 108330.
3. E. Alves, L. Costa, C. M. Carvalho, J. P. Tomé, M. A. F. Faustino, M. G. P. M. S. Neves, A. C. Tomé, J. A. Cavaleiro, Â. Cunha and A. Almeida, *BMC Microbiol.*, 2009, **9**, 70.
4. J. Hou, X. Long, X. Wang, L. Li, D. Mao, Y. Luo and H. Ren, *J. Hazard. Mater.*, 2023, **442**, 130042.

Heterometallic coordination polymers and tetranuclear copper(II) complexes: Self-assembly, magnetic properties, and catalytic activity

I. F. M. Costa[1,2,*], C. H. J. Franco[1], V. André[1], L. C. J. Pereira[2], M. V. Kirillova[1], A. M. Kirillov[1]

[1]*Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa.*
[2]*Centro de Ciências e Tecnologias Nucleares, Departamento de Engenharia e Ciências Nucleares, Instituto Superior Técnico, Universidade de Lisboa*
**inesfmcosta@tecnico.ulisboa.pt*

In recent decades, much interest has been focused on the design of metal-organic frameworks (MOFs) and coordination polymers (CPs) using a large variety of metal nodes and organic linkers. In particular, an interesting research direction concerns the heterometallic coordination compounds containing cyanometallate linkers on account of their promising magnetic behavior. Potential applications for such materials include data storage, quantum computing or molecular spintronics. Hexa- and tetra-cyanometallates, $[M(CN)_6]^{3-}$ and $[M(CN)_4]^{2-}$, have been extensively applied as attractive building blocks to interact with coordinatively unsaturated transition metal ions and construct a variety of coordination polymers (CPs) with remarkable magnetic behavior, including single-molecule (SMM), single-chain (SCM) magnetism or photomagnetism.[1-3]
In this study we report recent results on the synthesis and characterization of new heterometallic coordination compounds. The crystal structures of several products were determined including the alkoxo-bridged dicopper Cu(II)/Ni(II) CPs $[Cu_2(dmea)_2Ni(CN)_4]_n \cdot nH_2O$ (**1**) and $[Cu_2(Hbdea)_2Ni(CN)_4]_n$ (**2**) with dimethylethanolamine (Hdmea) or butyldiethanolamine (H_2bdea) ligands and Cu(II)/Co(III) CPs $[\{Cu_2K(H_2tipa)_2\}Co(CN)_6]_n \cdot 8nH_2O$ (**3**) and $[\{Cu_2(H_2tea)_2\}_3\{Co(CN)_6\}_2]_n \cdot 10nH_2O$ (**4**) with triisopropanolamine (H_3tipa) and triethanolamine (H_3tea) ligands. Structural features and magnetic properties of these compounds were investigated. In particular, magnetic susceptibility data for one of the Cu(II)/Ni(II) CPs reveal a strong antiferromagnetic interaction between the Cu(II) ions in the dimer units (J values between −200 and −400 cm^{-1}).
In addition to the synthesis of heterometallic coordination compounds, we also explored the chemistry of polynuclear copper(II) complexes due to their applications in the fields of magnetism and catalysis. Herein we also report on the self-assembly formation and magneto-structural characterization of four new tetracopper(II) complexes, $[Cu_4(2\text{-}OHmpy)_4]$ (**5**), $[Cu_4(Hbes)_4(4\text{-}brba)]\cdot 6H_2O$ (**6**), $[Cu_4(Hbes)_4(3,5\text{-}dhba)]\cdot 6H_2O$ (**7**), and $[Cu_4(\mu\text{-}Hbes)_4(\mu\text{-}H_2bes)(4\text{-}nba)]\cdot 2H_2O$ (**8**). These were obtained from 2-hydroxymethylpyridine (2-OHmpy), 4-bromobenzoic acid (4-Hbrba), 3,5-dihydroxybenzoic acid (3,5-Hdhba), or 4-nitrobenzoic acid (4-Hnba). The catalytic behavior of **5**−**8** was explored in two model reactions, namely (a) the mild oxidation of saturated hydrocarbons with hydrogen peroxide to form alcohols and ketones, and (b) the mild carboxylation of alkanes with carbon monoxide to give carboxylic acids.

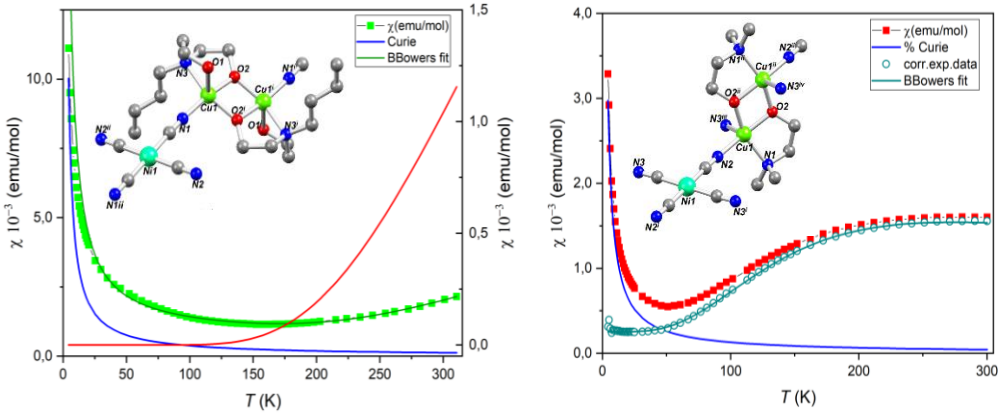


Figure 1: Temperature dependence of χ for $[Cu_2(bdea)_2Ni(CN)_4]_n$ (left) and $[Cu_2(dmea)_2Ni(CN)_4]_n \cdot nH_2O$ (right) and fitting with the Bleaney-Bowers model.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia (projects UIDB/00100/2020, PTDC/QUI-QIN/3898/2020, CEECIND/03708/2017, LISBOA-01-0145-FEDER-029697, UIDP/00100/2020, and REM2013 and PhD grant PD/BD/150418/2019).

References

1. M.G. Alexandru, D. Visinescu, J. Cano, F. Lloret and M. Julve, *Cryst. Growth Des.* 2023, **23**, 1288.
2. Y. Xie, R.B. Lin and B. Chen, *Adv. Sci.* 2022, **9**, 2104234.
3. J.H. Wang, Z. Y. Li, M. Yamashita, X. H. Bu, *Coord. Chem. Rev.* 2021, **428**, 213617.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Antibacterial starch-based biopolymer films doped with coordination compounds

T. A. Fernandes[1,*], I. F. M. Costa[1], P. Jorge[2], A. C. Sousa[1,3], V. André[1], R. G. Cabral[1,3], M. V. Kirillova[1], N. Cerca[2], A. M. Kirillov[1]

[1]Centro de Química Estrutural, Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal; [2]Centre of Biological Engineering, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal and LABBELS−Associate Laboratory, Braga/Guimarães, Portugal; [3]Departamento de Engenharia Química, ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, R. Conselheiro Emídio Navarro, 1, 1959-007 Lisbon, Portugal
**tiago.a.fernandes@tecnico.ulisboa.pt*

This work details the synthesis, characterization, and antibacterial properties of new hybrid biopolymer materials doped with bioactive coordination polymers (bioCPs) and coordination complexes (bioCCs).[1-3] Seven coordination compounds, $[Cu(NH_3)_2(nca)_2]$ (**1**), $[Cu(NH_3)_2(\mu\text{-ndca})]_n$ (**2**), $[Cu(NH_3)_2(\mu\text{-obba})]_n$ (**3**), $[Ag_4(\mu_8\text{-}H_2pma)_2]_n{\cdot}4nH_2O$ (**4**), $[Ag_5(\mu_6\text{-}H_{0.5}tma)_2(H_2O)_4]_n{\cdot}2nH_2O$ (**5**), $[Ag_2(\mu_6\text{-hfa})]_n$ (**6**), and $[Ag_2(\mu_4\text{-nda})(H_2O)_2]_n$ (**7**) were assembled from Cu or Ag sources ($Cu(NO_3)_2$, $AgNO_3$ or Ag_2O) and seven different building blocks: 2-naphthoic acid (Hnca), 2,6-naphthalenedicarboxylic acid (H_2ndca), 4,4′-oxybis(benzoic acid) (H_2obba), as well as pyromellitic (H_4pma), trimesic (H_3tma), homophthalic (H_2hfa), and 2,6-naphthalenedicarboxylic (H_2nda) acids. These compounds have been tested as active antimicrobial agents (dopants) in the development of doped biopolymer films based on epoxidized soybean oil acrylate (ESOA), potato starch (PS), or its combination with microcrystalline cellulose (PS-MCC). These model biopolymer materials may be customized to have varied rates of degradability/silver release.

Both types of materials, coordination compounds and their hybrid biopolymer films, displayed significant antibacterial action against Gram-positive (*S. epidermidis* and *S. aureus*) and Gram-negative (*P. aeruginosa* and *E. Coli*) bacteria. The biopolymer films additionally inhibited the formation of bacterial biofilms (Figure 1). Overall, **1**−**3**@$[ESOA]_n$ demonstrated particularly high performance against clinical isolates of *S. epidermidis*; **4**@$[ESOA]_n$ outperformed other doped films in terms of antibacterial activity; **6**@$[PS]_n$ revealed greater efficacy than **3**@$[ESOA]_n$, while **7**@$[ESOA]_n$ and **7**@$[PS]_n$ showed comparable antimicrobial and biofilm inhibition performance. This multidisciplinary study not only covers a wide variety of important research subjects, but also broadens the antibacterial use of bioactive coordination polymers and hybrid biopolymer materials derived from sustainable biofeedstocks such as soybean oil and potato starch.

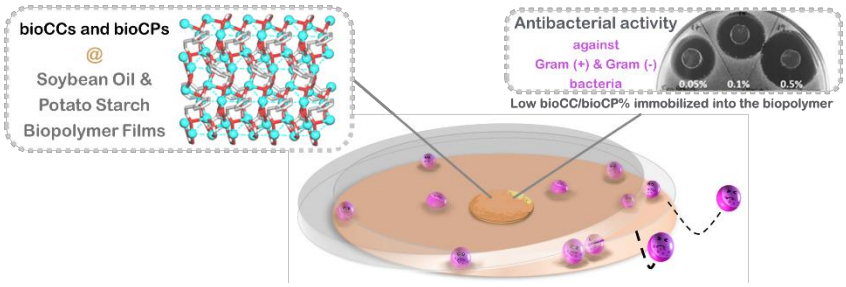


Figure 1: Illustration of the biofilm inhibiting and antimicrobial properties of hybrid biopolymer materials doped with bioactive coordination polymers.

Acknowledgements
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. This work was supported by the FCT and Portugal 2020 (projects PTDC/QUI-QIN/3898/2020, PTDC/QUI-QIN/29697/2017, LA/P/0056/2020, IPL/2021/Naf4Med3D_ISEL, and REM2013), contracts under DL No. 57/2016, CEECIND/02725/2018, and CEECIND/00194/2020.

References

1. T.A. Fernandes, I.F.M. Costa, P. Jorge, A.C. Sousa, V. André, N. Cerca, A.M. Kirillov, *ACS Appl. Mater. Interfaces*, 2021, **13**, 12836.
2. T.A. Fernandes, I.F.M. Costa, P. Jorge, A.C. Sousa, R.G. Cabral, V. André, N. Cerca, A.M. Kirillov, *ACS Appl. Mater. Interfaces*, 2022, **14**, 25104.
3. K.I. Trusau, P. Jorge, A.C. Sousa, T.A. Fernandes, V. Andre, M. Kirillova, A.I. Usevich, N. Cerca, A.M. Kirillov, *RSC Sustain.*, 2023, **1**, 10.1039/D2SU00150K.

Teaching data science for chemical applications: from experiments to large representative data

Rita Assis dos Santos[1], Helena Vendas[1], Remígio Machado[1], Catarina Barata[2], Pedro S. F. Mendes[1,*]

[1]*Departamento de Engenharia Química, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal*
[2]*Instituto de Sistemas e Robótica, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal*
**pedro.f.mendes@tecnico.ulisboa.pt*

Industry 5.0 aims at sustainable chemical processes with high efficiency and circularity through tailor-made design based on real data. Relevant research methods also generate a significant amount of data that is still under studied as a whole. The development of models of chemical applications based on data analysis are therefore core competences for modern chemists and chemical engineers. However, effective learning requires practical examples of data acquisition and data directly related to the topics learned by the students in their curriculum. Therefore, the goal is to develop a lab experimental setting to generate relevant data on which Chem and ChemE students can learn key data science concepts.

In the first instance, the lab case study was defined. The criteria were: (i) a minimum number of dependent (i.e. performance) variables that could be measured; (ii) the measurement of such variables should be automatable; and (iii) preferably allow for a clear visual inspection. Therefore, liquid-liquid extraction in which two immiscible liquids contact forming, one of them, droplets with various diameters depending on the operating conditions. The mass transfer of the solute between the two liquids is a function of two parameters: the droplets' diameter and the relative volume of the two liquid phases (so-called hold-up). Additionally, some organic solvents are colored and aqueous soluble solutes can also provide color, e.g. $CuSO_4$.

Secondly, an image acquisition setup to measure the droplet size was developed, installed and tested to an existing liquid-liquid pilot scale extraction column. The image acquisition setup consists of Raspberry Pi 10 MP C-Mount camera coupled to a 16mm lens. A series of images were acquired at various operating conditions, such that a large range of hold-ups was screened. The images below (Figure 1) were obtained from video recordings, and we can immediately see that the droplets on the foreground are much sharper than the ones on the background. Additionally, we can also verify that closer to the edges of the column the image becomes more blurred and that the smaller droplets look less sharp compared to the larger ones. These issues condition the image processing phase since it is necessary to select a portion of the image or post-process them.

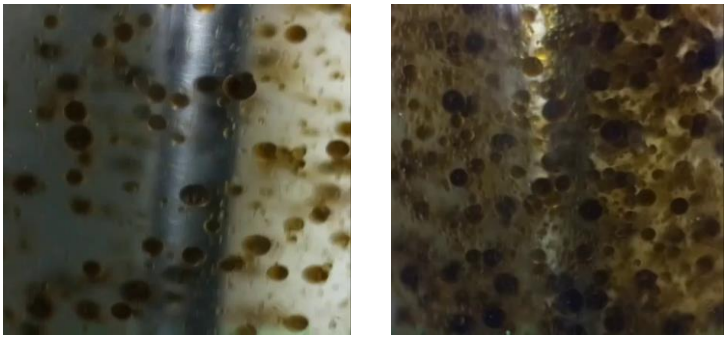


Figure 1: Images of liquid-liquid extraction column with low (left) and high (right) hold-ups.

Finally, an automated method to estimate the droplet diameter based on that image processing techniques was developed. Due to the simplicity in implementation, mathematical models were selected for edge identification and object segmentation. The methodology consists of a combination of various algorithms such that a similar diameter distribution to the actual one is obtained.

In summary, by applying automatic image acquisition to a liquid-liquid extraction column, a relatively large dataset of droplet diameters as function of operating conditions can be generated based on experimental results, but in an automated manner. The students can treat this as a unique variable applying univariate analysis or as a dependent variable applying machine learning models to simulate its value as a function of the operating conditions. This work will pave the way for data science teaching in the Chemical Engineering and related fields curricula at Técnico Lisboa.

Acknowledgements
We thank the Instituto Superior Técnico for the funding via the Pedagogical Innovation Project 1018P.06228.

References

1. Meng, Y., Zhang, Z., Yin, H., & Ma, T. (2018). Micron, 106, 34–41.

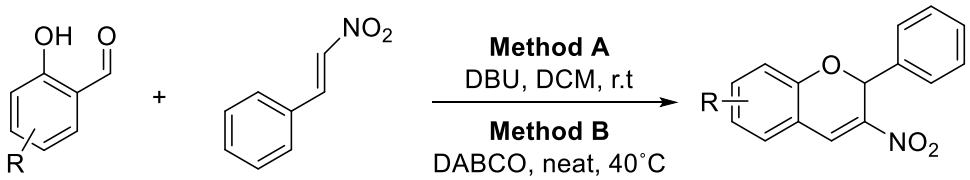
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Oxa-Michael Henry domino reaction for the synthesis of 3-nitro-2*H*-chromenes

Patrícia I. C. Godinho[1,*], Raquel Soengas[2], Artur M. S. Silva[1]

[1]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal.*
[2]*Departamento de Química Orgânica e Inorgânica, Universidad de Oviedo, Julián Claveria 7, 33006, Oviedo, Spain.*
**patricia.godinho@ua.pt*

Chromenes are important family of heterocyclic derivatives that are widespread in plants[1] and display a wide range of biological activities.[2] 3-Nitro-2*H*-chromenes possess a particular relevance not only to their promising pharmaceutical properties but also because they are useful building blocks for constructing diverse heterocyclic compounds in the pharmaceutical industry.[3]
The synthesis of 3-nitro-2*H*-chromenes is described in the literature through the condensation of substituted salicylaldehyde's with substituted nitrostyrene derivatives. The search for greener methodologies in organic chemistry focuses on high efficiency, yield and selectivity, least intermediate isolation and minimal energy cost and waste generation. The most direct and widespread approach is through oxa-Michael Henry domino reaction, where the reactions catalyzed by DBU or DABCO were the most interesting in terms of greener processes.[4,5]
Herein, we describe the synthesis of 3-nitro-2*H*-chromenes from the asymmetrical catalyzed oxa-Michael Henry domino reaction through two synthetic methodologies to obtain new 3-nitro-2*H*-chromenes.



R= H, NO_2, Br, Cl, COF_3

Scheme or Figure 1: Synthesis of 3-nitrochromenes

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the project LAQV-REQUI*M*TE (UIDB/50006/2020), the Principado de Asturias (FICYT AYUD/2021/51542), MINECO (PID2019-109253RB-I00), and the European Union (European Regional Development Fund-ERDF). Thanks are due to the National NMR Network (PT NMR) partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).

Fundings
Patrícia I. C. Godinho thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for her PhD grant 2022.11294.BD.

References
1. Ellis, G. P. Chromenes, Chromanones, and Chromones, in The Chemistry of Heterocyclic Compounds, Ed. G. P. Ellis, Wiley, New York, 1977, 31
2. Wang, G. X.; Wang, N. X.; Shi, T.; Yu, J. L.; Tang, X. L. Prog. Chem. 2008, **20**, 518–524
3. Das, S., Synth. Commun., 2022, **52**, 637-666.
4. Luque-Agudo, V.; Albarrán-Velo, J.; Light, M. E.; Padrón, J. M.; Román, E.; Serrano, J. A.; Gil, M. V., Bioorg. Chem., 2019, **87**, 112–116.
5. a) Baral, N., Mishra, D.R., Mishra, N.P., Mohapatra, S., Raiguru, B.P., Panda, P., Nayak, S., Nayak, M., Kumar, P.S., J. Heterocycl. Chem., 2020, **57**, 575–589. b) Yao, C.-F.; Yan, M.-C.; Jang, Y.-J.; Kuo, W.-Y.; Tu, Z.; Shen, K.-H.; Cuo, T.-S.; Ueng, C.-H., Heterocycles, 2002, **57**, 1033.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

P139

Ohmic heating assisted Hantzsch reaction for the synthesis of novel 1,4-dihydropiridines

Vera L. M. Silva[1,*], Joana Pinto[1], Ricardo F. Mendes[2], Filipe A. Paz[2], Artur M. S. Silva[1]

[1]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*CICECO−Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
** E-mail: verasilva@ua.pt*

Multicomponent reactions allow the sustainable construction of highly functionalized and biologically important molecules in a one-step process, with high atom economy, by combination of simple building blocks. Therefore, there has been an increasing interest in the use of this kind of reactions in medicinal chemistry and drug discovery.[1] Specifically, the multicomponent Hantzsch reaction offers an efficient way to prepare 1,4-dihydropyridines (1,4-DHPs) by reaction of an aldehyde with a β-ketoester and a nitrogen donor compound such as ammonia or ammonium acetate.[2]

The 1,4-DHPs are small molecules that occupy a prime place in medicinal chemistry as privileged pharmacophores because of their significant biological activities as calcium channel modulators, antioxidants, bronchodilators, antiatherosclerotic agents and candidates for Alzheimer's disease therapy, among other potential applications.[3] In turn, imidazoles and 4*H*-chromen-4-ones have been extensively studied as bioactive compounds and are well-recognized as, for example, antioxidant, anti-inflammatory, antiviral, antimicrobial, anticancer and neuroprotectant compounds.[4,5] When imidazolecarbaldehydes and 4-oxo-4*H*-chromene-3-carbaldehyde (also known as 3-formylchromone) are used as the aldehyde counterpart in the Hantzsch reaction, the obtained dihydropyridines are functionalized at C-4 with the imidazolyl and 3-chromonyl groups, respectively thus combining in each case two important pharmacophores in a single molecule.

Our group has been investigating the use of ohmic heating to assist different chemical reactions such as, Diels–Alder reactions, C-C cross coupling reactions, *N*-alkylations, nucleophilic substitutions, Knoevenagel condensation, indium-promoted reductive dehalogenation, and reductive elimination reactions, aiming to improve the sustainability of synthetic processes.[6] In this context, the objective of this work was to investigate the applicability of ohmic heating to multicomponent reactions, more specifically to the Hantzsch reaction of four imidazolecarbaldehydes and 3-formylchromone with methyl acetoacetate and ammonium acetate, in aqueous medium, using water or mixtures of water and polyethylene glycol as an alternative to organic solvents. Besides the 1,4-DHP functionalized at C-4 with different imidazolyl groups, and a 3-chromonyl group, which are the expected Hantzsch reaction product, two other compounds were obtained in the case of the reaction with 3-formylchromone. One of them resulted from the opening of the chromone ring in the reaction conditions, which is not surprising, but most intriguing was the formation of an unexpected compound, the methyl 5-imino-2-methyl-1,10a-dihydro-5*H*-chromeno[2,3-*b*]pyridine-3-carboxylate.[7] All the compounds were fully characterized by nuclear magnetic resonance spectroscopy and in some cases also by X-ray diffraction.

In this communication will be presented and discussed the synthesis of the novel 1,4-DHPs, in ohmic heating, their structural characterization, as well as the mechanism that led to the formation of the unexpected compound.

Acknowledgements
Vera L. M. Silva thanks funding through FCT under the Scientific Employment Stimulus – Institutional Call – reference CEECINST/00026/2018. Thanks are also due to the Portuguese NMR Network (PT NMR) partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). RFM gratefully acknowledges FCT for a Junior Research Position (CEECIND/00553/2017).

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.This work was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC).

References

1. R.C. Cioc, E. Ruijter, R.V.A. Orru, *Green Chem.* 2014, **16**, 2958–2975
2. A. Hantzsch, *Justus Liebigs Ann. Chem.* 1892, **215**, 1–81.
3. S.A. Khedkar, P.B. Auti, *Mini Rev. Med. Chem*. 2014, **14**, 282–290.
4. H.V. Tolomeu, C. A. M. Fraga, *Molecules* 2023, **28**, 838.
5. R. B. Semwal, D.K.Semwal, S. Combrinck, A.Viljoen, *Phytochem. Rev.* 2020, **19**, 761–785.
6. V.L.M. Silva, L.M.N.B.F. Santos, A.M.S. Silva, *Chem. Eur. J.* 2017, **23**, 7853–7865
7. J. Pinto, A.M.S. Silva, V.L.M. Silva, *Molbank* 2022, **2022**, M1453.

P140

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Polymeric bovine serum albumin nanoparticles as drug delivery systems for prostate cancer treatment: An *in vitro* study

Beatriz Teixeira[1,*], Maria J. Barreira[2], Sónia A. O. Santos[2], Mónica Almeida[1], Carmen S. R. Freire[1], Miguel Oliveira[1], Ricardo J. B. Pinto[2]

[1]*Department of Biology & CESAM, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*
[2]*Department of Chemistry – CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal*
**beatrizteixeira99@ua.pt*

Cancer is a primary global health concern, significantly burdening healthcare systems and leading to a high mortality rate. Prostate cancer is among the most prevalent types of cancer, ranking as the second most common cancer, being associated with substantial incidence and mortality rates among males. The currently used treatments include radical prostatectomy, external beam radiation, brachytherapy, cryotherapy, hormone therapy, and chemotherapy, most of them with significant side effects. Furthermore, the available treatments have several limitations, namely lack of specificity, heightened cytotoxicity, and increased resistance to chemotherapy leading to adverse outcomes for the organism.[1] To overcome some cancer treatment flaws, scientists focus on alternative approaches to develop new and more precise therapies. The use of distinct polymeric nanoparticles (NPs), namely as a drug delivery system, is a promising alternative.[2] Protein NPs are unique because of their efficiency, mild and environmentally friendly preparation methods, and inherent properties, such as stability, biodegradability, potential biocompatibility, and increased safety, often a problem inherent to inorganic nanocarriers.[2,3] However, new methods to enhance NPs uniformity, avoid toxic crosslinking agents (e.g., glutaraldehyde), increase drug loading, and evaluate clinical drugs remain limited.
In this work, Bovine Serum Albumin (BSA) NPs were synthesized using a genipin-crosslinked approach to be used as carriers to encapsulate specific drugs. The effect of different experimental parameters, namely temperature, stirring method, and concentrations of BSA and genipin, were studied to understand their influence on the size, morphology, stability, and reaction yield of the BSA NPs. Overall, the results show that the optimal size of BSA NPs for cell-based *in vitro* testing (≈300 nm) occurs when the concentration of BSA and genipin is equal (20 mg/mL) (Figure 1). The increase in the reaction temperature leads to a higher yield. However, it affects other properties, such as size and aggregation. For the best experimental conditions evaluated, two clinical drugs were encapsulated, namely sertraline (antidepressant with promising results as alternative therapies for cancer) and 5-fluorouracil (common anticancer drug), individually and combined in different ratios. BSA NPs were more effective in encapsulating sertraline, obtaining an encapsulation loading of 82% (HPLC-MS). The potential use of these NPs in prostate cancer treatment was evaluated through *in vitro* cell culture tests. In this step, PNT-2 (normal prostate cell line) and 22RV1 (prostate cancer cell line) cell lines were exposed to the loaded BSA NPs to assess whether these compounds are able to inhibit cancer cell proliferation while not affecting or barely affecting the normal cells. This study validates the high potential of BSA NPs in the biomedical field, namely as effective nanocarriers of active drugs for prostate cancer treatment.

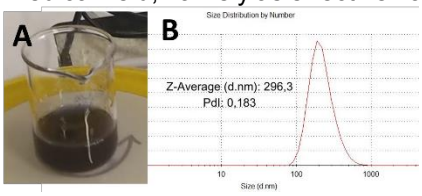


Figure 5: *A) Aqueous suspension of BSA NPs and B) respective hydrodynamic diameter.*

Acknowledgements
This work was partly developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The research contract of R.J.B. Pinto was funded by national funds (OE), through FCT in the scope of the framework contract foreseen in the numbers 4, 5, and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19.Thanks are due to FCT/MCTES for the financial support to the project NanoPlanet (2022.02340.PTDC), the research contract under Scientific Employment Stimulus to S.A.O. Santos (2021.03348.CEECIND), and CESAM (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020) through national funds.

References
1. M. Sekhoacha, K. Riet, P. Motloung, L. Gumenku, A. Adegoke and S. Mashele, *Molecules*, 2022, **27**, 5730.
2. Y. Miao, T. Yang, S. Yang, M. Yang and C. Mao, *Nano Converg*, 2022, **9**, 2.
3. M. J. Mitchell, M. M. Billingsley, R. M. Haley, M. E. Wechsler, N. A. Peppas and R. Langer, Engineering precision nanoparticles for drug delivery, *Nat Rev Drug Discov,* 2020, **20**, 101.

Achieving accurate measurements without breaking the bank: A highly sensitive technique for pitavastatin quantification in human plasma

João Basso[1,2], Alberto Pais[2], Ana Fortuna[1,3], Rui Vitorino[4], Carla Vitorino[1,2]

[1]*Faculty of Pharmacy, University of Coimbra, Coimbra, Portugal*
[2]*Coimbra Chemistry Centre, Institute of Molecular Sciences—IMS, Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal*
[3]*Coimbra Institute for Biomedical Imaging and Translational Research, University of Coimbra, Coimbra, Portugal.*
[4]*Department of Medical Sciences, Institute of Biomedicine-iBiMED, University of Aveiro, Aveiro, Portugal, UnIC@RISE, Department of Surgery and Physiology, Faculty of Medicine of the University of Porto, Porto, Portugal and LAQV/REQUIMTE, Department of Chemistry, University of Aveiro, Aveiro, Portugal*
**joaobasso@ff.uc.pt*

Liquid chromatography coupled to ultraviolet/visible or diode array detectors has become the standard technique for drug quantification in academia, as well as in R&D facilities worldwide. Nonetheless, its sensitivity may fall short for pharmacokinetics and bioanalytical studies. Alternatively, HPLC with fluorescence detection (HPLC-FLD) offers a cost-effective solution that significantly enhances the method sensitivity and specificity, thus ensuring the detection at lower concentrations and with less interferents.

Pitavastatin is a competitive coenzyme A reductase inhibitor used for reducing the circulating low-density lipoprotein (LDL) cholesterol levels and improve cardiovascular risk. In parallel, recent preclinical studies show that pitavastatin has anti-tumor properties and may be a promising adjuvant to cancer therapy.[1]

Pitavastatin is also a highly fluorescence molecule, due to the presence of a quinoline moiety in its structure. In light of this, an HPLC-FLD method for the quantification of pitavastatin in human plasma was developed and validated following the recommendations of the ICH M10 guideline.[2]

The analyte was separated from endogenous plasma interferents using a reversed-phase column and a gradient elution with acetic acid (2% v/v) and acetonitrile. Atorvastatin was used as an internal standard to ensure sample treatment reproducibility (Figure 1A). Sample preparation was performed by protein precipitation followed by centrifugation and filtration.

The linearity of the method was ensured from 3-900 ng/mL (R2 > 0.998), comprehending a signal gain of 54-70 times when compared to a conventional ultraviolet detection at λ_{max} (Figure 1B). The method was shown to be sensitive, specific and selective, with relative and absolute recoveries exceeding 94% and accuracy and precision below 7.15 % (bias) and 9.63 % (RSD), respectively. Importantly, this method enables the effective monitoring of patients on pitavastatin therapy, provides a valuable tool for conducting novel clinical investigations and serves as a foundation for establishing new chromatographic methods for preclinical investigations in other matrices.

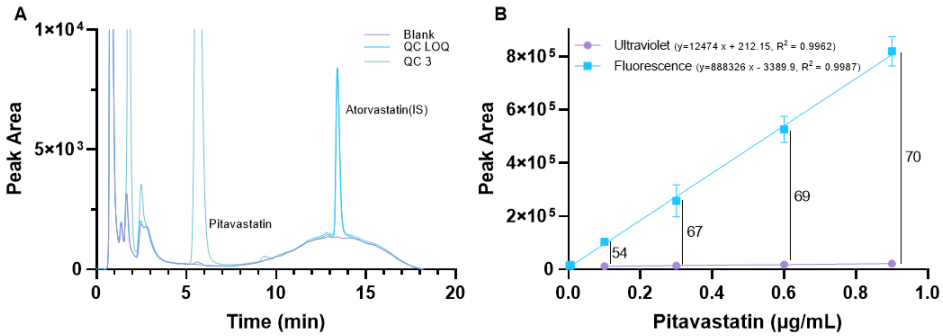


Figure 1: A Representative chromatogram; **B** Sensitivity gain between fluorescence and ultraviolet detection.

Acknowledgements
This research was funded by the Portuguese Foundation for Science and Technology (FCT), European Union, QREN, FEDER and COMPETE for funding the iBiMED (UIDB/04501/2020, POCI-01-0145-FEDER-007628), UIC (UID/IC/00051/2019), LAQV-REQUIMTE (UIDB/50006/2020) and CQC (UID/QUI/00313/2020). Rui Vitorino and João Basso also acknowledge FCT for the grants IF/00286/2015 and SFRH/BD/149138/2019, respectively.

References
1. Jiang, W., Hu, J. W., He, X. R., Jin, W. L., & He, X. Y. J Exp Clin Cancer Res, 2021, 40, 1-33.
2. ICH, guideline M10 on bioanalytical method validation and study sample analysis, in Amsterdam, M10, 2019, 1-45.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Photoactivatable VEGFR2 Inhibitors: Advancing precise cancer therapy

S. Hummeid[1,*] M. P. Carrasco[1], P. Remón[2], U. Pischel[2], R. Moreira[1]

[1]*Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Lisbon, Portugal.*
[2]*CIQSO – Center for Research in Sustainable Chemistry, University of Huelva, Huelva, Spain.*
**S.hummeid@ff.ulisboa.pt*

The formation of new blood vessels from pre-existing ones, known as angiogenesis, is a complex process that is tightly regulated in healthy tissues. However, in cancer the regulation of angiogenesis is disrupted, leading to the uncontrolled formation of new blood vessels to support tumor growth. VEGFR2, a critical tyrosine kinase receptor involved in angiogenesis, is often overexpressed in various types of solid tumors, making it an attractive target for therapeutic interventions[1]. Targeting VEGFR2 with selective inhibitors can be considered as a promising anticancer therapy and a useful strategy to understand the dynamic behavior of this enzyme.
Photopharmacology offers a powerful strategy for reducing side effects in cancer therapy by utilizing photoactive ligands that interact with their targets only after exposure to light. This approach allows for precise spatial and temporal control of drug activity, thereby minimizing off-target effects and the risk of toxicity to healthy tissues[2,3].
In the present study we aim to expand the toolbox of anti-angiogenic agents by developing new photoactivatable inhibitors based on known VEGFR2 inhibitors. These can be exclusively activated in situ, using light of biocompatible wavelength, suitable for cells and, ultimately, for living tissues. The photochemical transformations will generate configurational isomers with distinct geometries, displaying differentiated behavior when interacting with the target. For this purpose, new photoactivatable sorafenib derivatives, a known VEGFR2 inhibitor, (Figure 1) were synthesized and characterized for their photochemistry. The biological activity of the compounds was evaluated with and without irradiation.

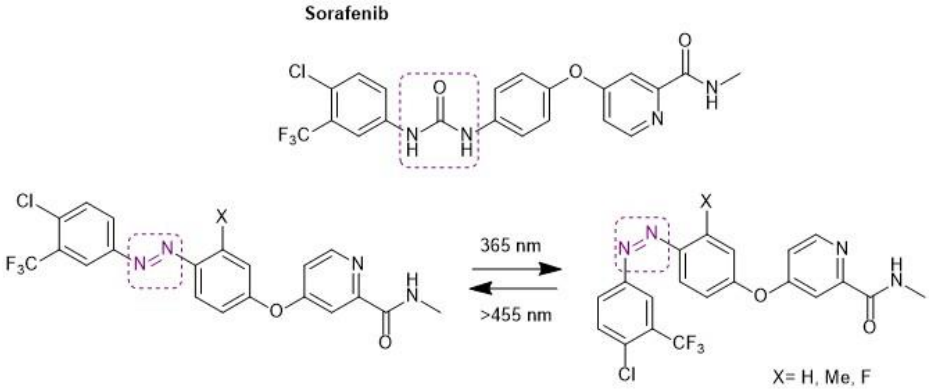


Figure 1: Photocotrollable sorafenib derivatives.

Acknowledgements
The work was financially supported by Fundação para a Ciência e Tecnologia, Portugal (grant 2021.05453.BD) and by the Spanish Ministerio de Ciencia e Innovación (PID2020-119992GB-I00 for U.P.).

References

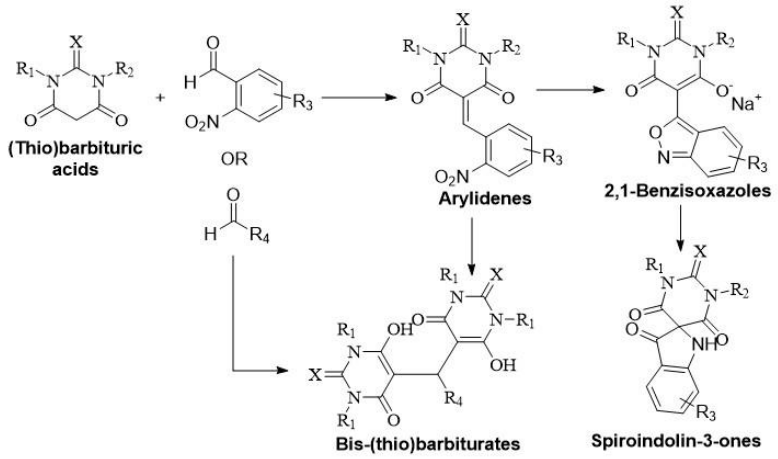
1. a) S. D. González, N. Marion, S. P. Nolan, Chem. Rev., 2009, 109, 3621; b) F. E. Hahn, Angew. Chem. Int. Ed., 2006, 45, 1348.
2. V. Nair, R. S. Menon, A. T. Biju, C. R. Sinu, R. R. Paul, A. Jose, V. Sreekumar, Chem. Soc. Rev., 2011, 40,
3. 5336.
4. W. A. Velema, W. Szymanski, B. L. Feringa, J. Am. Chem. Soc., 2014, 136, 2178.

(Thio)barbiturate derivatives as potential xanthine oxidase inhibitors and/or anticancer agents

J. L. Serrano[1,*], D. Lopes[1], P. Soeiro[1], M. Reis[1], S. M. Silvestre[1,2], P. Almeida[1]

[1]*CICS-UBI – Health Sciences Research Center, University of Beira Interior, Av. Infante D. Henrique, 6200-506 Covilhã, Portugal*
[2]*CNC – Center for Neuroscience and Cell Biology, University of Coimbra, Rua Larga, 3400-517 Coimbra, Portugal*
**joao.serrano@ubi.pt*

Xanthine oxidase (XO) expression and activity have been negatively associated with a high degree of malignancy and a worse prognosis in some types of cancer, namely of breast and gastrointestinal tract. In fact, chemotherapy is frequently associated with cell lysis that leads to the release of high levels of cellular components into the bloodstream, resulting in several metabolic disturbances, such as hyperuricemia. XO is the main target in hyperuricemia treatment since it catalyses the oxidative hydroxylation of hypoxanthine and xanthine to produce uric acid and reactive oxygen species (ROS). Recently we described and patented *bis*-(thio)barbiturates as potent XO inhibitors.[1-2] Looking for more potent XO inhibitors, we synthesised and evaluated the XO inhibition activity of thirty eight *bis*-(thio)barbiturates, twenty 2,1-benzisoxazoles and twenty spiroindolin-3-ones coupled with (thio)barbiturates (Scheme 1). From the point of view of a dual biological activity, the effects of all synthesized barbiturates on the viability of colorectal adenocarcinoma Caco-2, breast cancer MCF-7 and non-tumoral NHDF cell lines were also explored. *Bis*-thiobarbiturates presenting in their structure aryl groups and halogen substituents were the most potent XO inhibitors, with low cytotoxicity. On the other hand, *bis*-thiobarbiturate with styryl groups and halogen substituents showed the most important results with dual activities, being XO inhibitors and antiproliferative agents. On contrary to *bis*-(thio)barbiturates, both 2,1-benzisoxazoles and spiroindolin-3-ones demonstrate to be weak XO inhibitors. For both serials, a poor cytotoxic activity was also verified, despite a slight better activity presented by spiroindolin-3-ones.



Scheme 1: General synthetic route to bis-(thio)barbiturates, 2,1-benzisoxazoles and spiroindolin-3-ones.

Acknowledgements
This work was developed within the scope of the CICS-UBI projects UIDB/00709/2020 and UIDP/00709/2020, financed by national funds through the Portuguese Foundation for Science and Technology/MCTES. The NMR spectrometers are part of the Portuguese NMR Network (PTNMR) and are partially supported by the Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). João L. Serrano acknowledges a doctoral fellowship grant from the FCT (SFRH/BD/148028/2019).

References
1. J. L. Serrano, D. Lopes, M. J. A. Reis, R. E. F. Boto, S. Silvestre and P. Almeida, 2021, **9**, 1443.
2. J. L. Serrano, D. Lopes, M. J. A. Reis, R. E. F. Boto, S. Silvestre and P. Almeida, **2021**, PT Patent 116062 A.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Bioelectronic tongue for rapid detection of paralytic shellfish toxins

M. I. C. Raposo[1,*], M. T. S. R. Gomes[1], S. T. Costa[2,3], M. J. Botelho[2], A. Rudnitskaya[1]

[1]*CESAM and Chemistry Department, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*IPMA, Portuguese Institute for the Sea and Atmosphere, 1449-006 Lisbon, Portugal and CIIMAR, Interdisciplinary Centre of Marine and Environmental Research, University of Porto, 4050-123 Porto, Portugal*
[3]*ICBAS, Abel Salazar Biomedical Sciences Institute, University of Porto, Largo Prof. Abel Salazar, 2, 4099-003 Porto, Portugal*
**micr@ua.pt*

Phytotoxins produced by marine microalgae, such as paralytic shellfish toxins (PSTs), can accumulate in bivalve molluscs, representing a human health concern due to the life-threatening symptoms they cause. To avoid the commercialization of contaminated bivalves, monitoring programs were established in the EU[1]. There is a demand for rapid tools of PST detection that could be used for screening purposes. However, their development is challenging since PSTs is a group of more than 50 compounds with toxin profiles varying among different PST producing species. Several assays and biosensors proposed for detection of PSTs are mostly based on antibodies to saxitoxin (STX), which is the most common PSTs worldwide. As PST profile detected in bivalves from Portuguese coast during *G. catenatum* blooms differs due to the predominance of N-sulfocarbamoyl and decarbamoyl toxins, usefulness of these biosensors is quite limited.
The present work aimed at development of bioelectronic tongue comprising potentiometric chemical sensors and biosensors as a rapid tool for detection of PSTs common on the Atlantic coast of Portugal and Spain. Analytical characteristics of 8 potentiometric chemical sensors with PVC plasticized membranes were evaluated in the solutions of 6 major PSTs (dcSTX, GTX5, dcGTX2+3, C1+2, dcNEO, GTX6). Sensors displayed cross-sensitivity to all studied toxins except GTX6, to which low sensitivity and low selectivity was observed (Fig. 1). As GTX6 typically accounts for ca. 30-35% of PSTs, enzymatic biosensor for its detection was developed based on our previous work on carbamoylase-based assay for another N-sulfocarbamoyl toxin – GTX5[2]. Carbamoylase hydrolyses carbamate or N-sulfocarbamoyl PSTs producing respective decarbamoylated analogues, which in the case of GTX6 is dcNEO. Biosensor was constructed by immobilizing carbamoylase though carbodiimide coupling reaction on the surface of the potentiometric sensor with the membrane sensitive to the enzymatic reaction product – dcNEO. Potentiometric sensor 7 (Fig. 1) with high sensitivity and selectivity to dcNEO was selected with carboxilated PVC used for the membrane preparation. Conditions of the enzyme immobilization carboxilated PVC including concentrations of coupling agents (EDC and NHS) and enzyme, and reaction time were optimized prior to biosensor preparation. Selection of the sensors for the bioelectronic tongue for simultaneous quantification of major PSTs was carried out using genetic algorithm for further tests in bivalve extracts.

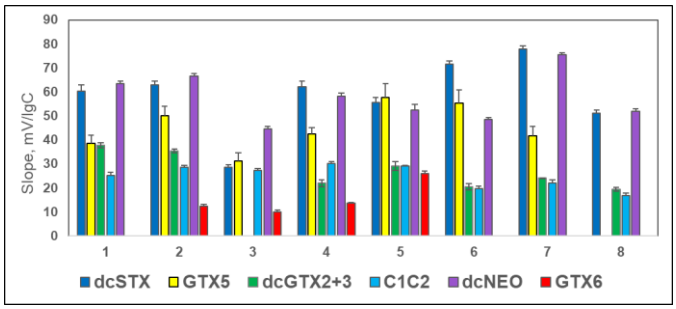


Figure 1: Sensitivity (slopes of the electrode function, mV/logC) of 8 sensors to studied PSTs.

Acknowledgements
We thank the financial support from Iceland, Liechtenstein and Norway through the EEA and Norway Grants, Blue Growth Program (PT-INNOVATION-0078 – COASTAL), and FCT/MCTES support to CESAM through national funds (UIDP/50017/2020; UIDB/50017/2020; LA/P/0094/2020). M.R. thanks support by FCT through doctoral fellowship SFRH/BD/120326/2016

References

1. L. M. Grattan, S. Holobaugh and J. G. Morris, Harmful Algae, 2016, 57, 2–8.
2. M. Raposo, M. J. Botelho, S. T. Costa, M. T. S. R. Gomes and A. Rudnitskaya, Sensors (Switzerland), 2020, 20(2), 507.

Cellulose-based materials functionalized with specific Immunoglobulin Y (IgY) antibodies aiming enhanced respiratory protection

F. Pereira[1], T. Fonte[1], D. Sousa[1], C. Almeida[1,2], P. Vilarinho[2], J. A. P. Coutinho[1,2], M. C. Neves[1,2], M. G. Freire[1,2*]

[1]CICECO-Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]RYA Purification Technologies, 3830-352 Ílhavo, Portugal
**maragfreire@ua.pt*

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is an enveloped virus with positive sense and single-stranded RNA genome that occurred in 2019 in Wuhan, being responsible for the Coronavirus Disease 2019 (COVID-19).[1] Due to the global crisis resultant from COVID-19, the employment of effective solutions to minimize the spread and cross-contamination of this virus is in high demand. Several measures, such as the use of masks, were recommended by regulatory agencies; however, they are not completely effective in preventing infections caused by the inhalation of small droplets exhaled by an infected person that can spread for long distances in the air.[2] Thus, it is urgent to develop other respiratory protective devices to prevent the transmission of SARS-CoV-2, mainly in confined spaces. There are already some strategies on the market, such as Heating, Ventilating, and Air Conditioning (HVAC) filters that, although being highly efficient in retaining viruses and bacteria, are not able to inactivate them.[1] Therefore, filters incorporated with biological materials, such as antibodies, allowing both filtration and inactivation, could be employed. Within these, Avian Immunoglobulin Y (IgY) antibodies are a promising solution. IgY is obtained through non-invasive techniques at high yields from hen's egg yolk.[3] Owing to their polyclonal nature, IgY can recognize numerous epitopes on an antigen, this being relevant when envisioned their use to tackle microbial species.
This work aims to develop HVAC filters functionalized with specific IgY to inactivate SARS-CoV-2, contributing to decrease its spreading and cross-contamination. IgY antibodies were recovered and purified according to a patented low-cost purification technology (PCT/IB2019/057993). The obtained antibodies were characterized regarding their purity, stability, and migration profile through Size Exclusion- High Performance Liquid Chromatography (SEC-HPLC), Circular Dichroism (CD) Spectroscopy, and Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE), respectively. Dot-Blot and Enzyme-Linked Immunosorbent Assay (ELISA) were performed to evaluate the recognition ability of IgY. Afterwards, IgY antibodies were covalently immobilized on cellulose-based filters using both periodate oxidation and glutaraldehyde cross-linking methodologies, after grafting amine functional groups to the cellulose-based sheet through a silane coupling technique. The resultant materials were characterized by ATR-Fourier-Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM). The proposed approach can be used to tackle the SARS-CoV-2 pandemic and future infections recurrences, as well as to tackle other problematic pathogens.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). CA acknowledges FCT for the doctoral grant 2022.11570.BD. MCN acknowledges FCT for the research contract CEECIND/00383/2017 under the Scientific Stimulus—Individual Call.

References
1. L. Dietz, P. F. Horve, D. A. Coil, M. Fretz, J. A. Eisen and K. Van Den Wymelenberg, *mSystems.*, 2020, **5**, 1–13.
2. L. Morawska and J. Cao, *Environ. Int.*, 2020,**139**, 105730.
3. E. P. V. Pereira, M. F. van Tilburg, E. O. P. T. Florean and M. I. F. Guedes, *Int Immunopharmacol.*, 2019, **73**, 293–303.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Flavones: synthesis and conjugation with chiral building blocks

A. M. Pereira[1,*], C. Pinto[1], M. Pinto[1], H. Cidade[1], M. E. Tiritan[1,2]

[1]Laboratório de Química Orgânica e Farmacêutica, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Rua Jorge de Viterbo Ferreira 228, 4050-313, Porto, Portugal and Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), Universidade do Porto, Terminal de Cruzeiros de Leixões, Av. General Norton de Matos S/N 4450-208, Matosinhos, Portugal; [2]TOXRUN—Toxicology Research Unit, University Institute of Health Sciences, CESPU, CRL, Rua Central de Gandra 1317, 4585-116 Gandra, Portugal
**up201703979@edu.ff.up.pt*

The World Health Organization recognized that natural organisms, such as plants and fungi, are a source of pharmacologically active compounds, which may be used in basic and high levels of health care practice.[1] However due the difficulty to industrial application, because of the small amount that can be supplied by natural source and their structural complexity for laboratory replicate, their unique structures inspire the design of new analogues with similar biological actions. Among the natural products with different therapeutic uses, flavonoid derivatives, representing a great diversity of compounds, possess a broad spectrum of biological and pharmacological activities.[2] Furthermore, it was shown that the inclusion of a chiral moiety, namely amino acids, can increase their target selectivity, bioavailability and antiproliferative activity.[3] In view of the formerly outlined, this work aimed to augment a compound library of chiral derivatives of flavones with amino esters and the respective amino acids, perform structure elucidation studies by NMR, IR and MS techniques and conduct biological assays for potential antitumor activity evaluation.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the Strategic Funding UIDB/04423/2020 and UIDP/04423/2020 (Group pf Marine Natural Products and Medicinal Chemistry-CIIMAR), within the framework of the program PT2020 and CESPU for project Flav4Tumor-GI2-CESPU-2022. Cláudia Pinto thanks the FCT for her PhD. grant (2022.12419.BD).

References
1. World Health Organization, https://apps.who.int/iris/bitstream/handle/10665/341376/9789289055581-eng.pdf, (accessed June 2023).
2. A. M. Pereira, H. Cidade and M. E. Tiritan, Molecules, 2023, **28(1)**, 426.
3. C. Pinto, H. Cidade, M. Pinto and M. E. Tiritan, Pharmaceuticals, 2021, **14(12)**, 1267.

Cyanine dyes functionalized with (thio)barbiturates as potential anticancer agentes

A. Varges[1,*], L. Santos[1], C. Mendes[1], P. Almeida[1], S. M. Silvestre[1,2], R. E. F. Boto[1], J. L. Serrano[1]

[1]CICS-UBI – Health Sciences Research Center, University of Beira Interior, Av. Infante D. Henrique, 6200-506 Covilhã, Portugal
[2]CNC – Center for Neuroscience and Cell Biology, University of Coimbra, Rua Larga, 3400-517 Coimbra, Portugal
**alexandra.varges@ubi.pt*

Cancer has been one of the most prevalent diseases worldwide and undoubtedly one of the most worrying due to the difficulty in its treatment. Different therapies have been applied to control this disease, including chemo-, radio-, and, more recently, photodynamic therapy. Given the complex nature of this disease, the search for new, safer, and more effective drugs is a daily challenge worldwide. In this regard, studies have been conducted using cyanines or barbiturates as potential antiproliferative agents. Cyanine dyes were discovered by Greville in 1856 and contain two heterocyclic rings linked together by a polymethine chain with an odd number of carbons. Due to their cationic properties, these dyes tend to accumulate in the mitochondria of cancer cells. In this context, recently, we verified the high potency and selectivity of some monomethine cyanine dyes against colorectal Caco-2 cells.[1] Another study involving squaraine cyanine dyes demonstrated an increase in their selectivity and antiproliferative effects when coupled with barbiturates.[2] In this line, several symmetric and asymmetric cyanine dyes functionalized with barbiturates were synthesized (Figure 1), and their antiproliferative activity was evaluated in two cancer cell lines (MCF-7 and Caco-2) and in one non-tumoral cell line (NHDF) at concentrations of 1 and 10 µM. So far, it has been observed that at these concentrations, monomethinecyanines exhibit higher efficacy than tricarbocyanines, and asymmetric dyes demonstrated greater efficacy than symmetric ones. In the near future, concentration-response curves will be performed for the most effective cyanine dyes, along with apoptosis induction studies and its effects on the cell cycle.

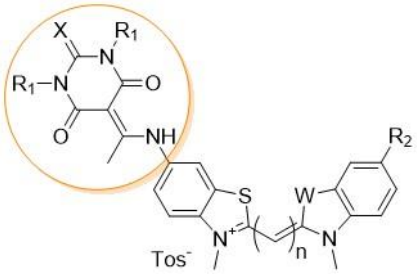


Figure 1: General structure of cyanine dye under study. X = S or O; W = S or O; R_1 = H, CH_3, Et or Ph; n = 1, or 3; R_2 = H or (thio)barbiturate moiety (orange circle).

Acknowledgments
This work was developed within the scope of the CICS-UBI projects UIDB/00709/2020 and UIDP/00709/2020, financed by national funds through the Portuguese Foundation for Science and Technology/MCTES. The NMR spectrometers are part of the Portuguese NMR Network (PTNMR) and are partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). João L. Serrano acknowledges a doctoral fellowship grant from the FCT (SFRH/BD/148028/2019).

References
1. J. L. Serrano, A. Maia, A. O. Santos, E. Lima, L. V. Reis, M. J. Nunes, R. E. F. Boto, S. Silvestre and P. Almeida, Molecules, 2022, **27**, 5779.
2. E. Lima, O. v. Ferreira, V. S. D. Gomes, A. O. Santos, R. E. Boto, J. R. Fernandes, P. Almeida, S. M. Silvestre and L. V. Reis, *Dyes and Pigments*, 2019, **167**, 98 - 108.

P148

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Chemical composition analysis of *Lycium barbarum L.* berries and *Lycium chinense Mill.* leaves cultivated in Southern Portugal

Mariana Monteiro[1,*], Artur M. S. Silva[1], Dulcineia F. Wessel[2], Susana M. Cardoso[1]

[1]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal;*
[2]*School of Agriculture, Polytechnic Institute of Viseu, 3500-606 Viseu, Portugal;*
**marianaicnamonteiro@ua.pt*

The species *Lycium Barbarum L.* (LB) and *Lycium chinense Mill.* (LC), commonly known as "goji", are cultivated globally for berry production, owing to their several beneficial properties.[1] Recent studies have highlighted the potential of extracts from goji berries and leaves as dietary supplements, functional ingredients in various food products, drugs and cosmetics due to their rich nutrient and phytochemical content, including polysaccharides, phenolic compounds, carotenoids, vitamins, and minerals. These compounds exhibit a range of biological activities, such as antioxidant, immunomodulating, hypoglycemic, hypolipidemic, anti-aging, neuroprotective, and cardioprotective effects[2,3].

China currently dominates goji berry production; however, the rising global demand has encouraged farmers in America, Canada, and Europe, including Portugal, to establish goji berry plantations. Portuguese producers are primarily focused on organic cultivation and the marketing of fresh berries, aiming to differentiate themselves from the Chinese market, which predominantly relies on conventional cultivations and the sale of dried berries[4]. Nevertheless, the chemical composition of goji berries and leaves can be influenced by various factors, such as variety, fruit maturity stage, cultivation system (organic or conventional), soil conditions, geographic location, and processing methods[5].

This research aims to investigate the chemical composition and antioxidant activity of extracts from LB berries and LC leaves cultivated in southern Portugal, contributing to a better understanding of their biological potential. Total sugars, total phenolic compounds, total carotenoid content, as well as the phenolic and carotenoid profiles (by UHPLC-DAD-MS) of hydroethanolic extracts from these matrices were evaluated. The LB berries extract was characterised by a high sugar content (968 mg D-glucose/g), a negligible amount of carotenoids (0.11 mg/g), and a phenolic content of 19.93 mg gallic acid equivalents (GAE)/g, with gallic acid, catechin, chlorogenic acid and rutin as its main phenolic constituents. In turn, LC leaves extract displayed a low amount of sugars (5 mg D-glucose/g), but a higher amount of phenolic compounds (26.69 mg GAE/g of extract), with the predominance of gallic acid, catechin, chlorogenic acid, *p*-hydroxybenzoic acid, *p*-coumaric acid and rutin. In addition, it contained considerable levels of carotenoids (5.77 mg/g), with lutein as the main carotenoid. Regarding the antioxidant activity, evaluated by ABTS and DPPH assays, the results indicated a superior activity of the LC leaves extract compared to that of LB berries, with values of 152 and 70 μmol trolox equivalent/g, respectively for the ABTS assay, and 117 and 13 μmol trolox equivalent/g, respectively, for the DPPH assay.

The results of this study confirm that Portuguese *L. barbarum L.* berries and *L. chinense Mill* leaves extracts are a rich source of bioactive compounds with potential biological properties, which raise awareness about their potential applications as functional food ingredients, dietary supplements, drugs and cosmetics and promote the cultivation of goji berries as a sustainable viable crop in Portugal.

Acknowledgements
This work received support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the LAQV-REQUIMTE projects UIDB/50006/2020 and UIDP/50006/2020. Mariana Monteiro acknowledges FCT for the Ph.D. grant 2021.08740.BD.

References

1. M. Castrica, L. Menchetti, C. M. Balzaretti, D. Ranucci, E. Cotozzolo, D. Vigo, G. Curone, G. Brecchia and D. Miraglia, 2020, 1–15.
2. Z. Lei, X. Chen, F. Cao, Q. Guo and J. Wang, *Int. J. Food Sci. \& Technol.*, 2022, **57**, 1451–1461.
3. D. T. Wu, H. Guo, S. Lin, S. C. Lam, L. Zhao, D. R. Lin and W. Qin, *Trends Food Sci. Technol.*, 2018, **79**, 171–183.
4. A. dos jovens A. de Portugal, in *Manual Competividade e Mercados para Culturas Emergentes*, 2018, pp. 7–47.
5. S.-C. Liu, J.-T. Lin, C.-C. Hu, B.-Y. Shen, T.-Y. Chen, Y.-L. Chang, C.-H. Shih and D.-J. Yang, *Food Chem.*, 2017, **215**, 284–291.

Steroids coupled with (thio)barbiturates as potential anticancer agents: Synthesis and biological evaluation

M. Matias[1], P. C. Arias[1], M. Machava[1], I. Figueiredo[1], A. Varges[1], J. L. Serrano[1], P. Almeida[1], S. M. Silvestre[1,2,*]

[1]*CICS-UBI: Health Sciences Research Center, University of Beira Interior, Covilhã, Portugal.*
[2]*CNC: Center for Neuroscience and Cell Biology, University of Coimbra, Coimbra, Portugal*
**sms@ubi.pt*

Steroid molecules are natural products that play a central physiological role in the human body, regulating a variety of biological processes. Therefore, they have been widely used due to their pharmacological and therapeutic properties and modifications in their scaffold can originate, for example, powerful molecules for use in cancer diseases.[1] In addition, (thio)barbituric acid derivatives have become increasingly attractive to medicinal chemists because of their wide biological activities, such as sedative-hypnotic and anesthetic effects, and recently they have also demonstrated antiproliferative properties.[2] Taking this into consideration, this work aimed to synthesize steroids coupled with (thio)barbiturates and to evaluate their *in vitro* cytotoxic activity. The chemical synthesis was carried out using different 5-acetylpyrimidinones, which were coupled to pregnenolone (PREG) or dehydroepiandrosterone (DHEA) hydrazones. The *in vitro* antiproliferative effect of these hybrids was performed at 30 µM on breast cancer cells (MCF-7) and normal human dermal fibroblasts (NHDF) by the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay after 72 h of exposure. Seven compounds of each series were successfully synthesized with moderate to excellent yields (66-96% for PREG series and 65-84% for DHEA series). The results of the biological evaluation showed a generally higher cytotoxicity for steroids coupled with barbiturate derivatives (cellular viability of 8-89% and 11-71% for PREG and DHEA series, respectively) compared with the corresponding thiobarbiturates analogues (cellular viability of 49-68% and 17-90% for PREG and DHEA series, respectively) in MCF-7 cells. The same trend was observed for the NHDF cell line. Globally, the most potent compound was **2e** (Figure 1) leading to a cellular viability of 4% for the breast cancer cells and this effect seemed to be selective for these cells. This suggested that higher aliphatic chains linked to nitrogens at the positions 1 and 3 of the (thio)barbiturate nucleus can be associated with higher cytotoxicity. To conclude, combining a steroid scaffold from PREG and DHEA molecules with the (thio)barbiturate nucleus, in most molecules studied, originated compounds with high antiproliferative effects. Additional studies are ongoing to understand their activity towards other cancer cells as well as the mechanism of action that can be involved in the cytotoxicity of these new chemical entities.

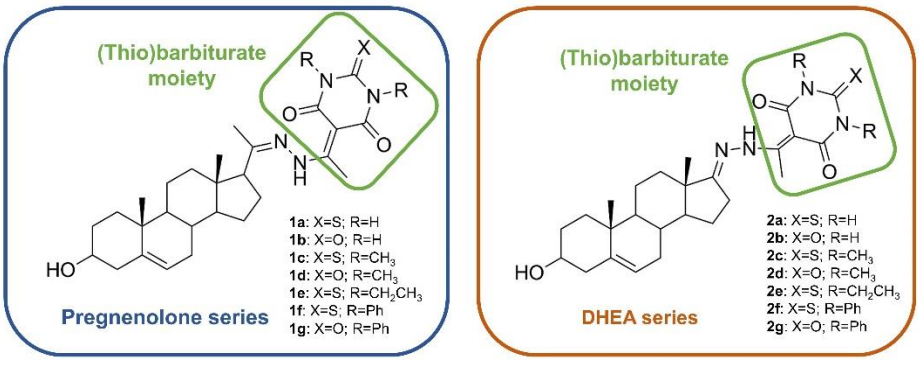


Figure 1: Synthesized compounds combining the steroid nucleus from pregnenolone or dehydroepiandrosterone (DHEA) with 5-acetylpyrimidinones derivatives.

Acknowledgements
This work was developed within the scope of the CICS-UBI projects UIDB/00709/2020 and UIDP/00709/2020, financed by national funds through the Portuguese Foundation for Science and Technology/MCTES. The NMR spectrometers are part of the Portuguese NMR Network (PTNMR) and are partially supported by the Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). João L. Serrano acknowledges a doctoral fellowship grant from the FCT (SFRH/BD/148028/2019).

References
1. C. Canário, M. Matias, V. Brito, P. Pires, A. O. Santos, A. Falcão, S. Silvestre and G. Alves, Appl. Sci., 2022, 12, 3579.
2. J. Figueiredo, J. L. Serrano, E. Cavalheiro, L. Keurulainen, J. Yli-Kauhaluoma, V. M. Moreira, S. Ferreira, F. C. Domingues, S. Silvestre and P. Almeida, Eur. J. Med. Chem., 2018, 143, 829–842.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Transparent and conductive silk films for application in thermotropic and electrochemical devices

J. P. S. Silva[1], T. A. G. Duarte[2], M. M. Silva[1], V. de Zea Bermudez[2], R. F. P. Pereira[1,*]

[1]*Chemistry Center and Chemistry Department, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal*
[2]*Chemistry Department and CQ-VR, University of Trás-os-Montes e Alto Douro, Apartado 1013, 5001-801 Vila Real, Portugal*
**rpereira@quimica.uminho.pt*

As every day goes by, the urge for sustainable, renewable, eco-friendly and affordable materials and devices increases due to Earth's environmental and energy issues. On the last few years, the research regarding devices to prevent these concerns has skyrocketed, which led to a greater understanding of certain feedstocks and resources, including some natural polymers like proteins, that were previously underestimated as sustainable materials. With the growing interest of the scientific community in these bioinspired approaches, the domain of energy materials has been one of the most impacted, leading to the development of many polysaccharide-based polymer electrolytes (PEs) for electrochemical devices but only a few proteins were applied.

Among the panoply of promising protein-based polymers, one of the most promising is the silk fiber, a biopolymer consisting of fibroin and sericin.[1] Silk fibroin (SF), the core protein of silk fiber, is typically applied in the biomedical field but, most recently, its application has expanded to several areas like optics, electronics and food.[2,3] Knowing that and having in consideration the exceptional mechanical properties, biocompatibility, and controllable biodegradability typical of *Bombyx mori*-derived SF, our research group synthesized the first PEs composed of SF, glycerol, and lithium salts to produce electrochromic devices (ECDs) for smart windows of energy efficient buildings.[4] This communication will show the latest results regarding the use of SF films doped with an innovative ionanofluid (INF) composed of silk-derived carbon dots (CDs) and ionic liquids (ILs),[5] resulting in highly transparent and conductive solid films. Various concentrations of ILs and INF were tested, through multiple types of characterization, namely impedance, UV-Vis and FTIR spectroscopy. Preliminary tests with a prototype sun-actuated thermotropic window (TTW) led to transmittance variations (ΔT) of around 16% at 550/1400 nm at 40 and 60 ºC, respectively. Coating one of the glass slides with silver islands, allowed to increase the ΔT to 25/34% and 18/29%, respectively.

Taking in mind the characteristics of the doped SF films, especially their mechanical properties and high conductivity, they are expected to provide great results, not only when integrated in thermotropic/ECDs, but also in other electrochemical devices.

Acknowledgements

Fundação para a Ciência e a Tecnologia, I.P. is acknowledged in the scope of the project SOLPOWINS-Solar-Powered Smart Windows for Sustainable Buildings (PTDC/CTM/4304/2020), and strategic projets UIDB/QUI/00686/2020, UIDP/QUI/00686/2020, UIDB/00616/2020 and UIDP/00616/2020. OBTAIN-Objective Sustainability (NORTE-01-0145-FEDER-000084), co-financed by the European Regional Development Fund (FEDER) through NORTE 2020 (Northern Regional Operational Programme 2014/2020). T.A.G.D. thanks OBTAIN for his postdoc grant (BIPD/UTAD/18/2021). R.F.P.P. acknowledges FCT-UMinho for his contract in the scope of Decreto-Lei 57/2016 57/2017.

References

1. R. F. P. Pereira, M. M. Silva and V. de Zea Bermudez, *Macromol. Mater. Eng.*, 2015, **300**, 1171-1198.
2. G. Guidetti, L. d'Amone, T. Kim, G. Matzeu, L. Mogas-Soldevila, B. Napier, N. Ostrovsky-Snider, J. Roshko, E. Ruggeri and F. G. Omenetto, Appl. Phys. Rev., 2022, **9**, 011302.
3. D.-L. Wen, D.-H. Sun, P. Huang, W. Huang, M. Su, Y. Wang, M.-D. Han, B. Kim, J. Brugger, H.-X. Zhang and X.-S. Zhang, Microsyst. Nanoeng., 2021, **7**, 35.
4. R. F. P. Pereira, F. Sentanin, A. Pawlicka, M. C. Gonçalves, M. M. Silva and V. de Zea Bermudez, *ChemElectroChem*, 2016, **3**, 1084-1097.
5. T. A. G. Duarte, R. F. P. Pereira, B. Medronho, E. S. Maltseva, E. F. Krivoshapkina, A. Varela-Dopico, P. Taboada, L. Fu, R. A. S. Ferreira, V. de Zea Bermudez, submitted.

Specific avian immunoglobulin Y (IgY) antibodies to tackle multiressistant bacteria

C. Almeida[1,2], D. Sousa[1], P. Vilarinho[2], J. A. P. Coutinho[1,2], M. C. Neves[1,2], M. G. Freire[1,2,*]

[1]*CICECO-Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*RYA Purification Technologies, 3830-352 Ílhavo, Portugal*
**maragfreire@ua.pt*

The inadequate use of antibiotics in the last decades have contributed to an increase of the Antimicrobial Resistance (AMR).[1] AMR is one of the most significant global public health threats, being Methicillin-resistant *Staphylococcus aureus* (MRSA) one of the most dangerous pathogenic bacteria.[2] Accordingly, it is urgent to identify alternative approaches, such as biopharmaceuticals, to effectively address this worrisome scenario. Within this, Avian Immunoglobulin Y (IgY), an antibody present in the egg yolk of hen's eggs, can be considered as a promising alternative to conventional antibiotics.[3] Contrarily to its mammalian equivalent Immunoglobulin G (IgG), IgY is recovered through a non-invasive methodology at high titers, and given their polyclonal nature, IgY can detect several epitopes on an antigen, which is particularly beneficial for the treatment of a variety of microbial infectious diseases.[3] Nevertheless, the complexity of egg yolk makes their recovery at high purity, high yields, and their preservation difficult to achieve, restraining their widespread application as biopharmaceuticals.

This work aims to evaluate the potential of IgY to tackle diseases caused by MRSA. To this end, non-specific and specific IgY antibodies were purified from the egg yolk of commercial and hyperimmune eggs from hens previously immunized with the recombinant Penicillin-Binding Protein 2a (PBP2a) of MRSA. Formulations comprising anti-PBP2a IgY were prepared and stored at 4 or -20 ºC, up to 3 months. The percentage of IgY aggregates formed and the stability of IgY in these formulations were evaluated by Size Exclusion-High Performance Liquid Chromatography (SEC-HPLC) and Circular Dichroism (CD) Spectroscopy, respectively. The capacity of anti-PBP2a IgY of recognizing the pathogen was assessed through Dot-Blot. *In vitro* studies were performed to assess the toxicity of non-specific IgY towards human colon epithelial (Caco-2) cell lines. Moreover, the toxicity of the anti-PBP2a IgY formulation was evaluated towards a rodent model by administration of two different doses. The results obtained reveal the potential of IgY-based biopharmaceuticals to tackle infectious diseases caused by multiressistant bacteria, while allowing to decrease the economic, societal and health burdens associated to AMR.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). CA acknowledge FCT for the doctoral grant 2022.11570.BD. MCN acknowledge FCT for the research contract CEECIND/00383/2017 under the Scientific Stimulus—Individual Call.

References
1. B. Aslam, W. Wang, M. I. Arshad, M. Khurshid, S. Muzammil, M. H. Rasool, M. A. Nisar, R. F. Alvi, M. A. Aslam, M. U. Qamar, M. K. F. Salamat and Z. Baloch, *Infect Drug Resist.*, 2018, **11**, 1645–1658.
2. F. Prestinaci, P. Pezzotti and A. Pantosti, *Pathog Glob Health.*, 2015, **109**, 309–318.
3. E. P. V. Pereira, M. F. van Tilburg, E. O. P. T. Florean and M. I. F. Guedes, *Int Immunopharmacol.*, 2019, **73**, 293–303.

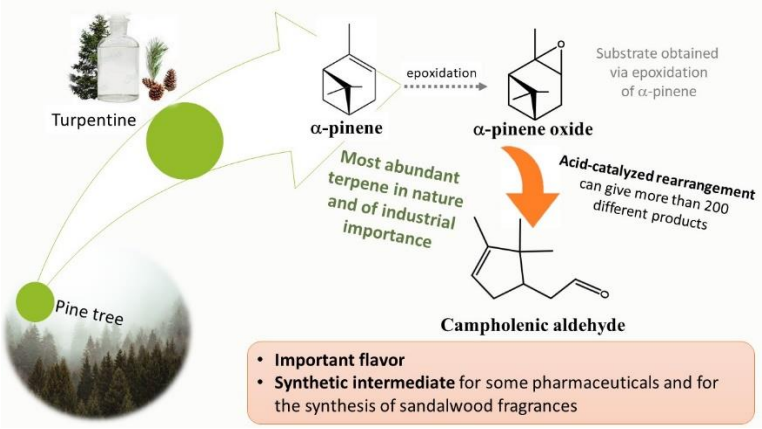
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Application of organomolybdenum complexes for mild synthesis of campholenic aldehyde

Sofia M. Bruno*, Martyn Pillinger, Isabel S. Gonçalves, Anabela A. Valente

CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
**sbruno@ua.pt*

Group 6 (Mo, W) metal carbonyl complexes may act as organometallic Lewis acids for several acid-catalysed reactions. Some patented technologies use metal halide salts as catalysts, which present numerous drawbacks such as corrosion problems, fast deactivation, the production of large volumes of acidic waste, and the need for high catalyst/substrate ratios. Hence, there is much interest in the development of novel reaction processes catalysed by highly active and selective Lewis acids that significantly reduce acidic wastes.
A commercially important reaction favored in the presence of Lewis acids is the catalytic isomerization of α-pinene oxide (PinOx) to campholenic aldehyde (CPA), see scheme 1. PinOx is a renewable chemical obtained from α-pinene, the most abundant terpene in nature and of industrial importance; it can be obtained by tapping trees (gum turpentine) or as a byproduct of paper pulping processes. CPA is an important flavor chemical and a synthetic intermediate for some pharmaceuticals and for the synthesis of sandalwood fragrances, e.g., Brahmanol® (Dragoso) and Polysantol® (Firmenich). Traditionally, zinc halides have been viewed as the state-of-the-art homogeneous catalysts, leading to CPA selectivities up to about 85%.[1]
The application of molybdenum-based complexes in this specific reaction is attractive due to the ready availability and relatively low cost of this element. Here, the catalytic activity, selectivity and recyclability of a series of organomolybdenum complexes is discussed with respect to CPA synthesis, emphasizing the importance of ionic liquids as neoteric solvents.



Scheme 1: Schematic representation of the processes for obtaining campholenic aldehyde.

Acknowledgements
We acknowledge funding provided within the project CICECO - Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020, and the CENTRO 2020 Regional Operational Programme (project references CENTRO-01–0145-FEDER- 028031 and PTDC/QUIQOR/28031/2017), financed by national funds through the FCT (Fundação para a Ciência e a Tecnologia)/MEC (Ministério da Educação e Ciência) (PIDDAC) and when appropriate co-financed by the European Union through the European Regional Development Fund under the Portugal 2020 Partnership Agreement.

References
1. B. J. Kane, G. P. Sanders, J. W. Snow, M. B. Erman. U.S. Patent 6,515,186 B2, 2003.

Glucose oxidase immobilization onto graphitic carbon nitride for improved starvation therapy of cancer

Rita A. M. Barros*, Raquel O. Cristóvão, Maria J. Sampaio, Cláudia G. Silva, Joaquim L. Faria

LSRE-LCM - Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal and ALiCE – Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
**up201604653@edu.fe.up.pt*

According to the World Health Organization, cancer is still the main cause of human mortality, causing millions of deaths worldwide[1]. In recent years, a new starvation therapy (ST) based on cutting off nutrient sources to inhibit tumor cell growth has gained great attention[2]. This promising novel treatment uses glucose oxidase (GOx) to convert glucose (a nutrient used for tumor growth) into gluconic acid and hydrogen peroxide (H_2O_2). Still, its therapeutic efficacy is limited by the enzyme's low stability and poor blood circulation, which restricts the *in vivo* application for cancer therapy. To mitigate these problems, nanoparticle catalysts can integrate enzymes to improve their kinetics and stability, allowing their effective accumulation and release in tumor regions, which may improve the therapeutic efficacy and reduce side effects[3].

The aim of this work is to evaluate and maximize the efficiency of thermally exfoliated graphitic carbon nitride (GCN-T) for the immobilization of GOx and further assessment of its ability to degrade the nutrient glucose, for cancer treatment by ST. Synthetized by earth-abundant elements (*i.e.,* C, N and H), GCN-T has outstanding biocompatibility, thermal and chemical stability, photocatalytic activity, and tunable functionalization, all of which provide a unique set of interesting properties for its use in various fields[4,5]. Different immobilization conditions were optimized, such as GCN-T/GOx ratio, contact time between the enzyme and the nanomaterial, and solution pH. The GCN-T adsorption capacity and GOx recovered activity were determined by UV-vis spectroscopy. The results demonstrate the excellent performance of the GCN-T as support of GOx with a maximum enzyme loading of 215 U per g of material. The reusability of the bioconjugate and the stability of the system were also evaluated over time and at various temperatures and pH values. After obtaining the optimal system, the bioconjugate material capacity for glucose degradation and H_2O_2 production was investigated to verify the potential of the system to be used in cancer treatment by ST (Figure 1).

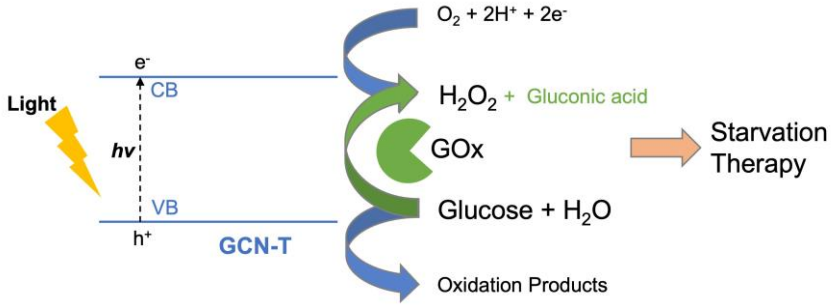


Figure 1: Mechanism scheme on the use of GCN-T/GOx bioconjugate for starvation therapy of cancer.

Acknowledgements
This work was financially supported by: LA/P/0045/2020 (ALiCE) and UIDB/50020/2020 - UIDP/50020/2020 (LSRE-LCM) funded by national funds through FCT/MCTES (PIDDAC). R.A.M. Barros acknowledges FCT for her PhD grant 2022.12055.BD. MJS acknowledges FCT funding under the Scientific Employment Stimulus - Institutional Call (CEECINST/00010/2021).

References
1. World Health Organization, Cancer.
2. S. Yu, Z. Chen, X. Zeng, X. Chen and Z. Gu, *Theranostics*, 2019, **9**, 8026–8047.
3. M. Wang, D. Wang, Q. Chen, C. Li, Z. Li and J. Lin, *Small*, 2019, **15**, 1–26.
4. D. Mittal and D. P. Dutta, *Journal of Materials Science: Materials in Electronics*, 2021, **32**, 18512–18543.
5. A. Torres-Pinto, M. J. Sampaio, J. Teixo, C. G. Silva, J. L. Faria and A. M. T. Silva, *Journal of Water Process Engineering*, 2020, **37**, 101467

P154

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Immunoglobin G purification using carbon nanomaterials obtained from food waste

Francisco M. Moreira[1,*], Kumud Malika Tripathi[2], Ana P. Tavares[1], Mara G. Freire[1]

[1]CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]Department of Bionanotechnology, Gachon University, 1342 Seongnam-daero, Sujeong-gu, Seongnam-si, Gyeonggi-*do* *13120, South Korea*
**francisco.moreira@ua.pt*

Immunoglobin G (IgG) has increasing importance in the development of new biopharmaceuticals, Due to its specific characteristics it can be used to treat several illnesses, ranging from autoimmune diseases to antibiotic-resistant bacteria infections[1,2,3]. However, IgG purification technologies are complex, time-consuming, and expensive, resulting in a final product extremely costly to the final consumer, hindering the accessibility of life-saving treatments to the wider public[4,5]. To overcome this problem, it is necessary to develop a new IgG purification process that can maintain high purification and yield levels, while being simpler and cheaper than traditional processes. This work aims to study a new purification process using carbon aerogel materials obtained from food waste as a platform to selectively adsorb, and thus purify, IgG from human serum. The influence of the contact time between the material and serum samples containing IgG, pH, mass of adsorbent, and serum dilution were evaluated using a central point design experiment. At the optimized conditions, the material can selectively adsorb IgG, reaching a purification factor above 2 and an adsorption yield above 40%.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). Ana P. M. Tavares acknowledges the FCT for the research contract CEECIND/2020/01867.

References

1. A. L. Grilo and A. Mantalaris, *Trends Biotechnol*, 2019, **37**, 9–16.
2. J. G. Elvin, R. G. Couston and C. F. van der Walle, *Int J Pharm*, 2013, **440**, 83–98.
3. C. Ghosh, P. Sarkar, R. Issa and J. Haldar, *Trends in Microbiology*, 2019, **27**, 323–338.
4. A. M. Ferreira, V. F. M. Faustino, D. Mondal, J. A. P. Coutinho and M. G. Freire, *J Biotechnol*, 2016, **236**, 166–175.
5. P. A. J. Rosa, A. M. Azevedo and M. R. Aires-Barros, *J Chromatogr A*, 2007, **1141**, 50–60.

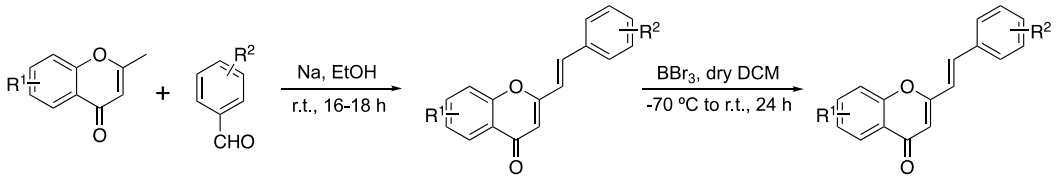
(*E*)-2-Styrylchromones: Synthesis and evaluation of the inhibitory effects on the oxidative burst of human monocytes

Catarina M. Correia[1,*], Marisa Freitas[2], Adelaide Sousa[2], Eduarda Fernandes[2], Artur M. S. Silva[1], Vera L. M. Silva[1]

[1]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, Aveiro 3810-193, Portugal*
[2]*LAQV-REQUIMTE, Laboratory of Applied Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Porto 4050-313, Portugal*
**catarina.m.c@ua.pt*

Several studies have attributed the onset and progression of several diseases, such as atherosclerosis and cell ageing to the overproduction of prooxidant reactive species (RS). Monocytes are key cells regarding the immune response of the body and can contribute to an exacerbated and uncontrolled production of RS.[1] The interest in (*E*)-2-styrylchromones has been increasing in the last years due to their biological activities related to their antioxidant and anti-inflammatory properties.[2] Therefore, the main goal of this work was the synthesis of (*E*)-2-styrylchromones and the evaluation of their potential inhibitory effects on the oxidative burst produced by human monocytes.

For that purpose, a library of nine (*E*)-2-styrylchromones **1f** and **2a-h**, were synthetized, and obtained in moderate to good yields (45-86%) except for compound **2h** (16%), by the aldol condensation of 2-methylchromones with substituted benzaldehydes at room temperature, followed by BBr_3-promoted cleavage of the methoxy groups (Scheme 1).[3] These compounds were evaluated for their ability to inhibit the oxidative burst of human monocytes, using the fluorescent probe dihydrorhodamine 123. Among the nine compounds tested, only two (*E*)-2-styrylchromones **1a** and **1h** were active, presenting an IC_{50} = 10 ± 2 μM and IC_{50} = 10 ± 1 μM, respectively, higher than the IC_{50} found for the positive control diphenyleneiodonium chloride (IC_{50} = 0.9 ± 0.1 μM). Based on the results obtained, we conclude that the presence of the hydroxy groups at both C-5 and C-4' may be crucial to the burst oxidative inhibitory activity, which is key information for the design of novel and more active derivatives.



1a) R^1 = 5-OCH_3, 7-OCH_3; R^2 = 4'-OH
1b) R^1 = 5-OCH_3; R^2 = 3'-Cl
1c) R^1 = 5-OCH_3; R^2 = 3',4'-$(Cl)_2$
1d) R^1 = 5-OCH_3; R^2 = 2',6'-$(Cl)_2$
1e) R^1 = 5-OCH_3; R^2 = 2'-OCH_3
1f) R^1 = 5-OCH_3; R^2 = 3'-OCH_3
1g) R^1 = 5-OCH_3; R^2 = 3',4',5'-$(OCH_3)_3$
1h) R^1 = H; R^2 = 3'-OCH_3

2a) R^1 = 5-OH, 7-OCH_3; R^2 = 4'-OH
2b) R^1 = 5-OH; R^2 = 3'-Cl
2c) R^1 = 5-OH; R^2 = 3',4'-$(Cl)_2$
2d) R^1 = 5-OH; R^2 = 2',6'-$(Cl)_2$
2e) R^1 = 5-OH; R^2 = 2'-OH
2f) R^1 = 5-OH; R^2 = 3'-OH
2g) R^1 = 5-OH; R^2 = 3',4',5'-$(OH)_3$
2h) R^1 = H; R^2 = 3'-OH

Scheme 1: Synthesis of (*E*)-2-styrylchromones **1f** and **2a-h**.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.

Acknowledgements
Catarina M. Correia thanks FCT/MCTES and the project "2-Styrylchromones in the treatment of rheumatoid arthritis: a promising therapeutic alternative" - POCI-01-0145-FEDER-029253, for her research fellowship. Thanks are also due to the National NMR Network (PTNMR) and are partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).
Vera L.M. Silva thanks FCT for funding through the Scientific Employment Stimulus – Institutional call (Ref. CEECINST/ 00026/ 2018). Marisa Freitas acknowledges her CEEC Individual 2020. 04126.CEECIND/CP1596/CT0006 and LAQV-REQUIMTE for her contract under the reference LA/P/0008/2020.

References

1. T. A. Jacinto, G. S. Meireles, A. T. Dias, R. Aires, M. L. Porto, A. L. Gava, E. C. Vasquez, T. M. C. Pereira, B. P. Campagnaro and S. S. Meyrelles, *Biol. Res.*, 2018, **51**, 1–13.
2. M. Lucas, M. Freitas, A. M. S. Silva, E. Fernandes and D. Ribeiro, *Oxid. Med. Cell. Longev.*, 2021, **2021**, 1-47.
3. C. M. M. Santos and A. M. S. Silva, *Eur. J. Org. Chem.*, 2017, **2017**, 3115–3133.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

NMR Centre @ University of Aveiro

P. C. R. Soares-Santos

CICECO – Aveiro Institute of Materials, Chemistry Department, NMR Centre, University of Aveiro, 3810-193 Aveiro, Portugal
paula.santos@ua.pt

The Nuclear Magnetic Nuclear (NMR) Laboratory of the Chemistry Department, University of Aveiro,[1,2] comprises the following NMR spectrometers:

- 300 MHz narrow-bore (liquids)
- 400 MHz wide-bore (solids)
- 500 MHz with LC-NMR narrow-bore (metabonomics)
- 500 MHz narrow-bore with N_2 cryoprobe (liquids)
- 700 MHz narrow-bore (solids and liquids)
- 400 MHz wide-bore with DNP system (solids)

The Aveiro NMR Centre pioneered in Portugal solid-state NMR, LC-NMR and the study of natural products and metabonomics.
300 MHz and 500 MHz NMR spectrometers are dedicated to the study of liquid-state and solution samples while the 400 MHz and 700 MHz are dedicated (mostly) to solid-state research. The DNP NMR system is unique in the country and one of the few available in Europe.
The Aveiro NMR Centre is a partner in the Portuguese NMR Network (PTNMR) since December 2009, which now integrates 11 Portuguese NMR laboratories.[3]
The solid-state NMR Centre of the University of Aveiro is a partner in the running EU project PANACEA: Pan-European Solid-State NMR Infrastructure for Chemistry-Enabling Access, that comprises 7 solid-state NMR laboratories across Europe and 1 from the US (Figure 1).[4]
Until the end of 2023, all these NMR spectrometers will be moved and installed in a built-on-purpose building, materialising the future NMR Centre of the University of Aveiro (near the Chemistry Department) (Figure 1). This will become the main NMR for spectroscopy centre in the country.

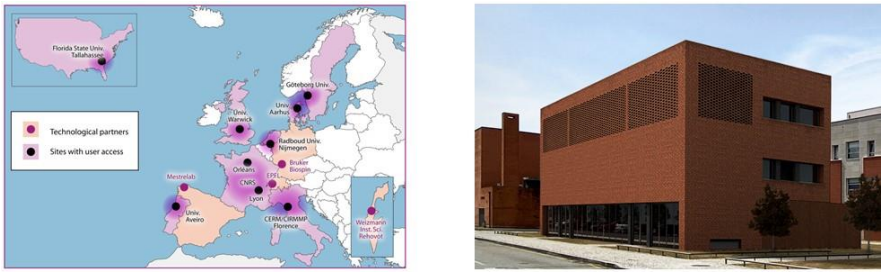


Figure 1: PANACEA network (left) and Future NMR Centre (right)

Acknowledgements
Thanks are due to University of Aveiro, CICECO – Aveiro Institute of Materials, LAQV-REQUIMTE - Laboratório Associado para a Química Verde, PTNMR and PANACEA (received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101008500).
"This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC)."
"The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC)."

References

1. Chemistry Department of University of Aveiro Online, https://www.ua.pt/pt/dqua/dqua-espectroscopia-de-ressonancia-magnetica-nuclear, (accessed June 2023).
2. CICECO – Aveiro Institute of Materials Online, https://www.ciceco.ua.pt/?menu=522&tabela=geral, (accessed June 2023).
3. PTNMR Online, http://ptnmr.web.ua.pt/, (accessed June 2023).
4. PANACEA Online, https://panacea-nmr.eu/, (accessed June 2023).

Graphitic carbon nitride polymeric films for selective aldehydes synthesis using mesostructured photoreactor

Rafael C. Carneio, Joana C. Lopes*, Dânia S. M. Constantino, Maria J. Sampaio, Joaquim L. Faria, Cláudia G. Silva

LSRE-LCM - Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal and ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
**joanacl@fe.up.pt*

Environmental concerns have led to significant advancements in the field of Chemical Engineering, aiming to mitigate the carbon footprint as well to establish sustainable processes. The drawbacks of conventional chemical manufacturing have received substantial attention from scientific community. Some disadvantages include complex reaction setups, generation of large quantities of waste and the requirement of high energy consumptions. In this way, photocatalysis offers a promising alternative to the conventional processes, as it operates under milder reaction conditions. The integration of sustainable processes and materials with high activity, such metal-free graphitic carbon nitride-based (g-C_3N_4) photocatalysts, represents a crucial step towards industrial implementation.

Traditionally, photocatalytic processes involve the use of suspended catalyst, requiring additional separation processes for the catalyst recovery. In turn, immobilized materials offer several benefits, including its reusability and catalyst stability, protecting the photocatalyst from harsh reaction conditions. Additionally, immobilized photocatalysts are easily scalable, making them proper for large-scale applications, which enables efficient production and reduces the amount of catalyst required. Furthermore, the use of micro-mesostructured photoreactors provides larger surface areas per reaction volume, ensuring a higher spatial illumination homogeneity and better light penetration through the entire reactor[1].

In this work, the NETmix reactor was integrated with a LEDs compact system using an immobilized photocatalytic film to be carried out selective oxidation reactions. An exfoliated g-C_3N_4 nanosheets (GCN-TS) photocatalyst was immobilized in a biodegradable matrix (sodium alginate). The photocatalytic performance of the immobilized catalyst was investigated for the photocatalytic oxidation of aromatic alcohols, including anisyl alcohol (AA), benzyl alcohol (BA), piperonyl alcohol (PA), tolyl alcohol (TA) and vanillin alcohol (VA) to the synthesis of their respective aldehydes, anisaldehyde (AAD), benzaldehyde (BAD), piperonal (PAD), tolualdehyde (TAD) and vanillin (VAD) (Figure 1).

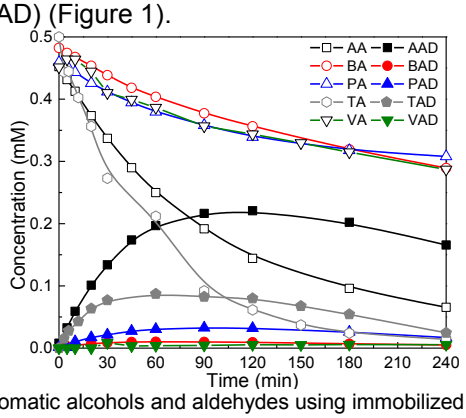


Figure 1: Concentration profiles of the aromatic alcohols and aldehydes using immobilized g-C_3N_4 catalyst on NETmix photoreactor.

The photocatalytic system showed the best results for AAD production. Therefore, the study was proceeded by evaluating the catalyst load in the film (0.4 - 3.2 g L^{-1}). The results revealed an optimal compromise for AAD production using 2.4 g L^{-1} of GCN-TS load on the film, being achieved 64% of AAD conversion after 3 hours of reaction under visible-light irradiation.

Acknowledgements
This work was financially supported by LA/P/0045/2020 (ALiCE), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM), funded by national funds through FCT/MCTES (PIDDAC). The authors also thank the project ClimActic (NORTE-01-0145-FEDER-000071). M.J.S. acknowledges FCT funding under the Scientific Employment Stimulus - Institutional Call (CEECINST/00010/2021). JCL acknowledges the PhD research grant from FCT, Ref. 2020.04651.BD.

References

1. Y. Matsushita, T. Ichimura, N. Ohba, S. Kumada, K. Sakeda, T. Suzuki, H. Tanibata and T. Murata, *Pure and Applied Chemistry*, 2007, **79**, 1959-1968.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Pharmaceuticals determination in water samples by solid phase extraction using low-cost waste-based sorbents

Diana L. D. Lima[1,*], A. Stratulat[2], Érika M. L. Sousa[1], V. Calisto[1]

[1]*CESAM & Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal*
[2]*Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal*
**diana.lima@ua.pt*

Given the enormous increase in the contamination of aquatic ecosystems by pharmaceuticals, and considering the low levels at which these contaminants occur, effective sample clean-up and preconcentration techniques, in combination with adequate quantification methodologies, are necessary for the analysis of these compounds at environmentally relevant levels. Solid phase extraction (SPE) is the generally applied procedure for the extraction of a wide variety of contaminants in water samples. However, the costs associated with the sorbents make it prohibitive for application in large environmental screenings. The development of alternative sorbents derived from wastes is especially attractive, not only due to the cost reduction, but also considering the circular economy paradigm. In this work, two biomass-based sorbents, derived from waste materials (spent brewery grains (SBG) and primary paper mill sludge (PPS)) were successfully produced through chemical activation and pyrolysis. Two microporous materials were obtained with remarkably similar properties in what concerns average pore diameter (D), average micropore width (L) and total pore volume (V_p). Also, scanning electron microscopy (SEM) images (**Figure 1**) corroborated the high porosity of the materials.
Activated carbons obtained from PPS (AC-PPS) and from SBG (AC-SBG) were used in SPE cartridges for the preconcentration of carbamazepine (CBZ) and sulfamethoxazole (SMX), that have been detected in aquatic environment at ng L^{-1} and μg L^{-1}, and then quantified using high-performance liquid chromatography with UV or fluorescence detection, respectively. Initially, an optimization step based on the evaluation of type and amount of sorbent used, eluent type, eluent volume, contact time and sample volume was performed. Then, under optimized conditions, calibration curves were obtained for CBZ with standards ranging from 1 to 10 μg L^{-1} and for SMX, with standards ranging from 0.050 and 1 μg L^{-1}, resulting in limits of detection of 0.69 μg L^{-1} for CBZ and 0.015 μg L^{-1} for SMX. After the optimization step, recovery tests were performed at three levels of concentration and using two different water samples (river water and urban wastewater collected in a wastewater treatment plant). Recovery efficiency in river water was maintained for both pharmaceuticals for a wide range of concentrations, however for wastewater it decreased significantly, due to pH implications for SMX, and high DOC values for both SMX and CBZ. From this work, it was concluded that the developed method was accurate and repeatable, being suitable to be applied in the determination of SMX and CBZ in surface waters.

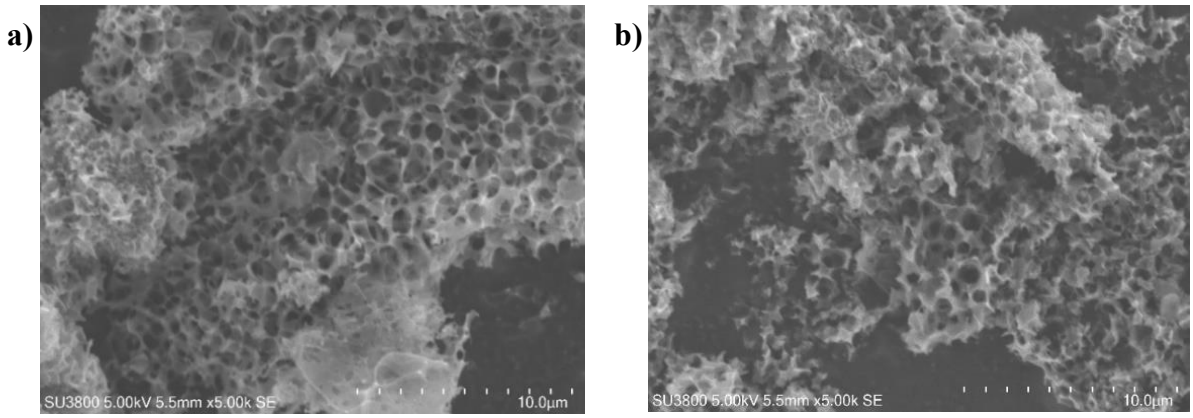


Figure 1: Scanning electron microscopy images for a) AC-PPS and b) AC-SBG at magnifications of 5000x

Acknowledgements
Diana Lima acknowledges funding from Fundação para a Ciência e a Tecnologia (FCT) under the Scientific Employment Stimulus (2022.00570.CEECIND). The authors acknowledge financial support to CESAM by FCT/MCTES (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020), through national funds.

Bimetallic catalyzed approaches for the synthesis of indole derivatives

Nuno Viduedo[1,*], Rita Ferro[1], A. Sofia Santos[1,2], Artur M. S. Silva[2], Beatriz Royo[3], M. Manuel B. Marques[1]

[1]LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal; [2]LAQV@REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [3]ITQB NOVA, Instituto de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Av. da República, 2780-157 Oeiras, Portugal.
**n.viduedo@campus.fct.unl.pt*

The synthesis of indole derivatives, renowned for their remarkable pharmacological properties as anticancer, antioxidant, and anti-inflammatory agents, has attracted considerable attention within the realms of synthetic and medicinal chemistry.1 In order to enhance the synthetic methodologies for indole-based compounds, there has been a particular emphasis on metal-catalyzed approaches that employ imine intermediates to generate diverse N-heterocycles.2 Over the past few years, the utilization of bimetallic catalysis has emerged as a promising strategy for the construction of C–C and C–heteroatom bonds, particularly by combining palladium catalysts with inexpensive and Earth-abundant metals, not commonly used in cross-coupling reactions.3 In this study, we introduced a novel bimetallic synthesis strategy for the preparation of 2-arylindoles using alcohols and anilines as the starting materials. The dehydrogenation or oxidation of secondary alcohols was accomplished through nickel- or manganese-catalyzed reactions, respectively. The resulting ketone product was subsequently transformed into an imine intermediate, which underwent cyclization to afford the desired 2-arylindole via a palladium-catalyzed oxidative cyclization process. The synthesis was performed without isolating intermediates, simplifying the process. Furthermore, the compatibility of the catalysts was investigated and an optimized protocol was developed, integrating Earth-abundant metals and palladium complexes, thereby enhancing the sustainability of N-heterocycles synthesis (Figure 1).4

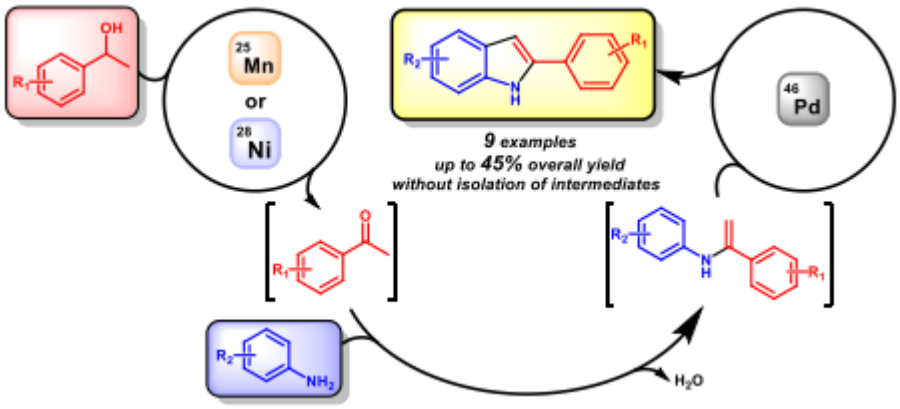


Figure 1: Bimetallic synthesis of 2-arylindoles from 1-phenylethanol derivatives and aniline derivatives.

Acknowledgements
We thank the Fundação para a Ciência e Tecnologia for financial support (FCT, projects PTDC/QUI-QOR/0712/2020 and PTDC/QUI-QIN/0359/2021, and PhD Fellowship 2022.12365.BD). The authors also thank the support by the Laboratório Associado para a Química Verde (LAQV), which is financed by national funds from FCT/Ministério da Ciência, Tecnologia e Ensino Superior and MOSTMICRO-ITQB, UIDB/04612/2020 and UIPD/04612/2020. The National NMR Facility is supported by FCT, ROTEIRO/0031/2013–PINFRA/22161/2016, co-financed by FEDER through COMPETE 2020, POCI, and PORL and FCTthrough PID-DAC) and CERMAX (022162).

References
1. T. Singh and O. Singh, Mini-Reviews in Medicinal Chemistry, 2017, 18.
2. a) A. S. Santos, M. M. Martins, A. C. Mortinho, A. M. S. Silva and M. M. Marques, Tetrahedron Letters, 2020, 61, 152303. b) D. Raydan, S. Friães, B. Royo, M. M. Marques, N. Viduedo, A. S. Santos and C. S. Gomes, Synlett, 2022, 33, 1290–1294.
3. D. R. Pye and N. P. Mankad, Chemical Science, 2017, 8, 1705–1718. 4. M. M. Marques, R. Ferro, N. Viduedo, A. S. Santos, A. M. Silva and B. Royo, Synthesis, 2023

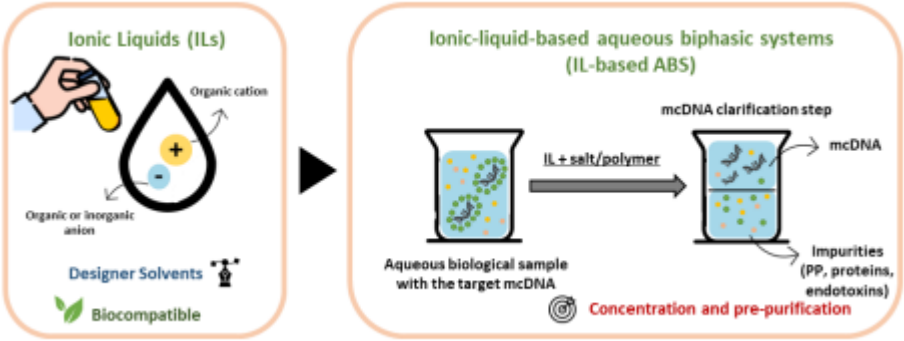
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Production and purification of non-viral vectors for gene therapy applications

A. I. Valente[1], L. S. Castro[1], I. D. Rios[1], A. Q. Pedro[1], A. P. M. Tavares[1], F. Sousa[2], M. G. Freire[1,*]

[1]CICECO – Aveiro Institute of Materials, Chemistry Department, University of Aveiro, Portugal; [2]CICS-UBI – Health Sciences Research Centre, University of Beira Interior, Portugal
**maragfreire@ua.pt*

Cancer is the second cause of death worldwide with relevant societal and economic burdens. Approximately 19.3 million new cases and 10 million cancer deaths were registered in 2020, being projected an increase in cancer incidence in the coming years.1 To counteract this trend and mitigate consequences, multiple innovations have been achieved in oncology, from which the manufacturing of biopharmaceuticals as effective therapeutic agents stands out. Nowadays, there are more than 540 biopharmaceuticals approved in the EU/USA, and nucleic acids are gaining momentum both in the prophylaxis of infections and as therapeutic agents in gene therapy.2 Gene therapy is based on the transfection of eukaryotic cells with gene-based products to correct the target malfunction. Among these, non-viral vectors including plasmid DNA and minicircle DNA (mcDNA) attracted increased importance.3 Despite their clinical relevance, current manufacturing strategies are still complex and involve multi-step purification processes, ultimately increasing their cost.3 To overcome this obstacle, this work investigates the application of ionic-liquid-based aqueous biphasic systems (IL-ABS) as a primary capture strategy of p53-mcDNA biopharmaceuticals with broad therapeutic efficiency to multiple cancer types (scheme 1). Considering the biological medium complexity in which the target biopharmaceutical is produced, a clarification and concentration step, to be achieved by ILABS, is key before moving to high-resolution chromatographic purification techniques. p53-mcDNA was produced using recombinant Escherichia coli cells in shake flasks and using a suitable culture medium. To promote cell growth and parental plasmid (PP) bioproduction, cells were incubated at optimized conditions. Afterward, recombination was successfully induced using L-arabinose, yielding the p53-mcDNA. The fraction containing the PP and p53-mcDNA was subsequently isolated using a commercial kit, and their partitioning behavior in ABS comprising bromide-based ILs and citrate potassium salt was investigated. Ongoing studies are focused on optimizing the separation of PP and p53-mcDNA using the designed IL-ABS, after which a sample of increased complexity without pretreatment will be applied.



Scheme 1: Proposed application of IL-ABS as a capture strategy for mcDNA biopharmaceuticals.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). This work was additionally developed within the project "PureDNA - Development of cost-effective platforms based on ionic liquids for the purification of p53-minicircle DNA biopharmaceuticals with application in oncology", 2022.03394.PTDC, financially supported by national funds (OE), through FCT/MCTES. Augusto Q. Pedro and Ana P. M. Tavares acknowledge FCT, respectively, for the research contracts CEECIND/02599/2020 and CEECIND/2020/01867 under the Scientific Stimulus – Individual Call. Ana I. Valente and Leonor S. Castro acknowledge FCT, respectively, for the PhD grants 2020/05090/BD and SFRH/BD/08352/2021.

References

1. H. Sung, R. L. Siegel, M. Laversanne, I. Soerjomataram, A. Jemal, F. Bray, CA: Cancer J. Clin., 2021, 71, 209-249.
2. G. Walsh, E. Walsh, Nature, 2022, 40, 1722-1760.
3. A. M. Almeida, D. Eusébio, J. A. Queiroz, F. Sousa, A. Sousa, J. Chromatogr. A, 2020, 1609, 460444

Study of the effects of ohmic heating parameters in the synthesis of potential anticancer *C*-glycosylquinolones

Pedro M. O. Gomes[1,*], Lucie Militão[1], Raquel G. Soengas[2], Artur M. S. Silva[1], Paula B. Andrade[3], Vera L. M. Silva[1]

[1]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Department of Organic and Inorganic Chemistry, University of Oviedo, Julián Clavería 7, 33006 Oviedo, Spain*
[3]*LAQV-REQUIMTE, Laboratório de Farmacognosia, Departamento de Química, Faculdade de Farmácia, Universidade do Porto, R. Jorge Viterbo Ferreira, nº 228, 4050-313 Porto, Portugal*
**pm.gomes@ua.pt*

Quinolin-4(1*H*)-ones (or 4-quinolones), which are very well-known as antibiotics agents, have a remarkable ability to target type IIA topoisomerases, as DNA gyrase and topoisomerase IV, enzymes involved in DNA replication and repair, being regarded as promising anticancer compounds. Some studies have shown that quinolones can induce cell cycle arrest, inhibit cell proliferation, and promote apoptosis in cancer cells.[1]
Glycosylation, the attachment of a carbohydrate to a compound, can enhance its biological properties, including its anticancer activity.[2] Glycosylated compounds, such as quinolines, have been investigated for their potential as anticancer agents due to their improved solubility, bioavailability, and targeted delivery to cancer cells. Some studies have explored their anticancer effects *in vitro* and *in vivo*, and it was found that glycosylation improved selectivity towards cancer cells, sparing normal healthy cells to some extent.[3] Although quinolines are compounds closely related to quinolones, as far as we know, there are no studies about the evaluation of the anticancer activity of glycosylated quinolones.
In this context, we have been interested in the synthesis of novel *C*-glycosylquinolones **3** for further evaluation of their potential as anticancer drugs. We envisioned that compounds **3** could be synthetized in a straightforward manner by a palladium(Pd)-catalyzed Heck reaction of a iodinated quinolone **1** with a vinylsugar derivative **2**. In our group, we have been using ohmic heating to promote Pd-catalyzed reactions with success.[4] However, the effects of ohmic heating parameters such as the frequency and waveform in this kind of reactions remain unexplored. In this work, we studied the effects of frequency and waveform on the heating profile and yield of the Heck reaction shown in Figure 1, which was performed using water and polyethylene glycol as solvent, and we did a comparative study with microwave heating and classical heating conditions. Moreover, the reaction was performed under heterogenous catalysis conditions by using a Pd-silica-supported ionic liquid phase catalyst. The best reaction conditions found were applied to the Heck reaction of different 3-iodoquinolones **1** with the vinylsugar **2** yielding the desired *C*-glycosylquinolones **3** with moderated yields, in short reaction time (Figure 1). More details about this study, that allowed the development of a more sustainable methodology for the synthesis of *C*-glycosylquinolones, will be presented and discussed in this communication.

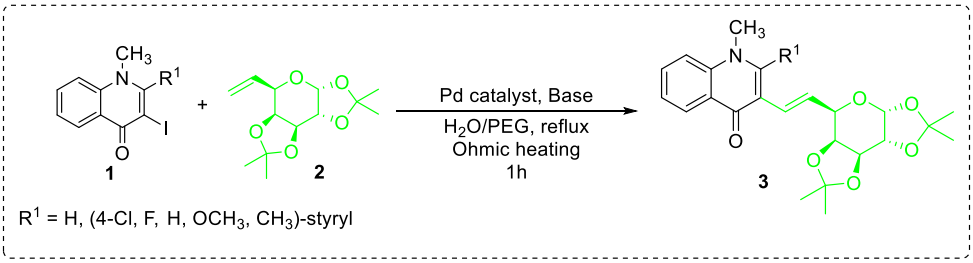


Figure 1: Ohmic heating assisted Heck reaction for the synthesis of *C*-glycosylquinolones **3**.

Funding
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.
Acknowledgements
Pedro M.O. Gomes thanks FCT/MCTES and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for his PhD grant 2020.04972.BD. Thanks are also due to the National NMR Network (PT NMR) partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). Vera L.M. Silva thanks FCT for funding through the Scientific Employment Stimulus – Institutional Call (Ref. CEECINST/ 00026/ 2018).

References
1. V. Yadav, P. Talwar, Biomed Pharmacother., 2019, **111**, 934-946;
2. H. Martin, L. R. Lázaro, T. Gunnlaugsson, E. M. Scanlan, Chem. Soc. Rev., 2022, **51**, 9694-9716
3. V. Oliveri, M. L. Giuffrida, G. Vecchio, C. Aiello, M. Viale, Dalton Trans., 2021, **41**, 4530-4535
4. V. L. M. Silva, L. M. N. B. F. Santos, A. M. S. Silva, Chem. Eur. J., 2017, **23**, 7853-7865

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Evaluation of the antimicrobial activity of porphyrins bearing *N*-donor moieties at 10,20-positions

Melani J. A. Reis[1*], Fabiana Relvas[4], Ana M. V. M. Pereira[2,3], M. Amparo F. Faustino[1], Adelaide Almeida[4], Maria Graça P. M. S. Neves[1], Nuno M. M. Moura[1]

[1]LAQV-Requimte and Department of Chemistry, University of Aveiro, 3010-193 Aveiro, Portugal; [2]ALiCE - Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; [3]LEPABE - Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal; [4]Department of Biology and CESAM, University of Aveiro, Aveiro, Portugal
**melani@ua.pt*

Antibiotics have a key role in global health and modern medicine leading to higher average life expectancy.[1,2] However, currently one of the greatest public health challenges is associated to antibiotic resistance, due to the inadequate prescription and overuse of antibiotics, with the consequent growing number of infections caused by microorganisms. Combating these threats is a public health priority that requires the development of efficient antimicrobial therapeutics.[3] Antimicrobial photodynamic therapy (aPDT) is considered a promising alternative to the use of conventional antimicrobials, mainly in the case of localized infections. This approach combines the use of light, dioxygen ($^3O_2$) and a photosensitizer (PS), leading to the generation of reactive oxygen species (ROS), especially singlet oxygen ($^1O_2$) which is responsible for cell inactivation (figure 1).[4] Tetrapyrrolic macrocycles, such as porphyrins have been receiving great attention from the scientific community due to their unique set of features, making this family of compounds one of the most studied. Among the specific properties that make these PS appropriate for aPDT are their absorption features in the visible range of the electromagnetic spectrum, effectiveness in ROS production, low cytotoxicity in the dark, stability and biocompatibility.[3]

In this communication, we will discuss the modification of 5,15-diarylporphyrin scaffold with nitrogen-donor moieties, and the incorporation of the obtained products into polyvinylpyrrolidone (PVP). The capability of the resulting PVP-based formulations to photoinactivate Gram-(+) bacterium *Staphylococcus aureus* was evaluated showing their potential as PSs for aPDT.

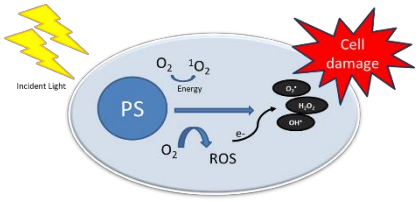


Figure 1: Schematic representation of aPDT mechanism.

Acknowledgements
The authors thank the University of Aveiro and the University of Porto and FCT/MCTES (PIDDAC) for their financial support to the LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), LEPABE (UIDB/00511/2020) and (UIDP/50017/2020 + UIDB/50017/2020 + LA/P/0094/2020) Research Units, and Portuguese NMR Network. This work was financially supported by the FCT project PORP2PS (EXPL/QUI-QOR/0586/2021). M.J.A. Reis (2020.05838.BD) and A.M.V.M. Pereira thanked the FCT and project POCI-01-0145-FEDER-030357 for the research contracts and concession agreements. N.M.M. Moura thanks FCT for funding through program DL 57/2016 – Norma transitória (CDL-CTTRI-048-88-ARH/2018).

References

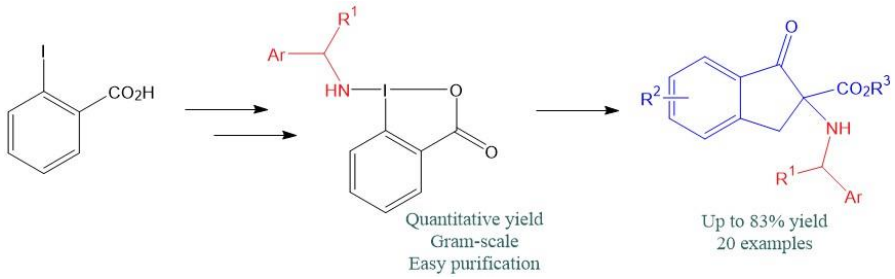
1. C. Vieira, A. T. P. C. Gomes, M. Q. Mesquita, N. M. M. Moura, G. P. M. S. Neves, A. F. Faustino and A. Almeida, *Front. Microbiol.*, 2018, **9**, 1–16.
2. F. Cieplik, D. Deng, W. Crielaard, W. Buchalla, E. Hellwig, A. Al-Ahmad and T. Maisch, *Crit. Rev. Microbiol.*, 2018, **44**, 571–589.
3. M. Q. Mesquita, C. J. Dias, M. G. P. M. S. Neves, A. Almeida and M. A. F. Faustino, *Molecules*, DOI:10.3390/molecules23102424.
4. N. Kashef, Y. Y. Huang and M. R. Hamblin, *Nanophotonics*, 2017, **6**, 853–879.

Hypervalent iodine(III) reagents with transferable primary amines for electrophilic α–amination of stabilized enolates

Ana Cláudia R. Negrão*, Diogo L. Poeira, M. Manuel B. Marques

LAQV@REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, Campus de Caparica, 2829-516, Caparica, Portugal
**ac.negrao@campus.fct.unl.pt*

The C-N bond is one of the utmost importance due to its abundance in organic compounds showing biological activity.[1] Furthermore, the α-aminocarbonyl moiety plays a significant role as it is the structural component of α-amino acids. Driven by the broad scope of their biotechnological application, unnatural amino acids bearing atypical side chains have attracted attention in the scientific community making the search for efficient construction of C-N bonds a current topic.[2]
Iodine(III) compounds have been explored as electrophilic synthons of usually nucleophilic functionalities. The electron deficient iodine atom and the reactivity of the hypervalent bond causes an inversion of the polarity of a bound moiety.[3] Cyclic benziodoxoles and benziodoxolones are particularly interesting as they show enhanced stability when compared to their acyclic analogues due to conjugation between the aromatic ring and the iodine atom.[4] Iodine(III) reagents for the transfer of electrophilic nitrogen-containing groups such as azides[5], bissulfonimides[6] and imines[7] have been established. Taking advantage of the *umpolung* reactivity, our group has previously reported the use of hypervalent iodine reagents for the transfer of sulfonyl groups to amines.[8] In the follow-up of this work, we recently developed four novel benziodoxolone-derived iodine(III) reagents for electrophilic α−amination and reported its employment in the α-amination of stabilized enolates (Scheme 1). In this communication our results will be presented.[9]



Scheme 1: Electrophilic α□amination of carbonyl compounds with benzylaminobenziodoxolone.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the fellowships 2022.04623.PTDC and 2022.13650.BD. This work was supported by the Associated Laboratory for Sustainable Chemistry – Clean Processes and Technologies-LAQV which is financed by national funds from FCT/MEC(UID/QUI/50006/2013) and co-financed by the ERDF under the PT2020 Partnership Agreement (POCI-01-0145-FEDER-007265). The NMR spectrometers are part of The National NMR Facility, supported by Fundação para a Ciência e Tecnologia (RECI/BBB-BQB/0230/2012).

References
1. J. Bariwal, E. Van der Eycken, Chem. Soc. Rev., 2013, **42**, 9283-9303.
2. A. Stevenazzi, M. Marchini, G. Sandrone, B. Vergani, M. Lattanzio, *Bioorg. Med. Chem. Lett.*, 2014, **24**, 5349-5356.
3. D. P. Hari, P. Caramenti, J. Waser, *Acc. Chem. Res.*, 2018, **51**, 3212-3225.
4. A. Yoshimura, V. V. Zhdankin, *Chem. Rev.*, 2016, **116**, 3328-3435.
5. M. V. Vita, J. Waser, *Org. Lett.*, 2013, **15**, 3246-3249.
6. K. Muñiz, *Acc. Chem. Res.*, 2018, **51**, 1507-1519.
7. K. Kiyokawa, D. Okumatsu, S. Minakata, *Angew. Chem. Int. Ed.*, 2019, **58**, 8907-8911.
8. D. L. Poeira, J. Macara, H. Faustino, J. A. S. Coelho, P.M. P. Gois, M. M. B. Marques, *Eur. J. Org. Chem.*, 2019, **15**, 2695-2701.
9. D. L. Poeira, A. C. R. Negrão, H. Faustino, J. A. S. Coelho, C. S. B. Gomes, P. M. P. Gois, M. M. B. Marques, *Org. Lett.*, 2022, **24**, 776-781.

Development of a cosmetic product added with *Fucus vesiculosus* extract rich in phlorotannins and fucoxanthin

Aurora Figueiredo[1], Marcelo D. Catarino[2]*, Ana Rita Circuncisão[2], Artur M. S. Silva[2], Susana M. Cardoso[2]

[1]Department of Chemistry, *University of Aveiro, 3810-193 Aveiro, Portugal*
[2]LAQV-REQUIMTE, *Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
mcatarino@ua.pt

The skin is an organ that plays a key role in protecting the human body against external aggressions such as microorganisms, chemical agents and radiation.[1] Such aggressions can lead to reactions that can cause oxidative stress and skin damage.
Currently, macroalgae are highly sought after and used by the cosmetics industry due to their great diversity in bioactive compounds, namely fucoxanthin and phlorotannins, which have been described with relevant properties, including antibacterial and antifungal, antioxidant and photoprotection, that are particularly relevant for the skin.[2] The aim of this work is to develop a cosmetic product fortified with an extract of the algae *Fucus vesiculosus*, particularly rich in fucoxanthin and phlorotannins, which will act as active ingredients to provide antioxidant and photoprotective effects. After testing several solvents (ethanol, methanol and acetone) the extraction with acetone (24 h, room temperature, in the dark) revealed the highest content in phlorotannins (3.5 ± 0.2 g phloroglucinol equivalents/100 g extract, determined by DMBA method) and fucoxanthin (1.5 g/100 g extract, determined by HPLC-MS) combined. This extract also showed a considerable sun protection factor (SPF) of 15 and strong antioxidant activity, displaying better $ABTS^{\bullet+}$ scavenging activity than ascorbic acid (IC_{50} = 11 µg/mL versus 33 µg/mL).

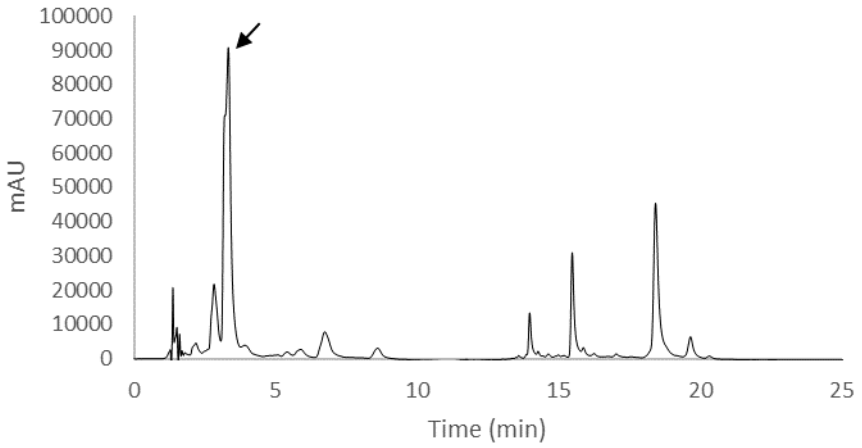


Figure 1: Chromatographic profile of pigments from *Fucus vesiculosus* acetone extract. The peak highlighted corresponds to fucoxanthin.

The final seaweed-containing cosmetic product was also evaluated for its antioxidant activity and accelerated lipid oxidation, by ABTS and TBARS respectively. Interestingly, although the addition of the extract conferred antioxidant properties to the lotion, the lipid oxidation in the seaweed-fortified cosmetic was found higher throughout the different time points analyzed, possibly due to the presence of other lipidic compounds in the extract which are also prone to lipid peroxidation.
Overall, this work demonstrates that extracts rich in fucoxanthin and phlorotannins from *Fucus vesiculosus*, display interesting antioxidant and photoprotective properties making them strong candidates to be used in the development of cosmetic products that promote skin protection against oxidative stress and radiation.

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020. Marcelo Catarino thanks LAQV-REQUIMTE for funding his research contract through the projects UIDB/50006/2020 and UIDP/50006/2020. Susana M. Cardoso thanks FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus Ref. 2022.06426.CEECIND.

References:

1. E. G. Brunt and J. G. Burgess, *Int J Cosmetic Sci*, 2018, **40**, 1-15.
2. M. Anis, S. Ahmed and M. M. Hasan, *World Journal of Pharmacy and Pharmaceutical Sciences*, 2017, DOI: 10.20959/wjpps20176-9447, 1934-1959.

Coordination polymers for exploring gas-phase processes: Syntheses, properties, and catalytic applications

C. H. J. Franco[1,*], A. Pastor[2], M. V. Kirillova[1], A. M. Kirillov[1]

[1]*Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal.*
[2]*Department of Inorganic Chemistry and Chemical Engineering, Institute of Chemistry for Energy and Environment, University of Córdoba, Córdoba, Spain.*
**chris.franco@tecnico.ulisboa.pt*

Coordination polymers (CPs) have emerged as materials with enormous potential in exploring gas-phase processes,[1,2] owing to their exceptional structural diversity. The metal centers within the bulk material can act as active sites, enabling various catalytic transformations.[3] Also, the porous nature of CPs allows reactant molecules to diffuse within the structure, promoting efficient mass transport and high reaction rates.[3,4] Tunable properties of CPs (e.g., high porosity, large surface area, and abundant active sites) make them versatile materials for gas adsorption/separation and catalytic uses.[4]
Following our interest in the catalytic application of CPs, namely in (i) the functionalization of alkanes including CH_4 and (ii) the reduction of NO_x gases ($NO+NO_2$), the present work outlines the synthesis and characterization of two new CPs, $\{[Nd(sbda)\cdot 4H_2O]\}_n$ (**CP 1**) and $\{[Ni(Kbtc)_2\cdot 6H_2O]\}_n$ (**CP 2**), and their prospective application in catalysis. It is suitable to make use of neodymium and nickel catalysts since both these metals display catalytic activity in a variety of process, including photocatalytic reactions.[4] **CP 1** was generated from a neodymium(III) salt and 5-sulfo-1,3-benzenedicarboxylic acid (H_2sbda) by hydrothermal process, while **CP 2** was prepared using a nickel(II) salt and potassium salt of 1,3,5-benzenetricarboxylic acid (H_2Kbtc) by aqueous self-assembly method. Both products were characterized by standard methods including single-crystal (SCXRD) and powder X-ray diffraction (PXRD). **CP 1** was loaded with Al(III) ions from $[Al(OH)_3]$ (50/50 ratio, named as **CP1@Al**) to estimate changes in surface properties of the bulk material, including defective levels in Nd. Catalytic activity of both CPs and **CP1@Al** was evaluated in the carboxylation and oxidation of CH_4 in the presence of CO and/or oxidant. The initial results reveal that both types of catalysts lead to moderate yields of oxidation products, and the reactions occur via a free radical mechanism.[3] To explore the application of CPs in gas phase processes, photocatalytic activity of **CP 1** and **CP1@Al** was investigated by using a 50x50 mm sample holder placed in a laminar flow reactor irradiated with artificial sunlight (550 W m^{-2}), and with an initial NO concentration of 150 ppb. The incorporation of Al(III) into the catalyst formulation containing **CP1** decreases the surface-area (BET), resulting in lower photocatalytic activity due to changes in light absorption by Nd ions. Moderate NOx conversions were obtained. The results demonstrate that the obtained CPs can be promising candidates for development of catalytic properties. However, optimization of catalytic transformations and modulation of some structural parameters, such as porosity and surface area-to-volume ratio, should be carried out to provide abundant active sites for gas molecules to interact with, resulting in enhanced catalytic properties.

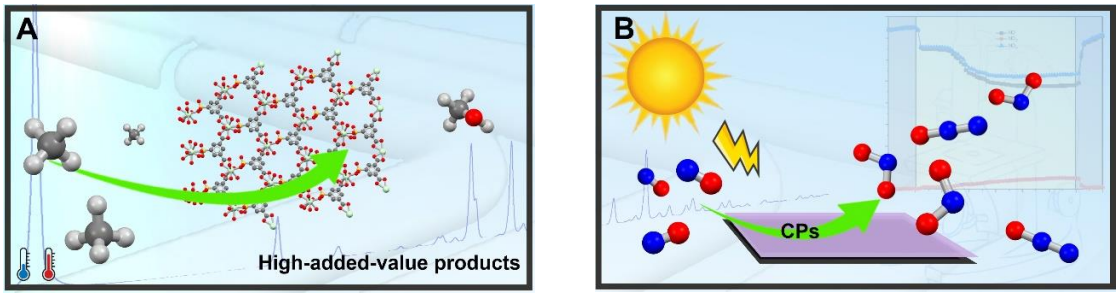


Figure 1: Scheme of catalytic **(A)** and photocatalytic **(B)** gas-phase process.

Acknowledgements
Financial support is provided by the FCT (PTDC/QUI-QIN/29697/2017, LA/P/0056/2020, and UIDB/00100/2020; Portugal).

References
1. G. Delen, M. Monai, K. Stančiaková *et al*., *Nat Commun.*, 2023, **14**, 129.
2. L. F. Dai, Y. Chenchen, Z. Fanglei *et al*., *Appl. Surf. Sci.*, 2023, **623**, 156991.
3. K. I. Trusau, M. V. Kirillova, V. André *et al*., *Mol. Catal.*, 2021, **503**, 111401.
4. J. Lin, W. Ho, X. Qin *et al*., *Small*, 2022, **18**, 2105484.

P166

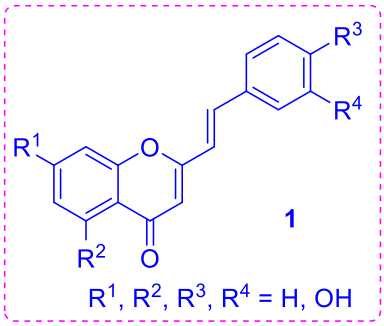
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Exploring the inhibitory potential of 2-styrylchromones on pancreatic α-amylase

C. M. M. Santos[1-4*], C. Proença[3], M. Freitas[3], A. N. Araújo[3], A. M. S. Silva[4], E. Fernandes[3]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [2]Laboratório para a Sustentabilidade e Tecnologia em Regiões de Montanha, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; [3]LAQV, REQUIMTE, Laboratory of Applied Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal; [4]LAQV, REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**clems@ipb.pt*

Diabetes *mellitus* is a metabolic disorder that afflicts about 537 million people worldwide and this number is predicted to rise to 643 million by 2030, according to the International Diabetes Federation.[1] It is characterized by hyperglycemia, caused by the deficiency in the secretion of insulin and/or in the action of this pancreatic hormone. To date, the best therapeutic strategy known consists of inhibiting carbohydrate-hydrolyzing enzymes, namely the α-amylase enzyme. The currently marketed inhibitors (e.g., acarbose, miglitol, and voglibose) are based on carbohydrate-related structures, with moderate affinity for the enzyme and with disturbing side effects.[2] Thus, an active pursuit for novel and more effective anti-diabetic drugs has been carried out and a wide variety of structurally diverse heterocyclic compounds has been studied. Chromones are among the oxygenated 6-membered heterocycles evaluated and the results exhibited by some 2-arylchromones point out the relevance of this class of compounds in the inhibition of α-amylase enzymatic activity.[3] Nonetheless, a detailed investigation of the effects of the restricted group of chromones known as 2-styrylchromones (2-SC) has not been conducted to date. With this rationale in mind and as part of our on-going project, the aim of the present study is to investigate the effect of a panel of twelve 2-SC **1** on pancreatic α-amylase activity and their mechanism of inhibition, to infer about the importance of this class of compounds in the management of type 2 diabetes and its complications.



α-Amylase was exposed to different concentrations of 2-SC **1** and the hydrolysis of the substrate 2-chloro-*p*-nitrophenyl-α-D-maltotriose was monitored spectrophotometrically at 405 nm. Acarbose was used as the standard inhibitor. In addition, the study of the inhibition type was carried out through nonlinear regression Michaelis-Menten enzymatic kinetics and the corresponding Lineweaver-Burk plot.[4]

The results showed that the IC_{50} values obtained ranged from 26 to 174 μM, considerably higher than the positive control acarbose (IC_{50} = 0.62 ± 0.07 μM). All active compounds revealed a competitive type of inhibition while for the positive control a mixed type of inhibition was obtained. More details concerning the structure-activity relationship will be presented and discussed in this communication.

Acknowledgements
This work received support from national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects of CIMO (UIDB/00690/2020 and UIDP/00690/2020), SusTEC (LA/P/0007/2021), REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) and through the project with the reference EXPL/MED-QUI/0815/2021. Carina Proença acknowledges funding from FCT through the project, EXPL/MED-QUI/0815/2021. Marisa Freitas acknowledges her contract under the Scientific Employment Stimulus - Individual Call (CEEC Individual) 2020.04126.CEECIND/CP1596/CT0006 and LAQV-REQUIMTE for her contract under the reference LA/P/0008/2020.

References

1. International Diabetes Federation. IDF Diabetes Atlas. In IDF Diabetes Atlas. 10th ed. 2021. Available from: https://www.diabetesatlas.org/en/.
2. R. Bashary, M. Vyas, S. K. Nayak, A. Suttee, S. Verma, R. Narang, G. L Khatik, *Curr. Diabetes Rev.*, 2020, **16**, 117-136.
3. C. Proença, M. Freitas, D. Ribeiro, E. F. T. Oliveira, J. L. C. Sousa, S. M. Tomé, M. J. Ramos, A. M. S. Silva, P. A. Fernandes, E. Fernandes, *J. Enz. Inhib. Med. Chem.*, 2019, **34**, 577-488.
4. C. M. M. Santos, C. Proença, M. Freitas, A. N. Araújo, A. M. S. Silva, E. Fernandes, *Food Funct.*, 2022, **13**, 7930-7941.

Synthesis, characterization and antimicrobial activity of hybrid biopolymer films doped with bioactive coordination compounds

R. G. Cabral[1,2,*], T. A. Fernandes[1], F. Macedo[3], P. Jorge[3], C. H. J. Franco[1], T. Guiu[2], V. André[1], A. C. Sousa[1,2], N. Cerca[3], A. M. Kirillov[1]

[1]Centro de Química Estrutural - Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal; [2]Departamento de Engenharia Química, Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, Rua Conselheiro Emídio Navarro 1, 1959-007 Lisboa, Portugal.
[3]Centre of Biological Engineering, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal.
**rafaela.cabral@tecnico.ulisboa.pt*

The spread of pathogens through contaminated high-touch surfaces is a major health issue that has led to the exploration of new effective antiseptic materials and coatings capable of inhibiting bacterial adhesion and biofilm formation (Figure 1).[1,2]
In this context, this presentation focuses on the synthesis and characterization of novel bioactive Ag(I), Cu(II), and Zn(II) coordination compounds (bioCCs) or coordination polymers (bioCPs), as well as the evaluation of their antimicrobial activity when incorporated into hybrid biopolymer films. Five new bioCPs and bioCCs, $[Ag_2(\mu_6\text{-sdba})]_n$ (**1**), $[Cu(\mu_4\text{-sdba})H_2O]_n \cdot 1.5nH_2O$ (**2**), $[Zn(obba)(NH_3)_2]_n$ (**3**), $[Ag(msba)]_n$ (**4**), and $[AgK_2(sba)(OH)]_n$ (**5**) were assembled from simple metal salts and different benzoic acid building blocks, namely 4,4'-sulfonyldibenzoic acid (H_2sdba), 4,4'-oxybis(benzoic acid) (H_2obba), 4-(methylsulfonyl)benzoic acid (Hmsba), and 4-sulfobenzoic acid (H_2sba). All compounds were fully characterized using standard methods. The selected compounds were then used in small amounts as active antimicrobial doping agents for bio-based polymers, based on potato starch and agarose, resulting in the fabrication of hybrid biopolymer films.
The antibacterial properties of the coordination compounds and the produced hybrid materials were tested against Gram-positive (*S. epidermidis* and *S. aureus*) and Gram-negative (*P. aeruginosa* and *E. Coli*) bacteria. Some biopolymer films were also effective in preventing the formation of bacterial biofilms. The outcomes are promising, and further research to produce new hybrid antimicrobial materials is currently in progress.

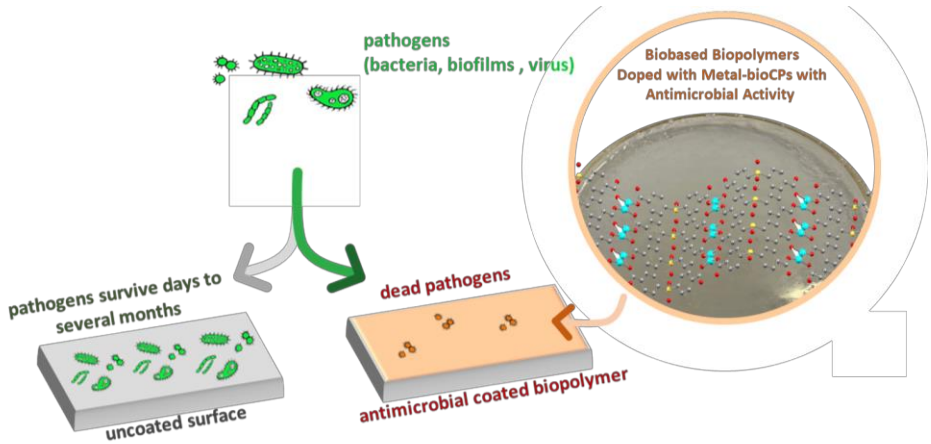


Figure 1: Schematic Representation of Assembly and Function of Antimicrobial Coatings.

Acknowledgements
This work was supported by the FCT (projects UIDB/00100/2020, UIDP/00100/2020, PTDC/QUI-QIN/29697/2017, LA/P/0056/2020 and contracts under DL No. 57/2016, CEECIND/02725/2018, CEECIND/00194/2020, and PhD grant 2022.09436.BD), and IPL (IPL/2022/3DBioProd_ISEL).

References
1. S. Wu, C. Xu, Y. Zhu, L. Zheng, L. Zhang, Y. Hu, B. Yu, Y. Wang and F. Xu, Adv. Funct. Mater. 2021, **31**, 2103591.
2. T.A. Fernandes, I. F. M. Costa, P. Jorge, A. C. Sousa, V. André, R. G. Cabral, N. Cerca and A. M. Kirillov, ACS Appl. Mater. Interfaces, 2022, **14**, 25104.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis and electrochemical studies of quinonemethides as potential new organic redox mediators

Flávia Leitão*, Gonçalo Vilela, Hugo Cruz, Luís C. Branco, Paula S. Branco

LAQV-REQUIMTE, Chemistry Department, NOVA School of Science and Technology, Caparica, Portugal
**fl.leitao@campus.fct.unl.pt*

There is an increasing global demand for energy and consequently the need for more efficient and sustainable energy sources is mandatory[1]. These alternatives may include the use of redox mediators, crucial components to many electrochemical devices.
Redox mediators are an important component of batteries for energy storage purposes. These devices convert chemical energy into electric energy through reversible oxidation/reduction processes[2]. However, most of them employ the use of toxic, hazardous, and expensive materials. Over the years organic redox mediators (ORM) have emerged as an alternative to solve these systems[2,3].
Huskinson et al. reported, in 2014, an aqueous organic redox flow battery employing 9,10-anthraquinone-2,7-disulphonic acid (AQDS) as the anolyte[4]. Since then, many studies in the search of suitable ORM for application as organic redox flow batteries (ORFB) have been reported. Quinones have been one the most studied families for ORFB due to their redox properties[5].
In this work, quinonemethides were synthesized in good yields from 2,6-di-*tert*-butylphenol and aldehydes. The electrochemical properties of all compounds were studied by cyclic voltammetry (Figure 1) with some compounds showing reversible transformations. The quinone like core of these molecules make them candidates to be used as potential alternative ORM to the already broadly studied quinones.

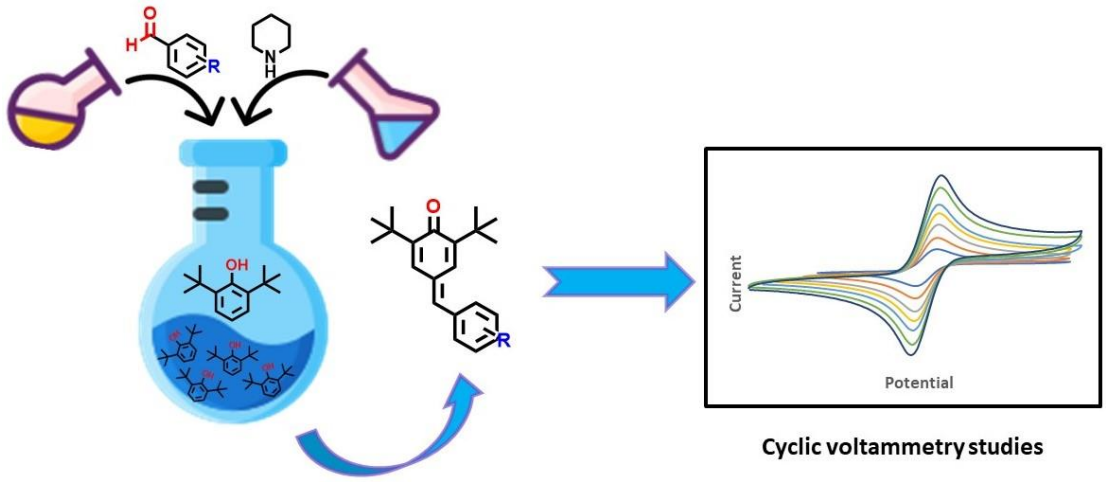


Figure 1: Schematic representation of the synthesis of different quinomethides analyzed by cyclic voltammetry.

Acknowledgements
We thank FCT – Fundação para a Ciência e a Tecnologia I. P, this work was performed under the project PTDC/QUI-QOR/7450/2020 "Organic Redox Mediators for Energy Conversion". This work was supported by the Associate Laboratory for Green Chemistry - LAQV financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). FCT/MCTES is also acknowledged for the National NMR Facility Network (ROTEIRO/0031/2013-PINFRA/22161/2016, co-financed by FEDER through COMPETE 2020, POCI, PORL, and FCT through PIDDAC).

References

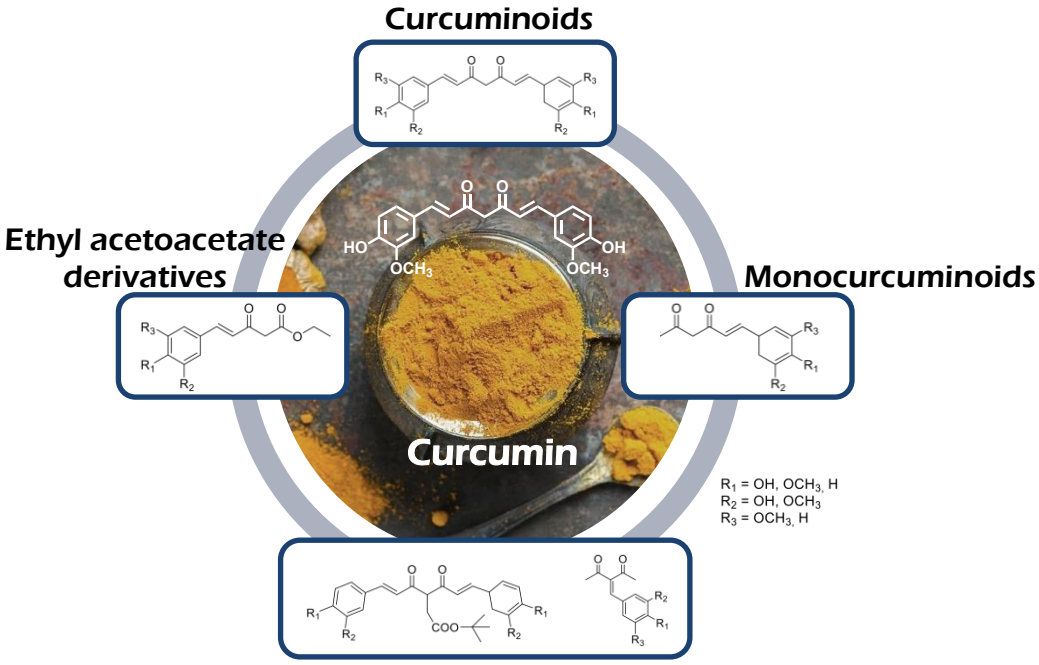
1 J. Cho, S. Jeong and Y. Kim, *Prog. Energy Combust. Sci.*, 2015, **48**, 84–101.
2 J. Luo, B. Hu, M. Hu, Y. Zhao and T. L. Liu, *ACS Energy Lett.*, 2019, **4**, 2220–2240.
3 M. Zhou, Y. Chen, M. Salla, H. Zhang, X. Wang, S. R. Mothe and Q. Wang, *Angew. Chemie - Int. Ed.*, 2020, **59**, 14286–14291.
4 B. Huskinson, M. P. Marshak, C. Suh, S. Er, M. R. Gerhardt, C. J. Galvin, X. Chen, A. Aspuru-Guzik, R. G. Gordon and M. J. Aziz, *Nature*, 2014, **505**, 195–198.
5 Q. Chen, Y. Lv, Z. Yuan, X. Li, G. Yu, Z. Yang and T. Xu, *Adv. Funct. Mater.*, 2022, **32**, 2108777.

Synthesis of curcuminoids with potential antioxidant properties

C. Henriques[1,2], M. F. Piedade[1,3], M. P. Robalo[1,2,*]

[1]*Centro de Química Estrutural – Institute of Molecular Sciences, Instituto Superior Técnico – Universidade de Lisboa, Lisbon, Portugal;* [2]*Departamento de Engenharia Química, ISEL – Instituto Politécnico de Lisboa, Lisbon, Portugal*
[3]*Departamento de Química e Bioquímica, Faculdade de Ciências – Universidade de Lisboa, Lisbon, Portugal*
**mprobalo@deq.isel.ipl.pt*

Curcumin is the principal constituent and active substance of turmeric i.e., the rhizome of Curcuma longa, a plant widely used in Indian cuisine, famous for its yellow colour and spicy flavour. Extensive research has been conducted on this compound over the years, due to its anti-inflammatory and antioxidant properties, including therapeutic and protective effects against cancer, diabetes, neurological and cardiovascular diseases. Despite its numerous benefits, curcumin has also limitations that block its therapeutic potential and restrict its clinical applicability, such as a low bioavailability upon oral administration and a low solubility in water.[1,2] Our recent studies with diabetic rats suggested that the substitution of the central position on the β-diketone chain generates curcuminoid derivatives that potentiate the effects of curcumin, improving the fasting glucose and endothelial function in type 2 diabetes[3].
The present work is based on the synthesis of curcumin analogues by introduction of different groups in the main β-diketonic chain, alteration of the substituent groups in the aromatic rings or formation of mono-curcuminoids, in order to improve both their biological properties, their bioavailability and solubility (scheme 1). The products obtained were characterized by usual spectroscopic techniques and X-ray diffraction. As part of the evaluation of their bioactive potential, water solubility and antioxidant capacities of the compounds were tested.



Scheme 1: Different types of synthesized curcuminoids.

Acknowledgments
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020.

References

1. S. C. Gupta, S. Patchva, W. Koh, and B. B Aggarwal, *Clin. Exp. Pharmacol. Physiol.,* 2012, **39**, 283-299.
2. R. R. Kotha and D. L. Luthria, *Molecules*, 2019, **24**, 2930.
3. S. Oliveira, T. Monteiro-Alfredo, R. Henriques, C.F. Ribeiro, R. Seiça, T. Cruz, C. Cabral, R. Fernandes, F. Piedade, M.P. Robalo, P. Matafome and S. Silva, *Int. J. Mol. Sci.*, 2022, **23**, 5652.

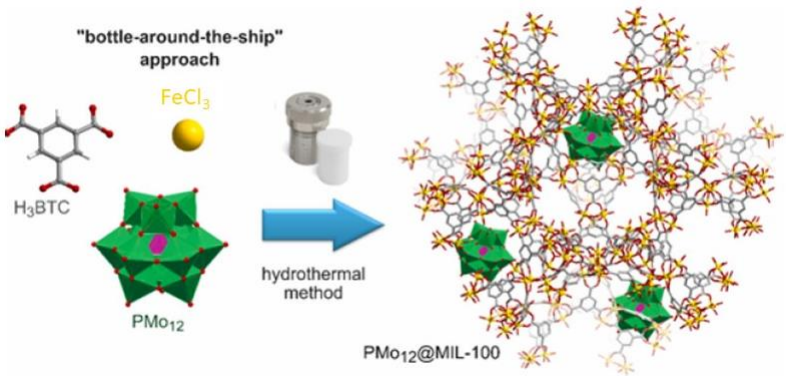
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Simultaneous sulfur and nitrogen removal from fuel combining activated porous MIL-100(Fe) catalyst and sustainable solvents

D. F. Silva[1,*], R. G. Faria[1], I. Santos-Vieira[2], L. Cunha-Silva[1], C. M. Granadeiro[1], S. S. Balula[1]

[1]REQUIMTE/LAQV & Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal; [2]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**up201404392@edu.fc.up.pt*

The high costs associated with available desulfurization technologies in the refinery industry sparked the demand for innovative, exceptionally efficient, and sustainable alternative processes.[1] On the other hand, the presence of nitrogen compounds significantly decreases the efficiency of the desulfurization process. Hence, the petroleum industry seeks desirable alternative methodologies capable to eliminate both sulfur and nitrogen compounds from fuels through economic and sustainable processes.[2] This work reports a sustainable catalytic process that conciliates oxidation and liquid-liquid extraction to remove efficiently sulfur and nitrogen from fuels. The effective catalytic oxidation was achieved by using a MIL-100(Fe) based composite encapsulating the catalytic active phosphomolybdic acid (PMo_{12}).[3] Complete desulfurization of a multicomponent model fuel containing the most refractory sulfur and nitrogen compounds was achieved after only 30 min. Also, the nitrogen compounds were able to be removed after this short period, largely by extraction procedure using strategic solvents. The simultaneous S/N removal process was faster when the expensive ionic liquid $(BMIM)PF_6$ was replaced by the cost-effective ethanol. Furthermore, the catalyst could be reused in several consecutive desulfurization and denitrogenation cycles; as well as the ethanol extraction solvent was reused for at least four cycles without loss of efficiency.



Scheme 1: Schematic representation of the preparation of the composite PMo_{12}@MIL100(Fe) *via* a "bottle-around-the-ship" approach.

Acknowledgements
This research work received financial support from portuguese national funds (FCT/MCTES, Fundacao para a Ciencia e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the strategic project UIDB/50006/2020 (for LAQV-REQUIMTE), and also from the European Union (FEDER funds through COMPETE POCI-01-0145-FEDER-031983). This work was partially developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The position held by ISV (Ref.197_97_ARH-2018) was funded by national funds (OE), through FCT, I. P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of article 23 of the Decree-Law 57/2016 of 29 August, changed by Law 57/2017 of 19 July. LCS, CMG and SSB thank FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus (Ref. CEECIND/00793/2018, Ref. 2022.02651. CEECIND and Ref. CEECIND/03877/2018, respectively). DFS and RF thanks FCT/MCTES and ESF (European Social Fund) through POCH (Programa Operacional Capital Humano) for their PhD grants (Refs. 2022.14787. BD and UI/BD/151277/2021, respectively).

References
1. H. Zhang, L. Yang, P. Yang, P. Wang, Y. Yue, T. Wang and X. Bao, Fuel, 2022, **15**, 124705.
2. F. Mirante, M. Salimian, P. A. A. P. Marques, C. M. Granadeiro and S. S. Balula, Sustain. Energy Fuels, 2022, **6**, 4681–4691
3. D. F. Silva, R. G. Faria, I. Santos-Vieira, L. Cunha-Silva, C. M. Granadeiro and S. S. Balula, Catal. Today, 2023, **423**, 114250.

Sustainable synthesis of an antifouling agent from grape wastes

S. Godinho[1], J. Teixeira[1], S. Cravo[1], M. Pinto[1], H. Cidade[1], Mara Freire[2], M. Correia-da-Silva[1,*]

[1]LQOF/FFUP -Laboratory of Organic and Pharmaceutical Chemistry, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal and CIIMAR - Interdisciplinary Center of Marine and Environment Research, University of Porto, Terminal dos Cruzeiros do Porto de Leixões, Avenida General Norton de Matos 4450-208 Matosinhos, Portugal; [2]CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
**m_correiadasilva@ff.up.pt*

The antifouling paints in use are continuing to leach persistent, bioaccumulative, and toxic substances into the oceans. It is crucial to invest in research to develop antifouling systems which are effective and environmentally safe to accelerate the substitution of harmful systems for harmless ones. In the CIIMAR group of Marine Natural Products and Medicinal Chemistry, two gallic acid (GA) derivatives (GAP and GBA26) were synthesized by bioprospection of known marine antifouling compounds[1] and were found to be harmless than commercial antifoulants.[2,3] Marine coatings containing these derivatives immobilized, were highly effective in preventing the adherence of mussels larvae.[2,4] This proof of concept on a lab scale addresses investing now in the optimization of the GA derivatives production. The aim of this work was to recover gallic acid (GA) from winery wastes by green techniques and transform it into GAP and GBA26 after molecular modification by chemical synthesis. In the first stage of this work, seeds, skins, and stalks were separated from grape pomace, and grape seeds were milled with a knife mill and sieved with a sieve shaker. The fractions within the particle size 355 to 500 µm range were extracted with water, the greenest of solvents (ratio S/L 1:5, pH 4), at room temperature, with stirring for 60 minutes.[5] Following, factorial planning was applied to optimize the extraction of GA by changing three parameters: ratio S/L, pH, and stirring period. In this regard, the Total Phenolic Content (TPC) was evaluated for each sample optimized, to calculate the total phenolics expressed as gallic acid equivalents (GAE). An analytical study of the extracts was performed by HPLC, to select the extract with the highest content of gallic acid. This extract was submitted without further purification to a synthetic procedure of two steps to obtain GBA26 by direct coupling the carboxylic acid of GA with the *N*-Boc protected amine with a water-soluble coupling reagent,[6] *N*-ethylcarbodiimide hydrochloride (EDC.HCl), followed by *N*-Boc deprotection with a solvent-free reaction step, a sustainable and green method, which allow us to obtain GBA26 in a quantitative yield through *ex situ* HCl gas generation technology, without the requirement of any solvent or post-cleavage manipulations, contributing to waste minimization and atom economy.[7] By extracting the starting material from grape waste and transforming it into a valuable antifouling product, under green chemistry processes, this product will be subject of great interest from both the winery and marine industries.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). This research was also supported by national funds through FCT (Foundation for Science and Technology) within the scope of Base Funding UIDB/04423/2020 & UIDP/04423/2020 (CIIMAR – Marine Natural Products and Medicinal Chemistry group) and as a result of the project PTDC/CTA-AMB/0853/2021. S. Godinho thanks for the scholarship 2022_072_BI_CTA_AMB. The authors thank Quintas de Vila Garcia for the grape pommace residue.

References

1. Vilas-Boas, C., Sousa, E., Pinto, M., and Correia-da-Silva, M., Biofouling, 2017, **33**, 927-942.
2. Rita Neves, A., Vilas Boas, C., Gonçalves, C., Vasconcelos, V., Pinto, M., Silva, E. R., Sousa, E., Almeida, J. R., and Correia-da-Silva, M., Bioorg Chem, 2022, **126**, 105911.
3. Almeida, J. R., Correia-da-Silva, M., Sousa, E., Antunes, J., Pinto, M., Vasconcelos, V., and Cunha, I., Scientific Reports, 2017, **7**, 42424.
4. Vilas-Boas, C., Carvalhal, F., Pereira, B., Carvalho, S., Sousa, E., Pinto, M. M. M., Calhorda, M. J., Vasconcelos, V., Almeida, J. R., Silva, E. R., and Correia-da-Silva, M., Marine Drugs, 2020, **18**, 489.
5. Jara-Palacios, M. J., Gonçalves, S., Heredia, F. J., Hernanz, D., and Romano, A., Antioxidants, 2020, **9**, 675.
6. Magano, J., Organic Process Research & Development, 2022, **26**, 1562-1689.
7. Verschueren, R. H., Gilles, P., Van Mileghem, S., and De Borggraeve, W. M., Organic & Biomolecular Chemistry, 2021, **19**, 5782-5787.

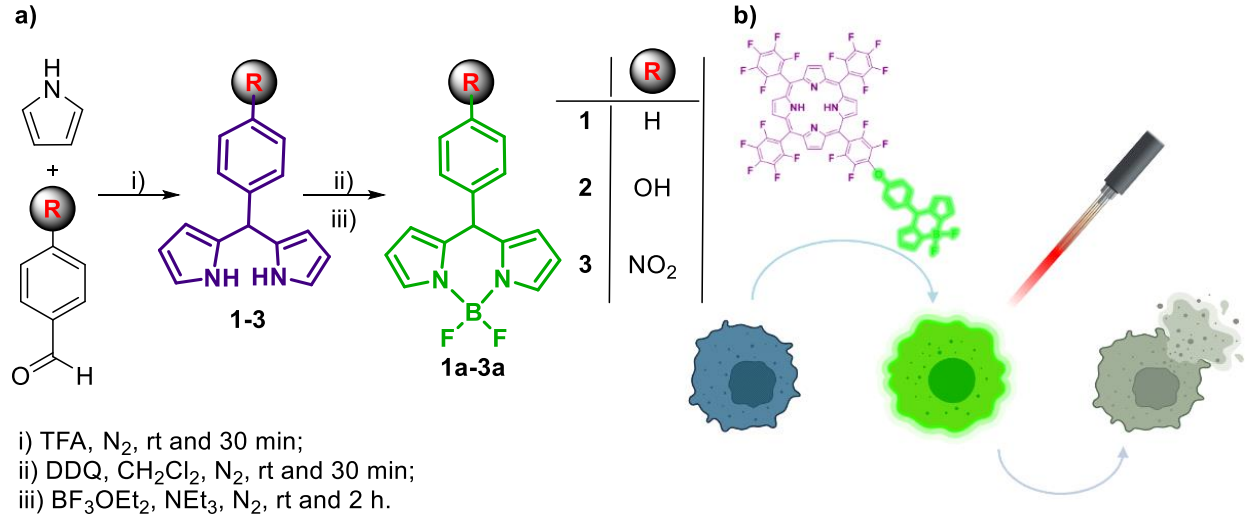
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of BODIPY for theranostic application

Cláudia P. S. Ribeiro[1,*], Leandro M. O. Lourenço[2], João P. C. Tomé[1]

[1]*CQE and Dep. de Eng. Química, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal.*
[2]*LAQV-REQUIMTE and Department of Chemistry, University of Aveiro, Aveiro, Portugal.*
**claudia.p.s.ribeiro@tecnico.ulisboa.pt*

In order to enhance current anticancer strategies like chemotherapy and radiotherapy, extensive research has focused on improving diagnosis, prognosis, and treatment to enhance patient outcomes, survival rates, and quality of life.[1] Recently, there has been a growing interest in theranostics, an approach that combines diagnosis and therapy using a single drug, enabling a comprehensive response encompassing diagnosis, treatment, and monitoring of treatment effectiveness.[2] One promising compound for this purpose is 4,4-Difluoro-4-bora-3a,4a-diaza-s-indacene (BODIPY), a dye developed 1968 by Treibs and Kreuzer. BODIPY exhibits strong absorption capacity, high fluorescence quantum yield, and photostability.[3] Despite its potential in biomedicine, the main challenge lies in its low solubility, preventing direct application into cells. Therefore, modifications or combinations with other substances are necessary to enhance its solubility.[4,5] Another alternative is the development of nanoparticles containing BODIPY, which can facilitate its application in biomedicine.[4,5] However, several aspects of these compounds require further investigation, such as their biocompatibility, combination with other therapies like immunotherapy, and determining the optimal dwell time in the blood to ensure effective performance without causing phototoxicity to healthy cells.[4,5] This work aims to develop new bioconjugated compounds with BODIPY for further application in cancer imaging and treatment. Only the precursors for these compounds have been synthesized (**Scheme 1**).



i) TFA, N_2, rt and 30 min;
ii) DDQ, CH_2Cl_2, N_2, rt and 30 min;
iii) BF_3OEt_2, NEt_3, N_2, rt and 2 h.

Scheme 1: a) Synthesis of BODIPY **b)** Diagnosis and treatment of cancerous cells.

Acknowledgments
Thanks to the University of Lisbon, University of Aveiro, and FCT/MCTES (Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) for the financial support to CQE (UIDB/00100/2020 and UIDP/00100/2020), IMS (LA/P/0056/2020), and LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), funded by FCT/MCTES through national funds. The authors also acknowledge FCT/MCTES for the national funds received through project P2020-PTDC/QUI-QOR/31770/2017. C. Ribeiro thanks FCT for her Ph.D. scholarships (UI/BD/152798/2022).

References

1. P. Sarbadhikary, B.P. George, H. Abrahamse, *Theranostics* 2021, ***11***, 9054.
2. S. Shrivastava, S. Jain, D. Kumar, S.L. Soni, M. Sharma, *Asian Journal of Pharmaceutical Research and Development*, 2019, ***7***, 63-69.
3. A. Treibs, F.H. Kreuzer, *Justus Liebigs Annalen der Chemie*, 1968, ***718***, 208-223
4. T. Koczorowski, A. Glowacka-Sobotta, S. Sysak, D.T. Mlynarczyk, R. Lesyk, T. Goslinski, L. Sobotta, *Sciences*, 2022, ***12***, 7815.
5. W. Lin, D. Colombani-Garay, L. Huang, C. Duan, G. Han, *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*, 2020, ***12***, e1627.

Use of silver nanoparticles for bacterial inactivation in water

Guilherme F. Pinto[1,*], Marta Tacão[2], Diana Lima[3], Vânia Calisto[3], Goreti Pereira[3]

[1]*Department of Chemistry, University of Aveiro, Aveiro, Portugal*
[2]*Department of Biology and CESAM, University of Aveiro, Aveiro, Portugal*
[3]*Department of Chemistry and CESAM, University of Aveiro, Aveiro, Portugal*
**guilhermepinto@ua.pt*

Antibiotic resistance of bacteria is among the main public health problems nowadays, which has been exacerbated by the discharge of human effluents contaminated with antibiotics. However, conventional water treatment methods are often ineffective in inactivating these microorganisms.[1] Thus, new approaches for their complete eradication have been developed, namely using silver nanoparticles (AgNPs).[2, 3] These nanomaterials act at the level of the cell membrane, releasing silver ions and inducing oxidative stress, which gives them a biocidal character against bacteria.[4] Thus, the main objective of this study was to evaluate the potential of AgNPs in the inactivation of bacteria, particularly *Escherichia coli* and *Staphylococcus aureus*, in water, which is a favorable medium for bacterial proliferation. In this work, AgNPs were synthesized using the chemical reducing method, with ascorbic acid as the stabilizing molecule. Since characteristics such as shape and size can influence the interaction of nanoparticles with bacteria, spherical and prismatic AgNPs were prepared and characterized using UV-visible spectroscopy (Figure 1) and scanning transmission electron microscopy (STEM). To evaluate the antibacterial activity of AgNPs against *E. coli* and *S. aureus*, the surface inoculation and well diffusion method was used, which involves filling with NP solutions the wells on agar plates inoculated with the bacteria of interest. After incubation, the growth inhibition zone is measured. The results showed that the AgNPs prepared were efficient in inhibiting bacteria growth, and that nano-spheres generally exhibited the highest antibacterial activity. Thus, AgNPs as antibiotic agents offer the possibility of effectively combating resistant bacteria and could be applied in new approaches in the field of public health.

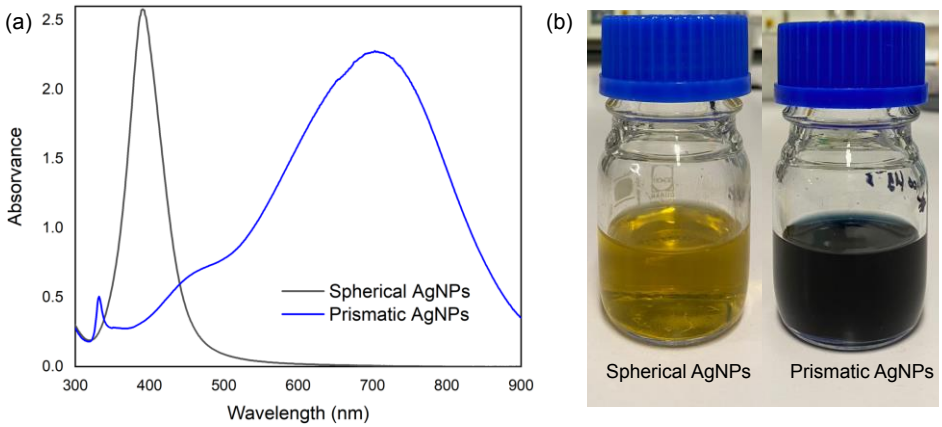


Figure 1: Absorption spectra (a) and photography (b) of spherical and prismatic silver nanoparticles (AgNPs)

Acknowledgements
The authors thank financial support to CESAM by FCT/MCTES (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020), through national funds. Diana Lima and Marta Tacão acknowledges funding from Fundação para a Ciência e a Tecnologia (FCT) under the Scientific Employment Stimulus (2022.00570.CEECIND and CEECIND/00977/2020, respectively).

References

1. S. Dhingra, N. A. A. Rahman, E. Peile, M. Rahman, M. Sartelli, M. A. Hassali, T. Islam, S. Islam and M. Haque, *Front. Public Health*, 2020, **8**, 535668.
2. C. H. Rodrigues, E. A. G. Araújo, R. P. Almeida, T. P. Nascimento, M. M. Silva, G. Abbas, F. D. Nunes, E. Lins, M. C. B. Lira-Nogueira, J. S. A. Falcão, A. Fontes, A. L. F. Porto, G. Pereira and B. S. Santos, *Photodiagnosis Photodyn. Ther.*, 2021, **34**, 102315.
3. B. L. Raposo, S. O. Souza, G. S. Santana, M. T. A. Lima, J. F. Sarmento-Neto, J. S. Reboucas, G. Pereira, B. S. Santos, P. E. Cabral Filho, M. S. Ribeiro and A. Fontes, *Int. J. Nanomed.*, 2023, **18**, 3007.
4. S. Tang and J. Zheng, *Adv. Healthc. Mater.*, 2018, **7**, 1701503.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Hybrid dye – redox mediator based-coumarin for DSSCs cells: Synthesis, spectroscopic and photophysical properties

Stéphanie Leal*, João Sarrato, A. Jorge Parola, Luís C. Branco, J. Carlos Lima, Paula Branco

LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, 2829-516, Caparica, Portugal
sb.leal@campus.fct.unl.pt

Solar energy is a renewable and clean energy, and solar collecting devices as those based on dye-sensitized solar cells (DSSCs) emerge as an alternative process over the commonly used Si-based solar cells. DSSCs possess great advantages due to their cost-effectiveness and ease of fabrication. In the last two decades extensive research on developing dyes with tailor-made photophysical and electrochemical properties for DSSCs has been done.[1]
Coumarin derivatives, especially when extension of the π-conjugated system is carried out at the 3-position, have been reported as relevant chromophores and fluorescent dyes due to their donor-π-acceptor (D-π-A) system.[2] The spectroscopic and photophysical properties they present makes them great candidates as laser dyes and solar chemical concentrators in photovoltaic cells. At the same time, ionic liquids (IL) have been used for the last two decades as electrolyte additives and have successfully improved solar cell efficiency.[3, 4] In an attempt to benefit from 3,7-substituted coumarins and IL properties, new hybrid dye – redox mediator systems have been synthesized for DSSCs.
Here we report the synthesis of a new hybrid dye – redox mediator system for DSSCs starting from 7-hydroxycoumarin. It comprises a cyanoacetic acid group as anchoring site to the TiO_2 and a redox mediator covalently linked to the coumarin scaffold via alkyl chains with different lengths (Figure 1). In addition, spectroscopic and photophysical properties, and influence of the charge nature of the ionic liquid moiety on the DSSCs' photovoltaic performance were also studied.

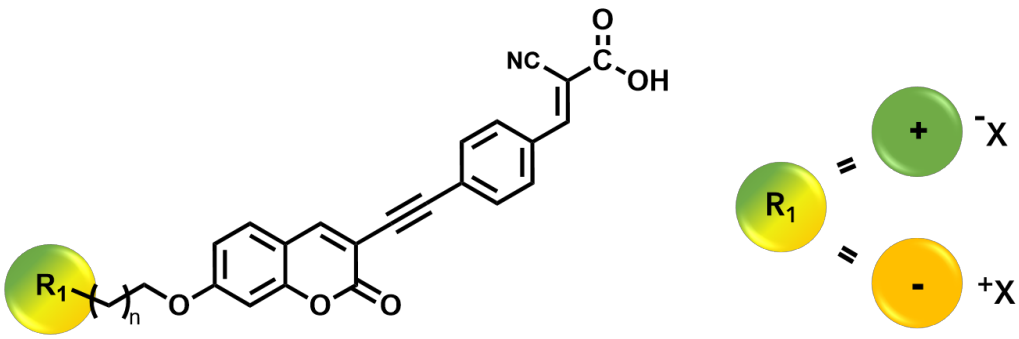


Figure 1: Representation of a new hybrid dye-redox mediator for DSSCs starting from 7-hydroxycoumarin.

Acknowledgements
This work was performed under the project PTDC/QUI-QOR/7450/2020 "Organic Redox Mediators For Energy Conversion" through FCT – Fundação para a Ciência e a Tecnologia I. P. This work was also supported by the Associate Laboratory for Green Chemistry - LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). FCT/MCTES is also acknowledged for the National NMR Facility (RECI/BBB-BQB/0230/2012 and RECI/BBB-BEP/0124/2012,) and PhD grants 2020.09047.BD, PTDC/QUI-QOR/7450/2020.

References
1. A. Aslam, U. Mehmood, M. H. Arshad, A. Ishfaq, J. Zaheer, A. U. H. Khan, M. Sufyan, *Sol. Energy*, **2020,** 207, 874-892.
2. J. Sarrato, A. L. Pinto, G. Malta, E. G. Rock, J. Pina, J. C. Lima, A. J. Parola, P. S. Branco, *Molecules*, **2021,** 26, 2934-2950.
3. J. Sarrato, A. L. Pinto, H. Cruz, N. Jordao, G. Malta, P. S. Branco, J. C. Lima, L. C. Branco, *Nanomaterials-Basel*, **2022,** 12, 2988-3003.
4. R. A. Abu Talip, W. Z. N. Yahya, M. A. Bustam, *Sustainability-Basel*, **2020,** 12, 7598-7621.

Photodegradation of the antibiotic amoxicillin in environmental aqueous matrices

Hugo Rocha[1,*], Valentina Silva[2], Vânia Calisto[2], Diana L. D. Lima[2]

[1]*Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal*
[2]*CESAM & Department of Chemistry, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal*
**hugofmr@ua.pt*

Amoxicillin (AMX), together with other high-usage antibiotics, is frequently detected in the aquatic environment due to the disposal of wastewater treatment plants effluents that are still contaminated with this pharmaceutical. This fact is particularly important for antibiotics, due to the possible induction of antimicrobial resistance, which is one the major public health concerns of the current century.
Once present in surface waters, pollutants can undergo natural attenuation processes (i.e., a combination of processes occurring naturally, e.g., volatilization, sorption, biodegradation, hydrolysis, photodegradation and oxidation). Considering that biodegradation and sorption are the primary removal processes during wastewater treatment, photodegradation might be especially important in surface waters, at least for those pharmaceuticals that have "shown to be resistant" to wastewater treatment. Therefore, the photodegradation of AMX under simulated solar radiation and influencing factors affecting this process were evaluated in different aqueous matrices to further understand its persistence in the aquatic environment. Photodegradation of AMX was shown to be more effective at higher pH ($t_{1/2}$ = 21.0 h at pH = 8.0; $t_{1/2}$ = 8.0 h at pH = 9.0) (**Figure 1**). On the other hand, photolysis in the presence of NaCl was significantly slower ($t_{1/2}$ = 25.12 h), indicating that AMX can be persistent in seawater. Photodegradation of AMX was also evaluated in the presence of humic substances, to simulate the effect of dissolved organic matter on this process, concluding that photolysis was faster ($t_{1/2}$ = 11.5 h in the presence of humic acids; $t_{1/2}$ = 9.02 h in the presence of fulvic acids). Through the use of $^{\cdot}OH$ and $^1O_2$ scavengers, isopropanol and sodium azide, respectively, it was also concluded that the main pathway for AMX photodegradation in ultrapure water is indirect photolysis, mainly induced by $^{\cdot}OH$. Finally, fresh water and brackish water (pH 8.0) were used to evaluate the photodegradation of AMX in natural waters, which were found to be faster than in ultrapure water possibly due to the high values of DOM in these matrices ($t_{1/2}$ = 12.5 h in fresh water; $t_{1/2}$ = 3.8 h in brackish water). Considering the continuous entrance of this antibiotic in aquatic environments through discharge of urban effluents, the high values obtained in this study for photodegradation half-life times might indicate that this process is not enough to ensure, by itself, the environmental elimination of AMX, which can lead to its potential accumulation.

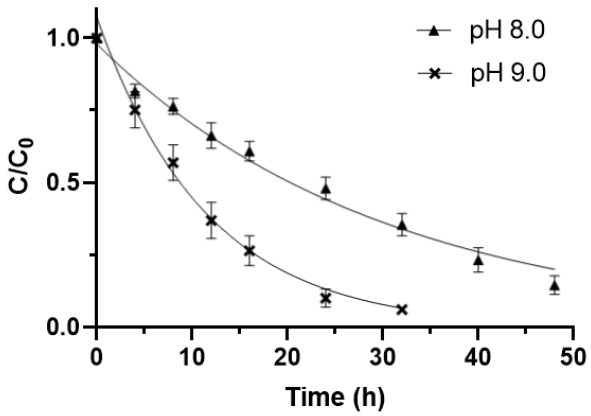


Figure 6: Experimental results obtained on AMX photodegradation throughout time with fittings to the pseudo-first order kinetic model obtained in ultrapure water at different pH values (n=3).

Acknowledgements
Diana Lima acknowledges funding from Fundação para a Ciência e a Tecnologia (FCT) under the Scientific Employment Stimulus (2022.00570.CEECIND). Valentina Silva thank support by Fundação para a Ciência e a Tecnologia (FCT) PhD Grant (2022.10472.BD). The authors acknowledge financial support to CESAM by FCT/MCTES (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020), through national funds.

P176

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Semi-synthetic abietane diterpenoids for breast cancer therapy: from molecular docking to protein kinase α activation

V. M. S. Isca[1,2], G. Bangay[1,3], D. J. V. A. Santos[1], Ana María Díaz-Lanza[3], Lucília Saraíva[4], Carlos A. M. Afonso[2], Patrícia Rijo[1,2*]

[1]CBIOS - Research Center for Biosciences & Health Technologies, Universidade Lusófona de Humanidades e Tecnologias, Lisboa, Portugal; [2]iMed.ULisboa, Faculdade de Farmácia, Universidade de Lisboa, Portugal. [3]Universidad de Alcalá de Henares. Facultad de Farmacia, Departamento de Ciencias Biomédicas (Área de Farmacología; Nuevos agentes antitumorales, Acción tóxica sobre células leucémicas). Ctra. Madrid-Barcelona km. 33,600 28805 Alcalá de Henares, Madrid, España; [4]LAQV/REQUIMTE, Laboratório de Microbiologia, Departamento de Ciências Biológicas, Faculdade de Farmácia, Universidade do Porto, Portugal.
**patricia.rijio@ulusofona.pt*

Breast cancer cases continue to increase worldwide, requiring the development of innovative anti-cancer therapeutics. Protein kinase C-α (PKC-α), a serine/threonine kinase member of the PKC family, has emerged as a key protein involved in breast cancer pathogenesis.[1,2] *Plectranthus* spp. (Lamiaceae) represent a rich source of biologically active compounds, particularly diterpenes. Among these, the cytotoxic abietane diterpenoid 7α-acetoxy-6β-hydroxyroyleanone (**1**, Figure 1) can be obtained in high amounts from *P. grandidentatus* acetonic extract[1] and revealed promising activity in several breast cancer cell lines, with potential as a lead molecule for PKC-α interaction.[2] In this work, the possibility of functionalizing the chemical structure of **1** through esterification was explored. The aim was to improve the cytotoxic effect of **1,** focusing on PKC-α activation. A library of new theoretical royleanone analogues was prepared and the PKC-α interaction was explored *in silico*, by molecular docking. The hit analogues obtained from the docking screening were successfully prepared from **1**. Finally, derivatives were evaluated against breast cancer cell lines (MCF-7, MDA-MB-231 and MDA-MB-468), as well as non-tumorigenic fibroblasts (HFF-1). Some of the derivatives displayed selectivity towards cancer cells and were selected for further investigation, namely derivatives **2** - **5** (Figure 1). PKC-α activation potential is currently in evaluation, on a yeast-based screening assay. Additionally, the selected derivatives should be assessed in a PKC activity assay to validate their ability to activate this central signaling protein in breast cancer treatment.

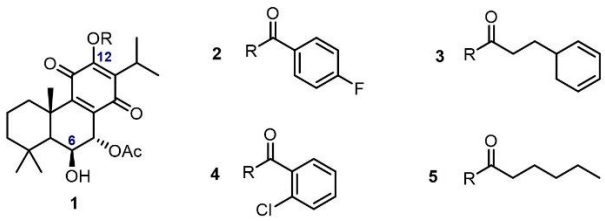


Figure 1: Abietane diterpenoids evaluated as PKC-α activators: natural 7α-acetoxy-6β-hydroxyroyleanone (**1**) obtained from *P. grandidentatus* and semi-synthetic analogues (**2** - **5**).

Acknowledgements
The authors acknowledge Fundação para a Ciência e a Tecnologia (FCT, Portugal), for funding this project through UIDB/04567/2020, UIDP/04567/2020 & UI/BD/151422/2021 and PhD grant SFRH/BD/137671/2018.

References
1. V. Isca, G. Bangay, S. Princiotto, L. Saraíva, D. Santos, A. García-Sosa and P. RIJO, 2023.
2. V. M. S. Isca, M. Sencanski, N. Filipovic, D. J. V. A. Dos Santos, A. Čipak Gašparović, L. Saraíva, C. A. M. Afonso, P. Rijo, A. T. García-Sosa, D. Santos, A. C. Gasparovic, L. Saraiva, C. A. M. Afonso, P. Rijo and A. T. García-Sosa, *Int J Mol Sci.*, 2020, **21**, 367.

Influence of electrolyte and binder on the performance of redox-active covalent organic framework cathode materials for lithium-ion batteries

Olivera Lužanin[1,2], Raquel Dantas*[,3], Robert Dominko[1,2], Jan Bitenc[2], Manuel Souto[3]

[1]*National Institute of Chemistry, Hajdrihova 19, 1000, Ljubljana, Slovenia*
[2]*Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večnapot 113, 1000, Ljubljana, Slovenia*
[3]*Department of Chemistry, CICECO-Aveiro Institute of Materials, University of Aveiro, Aveiro, 3810-393, Portugal.*
**raqueldantas@ua.pt*

Covalent organic frameworks (COFs) are crystalline porous organic polymers that have recently emerged as promising electrode materials for rechargeable batteries.[1,2] Two factors that are often overlooked when studying the performance of new COFs as the electrode active material are the choice of electrolyte and binder. Therefore, in this communication, we present a systematic study of the influence of the electrolyte and binder on the capacity of a redox-active covalent organic framework (DAAQ-TFP-COF[3–5]) used as cathode in lithium batteries. The performance of DAAQ-TFP-COF as the active material was carefully studied using four different electrolytes and two different binders in a Swagelock setup. Thereby, our results show a significant difference in the electrochemical performance depending on the electrolyte and binder used. The combination of lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) in tetraethylene glycol dimethyl ether (TEGDME) as electrolyte and poly(tetrafluoroethylene) (PTFE) as binder was identified as the one obtaining the best performance. In addition, electrochemical studies were also conducted in a half coin-cell setup. The results show that no further processing of the bulk COF was necessary to obtain good electrochemical performances. Thus, our findings demonstrate that the proper choice of both the electrolyte and the binder is crucial to maximize the performance of COF-based electrodes for energy storage devices.

Acknowledgements
This work has received funding from the European Research Council (ERC) under the European Union's Horizon Europe Framework Programme (ERC-2021-Starting Grant, grant agreement nº 101039748-ELECTROCOFS). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). We also thank FCT for funding the projects PTDC/QUI-ELT/2593/2021, PTDC/QUI-QIN/29834/2017 and IF/00894/2015.

References

1. T. Sun, J. Xie, W. Guo, D. S. Li and Q. Zhang, *Adv Energy Mater*, 2020, 10.
2. D. Zhu, G. Xu, M. Barnes, Y. Li, C. P. Tseng, Z. Zhang, J. J. Zhang, Y. Zhu, S. Khalil, M. M. Rahman, R. Verduzco and P. M. Ajayan, *Adv Funct Mater*, 2021, 31.
3. S. Wang, Q. Wang, P. Shao, Y. Han, X. Gao, L. Ma, S. Yuan, X. Ma, J. Zhou, X. Feng and B. Wang, *J Am Chem Soc*, 2017, **139**, 4258–4261.
4. C. R. Deblase, K. E. Silberstein, T. T. Truong, H. D. Abruña and W. R. Dichtel, *J Am Chem Soc*, 2013, 135, 16821–16824.
5. E. Vitaku, C. N. Gannett, K. L. Carpenter, L. Shen, H. D. Abruña and W. R. Dichtel, *J Am Chem Soc*, 2019, 142, 16–20.

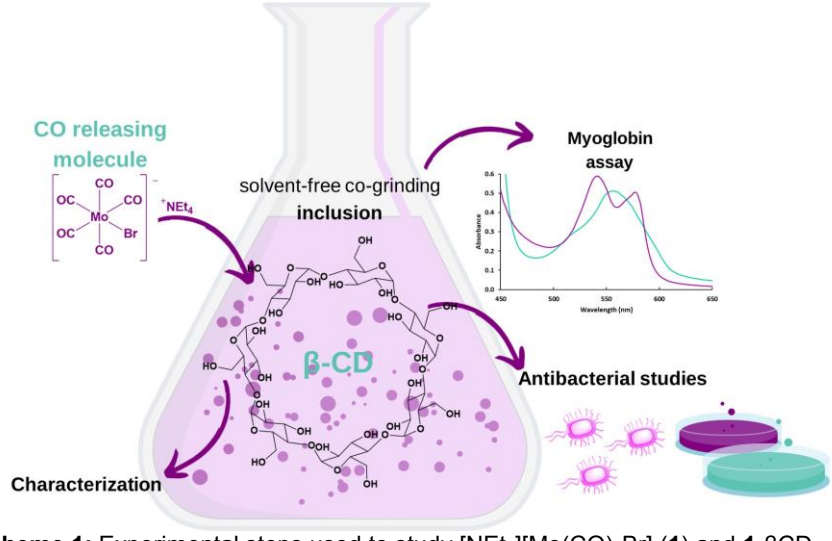
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Effect of β-cyclodextrin on the CO-release kinetics and antimicrobial activity of $[Mo(CO)_5Br][NEt_4]$

Isabel B. Calhau[1,*], Rodrigo P. Monteiro[1], Ana C. Gomes[1], Carla Pereira[2], Cátia Vieira[2], M. Amparo F. Faustino[3], Adelaide Almeida[2], Martyn Pillinger[1], Carlos C. Romão[4], Isabel S. Gonçalves[1]

[1]CICECO - Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]CESAM - Centre for Environmental and Marine Studies, Department of Biology, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [3]LAQV-Requimte & Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [4]Instituto de Tecnologia Química E Biológica António Xavier, Universidade Nova de Lisboa, Oeiras, Portugal
**isabel.calhau@ua.pt*

In the present work the possibility of improving the solubility, bioavailability and bactericidal activity of the carbon monoxide releasing molecule (CORM) $[Mo(CO)_5Br]^-$ (**1**) by solvent-free co-grinding with β-cyclodextrin (βCD) in a planetary ball mill was investigated. Data obtained by FT-IR spectroscopy, Raman spectroscopy, powder X-ray diffraction and thermogravimetric analysis showed that, other than a small decrease in the crystallinity of 1, the co-grinding process produced a finely dispersed physical mixture of crystalline CORM and crystalline excipient. The aqueous solubility of **1** in the **1**-βCD product was enhanced with respect to sparingly soluble pure **1**, which might be ascribed to increased wettability and a CD-CORM interaction in solution. Investigation of the CO release kinetics by the standard myoglobin assay showed that the half-life of CO release increased from ca. 6 min for **1** to ca. 19 min for **1**-βCD, while the number of equivalents released decreased from 3.2 to 1.8. The antibacterial properties of **1** and **1**-βCD were evaluated using the broth microdilution method to determine minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) against *Escherichia coli* ATCC 25922. The compounds showed similar growth inhibitory (MIC = 200 μM) and bactericidal (MBC = 400 μM) effects. Bacterial viability assays corroborated the MBC/MIC studies, showing 3 logs (99.9% of relative light units - RLU) reduction in viable cell count after 15 min exposure to MBC value. Although the CORM-CD system displays a lengthening of the half-life of CO release and a decrease in the CO release efficiency relatively to **1**, the co-grinding with βCD does not affect the bactericidal activity of the CORM. Overall, βCD could be a suitable excipient for the development of immediate-release formulations of CORMs similar to complex **1**.



Scheme 1: Experimental steps used to study $[NEt_4][Mo(CO)_5Br]$ (**1**) and **1**-βCD.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020), LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020), and CESAM (UIDB/50017/202 and UIDP/50017/2020), financed by national funds through the FCT (Fundação para a Ciência e a Tecnologia) / MCTES (Ministério da Ciência, Tecnologia e Ensino Superior) (PIDDAC). I.B.C. (ref. 2021.05953.BD), R.P.M. (ref. 2020.04758.BD), and C.V. (ref. SFRH/BD/150358/2019) are grateful to the FCT and the European Social Fund (ESF) for PhD grants. A.C.G. (CEECIND/02128/2017) thanks the FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Novel flow-through like mode platform for the purification of L-asparaginase

João C. F. Nunes[1,*], Mafalda R. Almeida[1], Gabriela B. de Paiva[2], Danielle B. Pedrolli[2], Valéria C. Santos-Ebinuma[2], Márcia C. Neves[1], Mara G. Freire[1], Ana P. M. Tavares[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
[2]School of Pharmaceutical Sciences, Department of Bioprocess Engineering and Biotechnology, São Paulo State University (UNESP), Araraquara, São Paulo 14800-903, Brazil
**jcfn@ua.pt*

L-Asparaginase, an amidohydrolase enzyme applied in the pharmaceutical and food industries, is widely distributed in nature.[1,2] Microorganisms are the preferential source of L-asparaginase production since they easily grow on inexpensive substrates.[2] However, high levels of enzyme purity are required for all industrial applications, highlighting the need of developing cost-effective L-asparaginase purification processes.[3]
The main focus of this work is the development of an alternative and simple semi-continuous flow-through downstream process for L-asparaginase purification through silica-based supported ionic liquid-like phase (SSILLP) materials. SSILLP materials comprise ionic liquids (ILs) that are covalently attached to the silica, enabling distinct interactions to be established among the target compounds and the support.
SSILLP materials based on quaternary ammonium cations with different alkyl chain lengths and the Cl^- anion were synthesized and chemically, surface and morphologically characterized.[2] The most promising SSILLP material for L-asparaginase purification was selected through an initial screening. The L-asparaginase purification conditions, e.g., pH and solid/liquid ratio, were then optimized using Response Surface Methodology.[2] The semi-continuous L-asparaginase purification was ultimately addressed using the most promising SSILLP material (silica functionalized with dimethylbutylpropylammonium chloride ([Si][N_{3114}]Cl)) and optimized purification conditions (pH 3 and solid/liquid ratio of 15), reaching a purification factor of 5.15. [2] Through this methodology, process costs could be significantly decreased, leading to the enzyme price reduction, enabling its widespread application.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). This work was supported by the project POCI-01-0145-FEDER-031268-funded by FEDER through COMPETE2020, and by national funds (OE) through FCT/MCTES, and by FAPESP (2018/06908-8). Ana P. M. Tavares and Márcia C. Neves acknowledge FCT for the research contract CEECIND/2020/01867 and CEECIND/00383/2017, respectively. João C. F. Nunes acknowledges SPQ and FCT for the PhD fellowship (SFRH/BD/150671/2020).

References
1. J. C. F. Nunes, M. R. Almeida, R. M. F. Bento, M. M. Pereira, V. C. Santos-Ebinuma, M. C. Neves, M. G. Freire and A. P. M. Tavares, Molecules, 2022, 27, 929.
2. J. C. F. Nunes, M. R. Almeida, G. B. de Paiva, D. B. Pedrolli, V. C. Santos-Ebinuma, M. C. Neves, M. G. Freire and A. P. M. Tavares, Sep. Purif. Technol., 2023, 315, 123718.
3. J. J. M. Cachumba, F. A. F. Antunes, G. F. D. Peres, L. P. Brumano, J. C. Dos Santos and S. S. Da Silva, Brazilian J. Microbiol., 2016, 47, 77–85.

P180

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Developing new acridine derivative doping polymers for optical sensing and antimicrobial studies

Inês Pereira-Gomes[1,*], Frederico Duarte[1], Joana Galhano[1], Georgi Dobrikov[2], Atanas Kurutos[2,3], Maria Paula Duarte[4], José Luis Capelo-Martínez[1,5], Carlos Lodeiro[1,5], Elisabete Oliveira[1,5]

[1]BIOSCOPE Research Group, LAQV-REQUIMTE, Chemistry Department, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal; [2]Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Acad. G. Bonchev str., bl. 9, 1113 Sofia, Bulgaria. [3]University of Chemical Technology and Metallurgy, 8 St. Kliment Ohridski blvd, 1756 Sofia, Bulgaria; [4]MEtRICs, Chemistry Department, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal; [5]PROTEOMASS Scientific Society, Rua dos Inventores, Madam Parque, Caparica Campus, 2829-516 Caparica, Portugal.
** ip.gomes@campus.fct.unl.pt*

Antimicrobial resistance poses a significant global challenge that undermines medical progress and the effective treatment of infectious diseases[1]. The paucity of new antimicrobial compounds derived from natural sources or representing novel classes has spurred researchers to explore alternative strategies, including the utilization of synthetic compounds with antimicrobial properties[1]. Acridine derivatives, encompassing both natural and synthetic variants, have attracted considerable attention from medicinal chemists due to their diverse biological activities, serving as anti-inflammatory, antibacterial, and antitumor agents[2]. Polymer materials possessing intrinsic antimicrobial properties or the capacity to be conjugated with antimicrobial agents offer potential alternatives to conventional antimicrobials, with potential applications in medical and industrial settings for controlling bacterial proliferation[3].

In this study, we present the synthesis of a novel acridine derivative, referred to as L1, in both solution and solid state. L1 was successfully incorporated into biocompatible polymers such as poly(vinyl acetate) (PVA) and polyvinylpyrrolidone (PVP). We thoroughly investigated the optical properties of L1 and evaluated its antimicrobial efficacy against both Gram-negative and Gram-positive bacteria. Through these experiments, we aimed to assess the compound's potential as an antimicrobial agent.

Acknowledgements
This work was supported by the Associated Laboratory for Green Chemistry - LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020) as well as the PROTEOMASS Scientific Society (Portugal) for funding support (General Funding Grant 2022-2023). F.D. and J.G. thank to FCT/MEC (Portugal) for their doctoral grant 2021.05161.BD and 2022.09495.BD, respectively. E.O thanks FCT/MEC (Portugal) for the individual contract, CEECIND/00648/2017.

References
1. N. F. Kamaruzzaman, L. P. Tan, R. H. Hamdan, S. S. Choong, W. K. Wong, A. J. Gibson, A. Chivu and M. De Fatima Pina, *Int. J. Mol. Sci.*, 2019, **20**, DOI:10.3390/ijms20112747.
2. R. Chen, L. Huo, Y. Jaiswal, J. Huang, Z. Zhong, J. Zhong, L. Williams, X. Xia, Y. Liang and Z. Yan, *Molecules*, 2019, **24**, DOI:10.3390/molecules24112065.
3. G. A. Marcelo, J. Galhano, M. P. Duarte, A. Kurutos, J. L. Capelo-Martínez, C. Lodeiro and E. Oliveira, *Macromol. Biosci.*, 2022, 22, DOI:10.1002/mabi.202200244.

Studying a novel fluorescent molecular probe containing a naphthalimide unit as a temperature and toxic metal ions sensor

Diogo Torres[1,*], Frederico Duarte[1], Georgi Dobrikov[2], Atanas Kurutos[2,3], José Luis Capelo-Martínez[1,4], Carlos Lodeiro[1,4], Hugo M. Santos[1,4], Elisabete Oliveira[1,4]

[1]BIOSCOPE Research Group, LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal; [2]Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Acad. G. Bonchev str., bl. 9, 1113 Sofia, Bulgaria; [3]University of Chemical Technology and Metallurgy, 8 St. Kliment Ohridski blvd, 1756 Sofia, Bulgaria; [4]PROTEOMASS Scientific Society, Rua dos Inventores, Madam Parque, Caparica Campus, 2829-516 Caparica, Portugal
**dm.torres@campus.fct.unl.pt*

In our research project on multifunctional molecules[1–3], we have investigated a newly synthesized naphthalimide derivative as a potential fluorescent chemosensor for detecting trace amounts of pollutant ions and monitoring temperature in various samples, including chemical, biological, and environmental systems. The compound's photophysical properties were thoroughly examined using UV–visible, steady-state, and time-resolved fluorescence spectroscopy in both the solid state and polar as well as apolar solvents. Remarkably, the reported compounds exhibited positive solvatochromism, relatively high fluorescence quantum yields ranging from 0.37 to 0.43, and fluorescence lifetimes in the nanosecond range.
In this study, we have demonstrated that this novel chemosensor holds great potential as a disposable molecular thermometer, specifically designed for the temperature range of 20–50 °C, encompassing both heating and cooling processes. To enhance its practical utility, we incorporated the dye into thin films of polymethylmethacrylate (PMMA) and poly(styrene-butadiene-styrene) (SBS), and investigated the thermostability of these films to ensure their performance under varying temperature conditions. Additionally, spectrophotometric and spectrofluorimetric titrations of the compound were conducted with a variety of metal ions in acetonitrile, exhibiting high sensitivity to Cu^{2+} and Hg^{2+}.

Acknowledgements
This work was supported by the Associated Laboratory for Green Chemistry (LAQV-REQUIMTE), which is financed by national funds from FCT/MCTES (Portugal, UIDB/50006/2020 and UIDP/50006/2020) as well as by the PROTEOMASS Scientific Society (General Funding Grant 2022–2023). F.D. thanks to FCT/MEC (Portugal) for their doctoral grant (2021.05161.BD). E.O thanks FCT/MEC (Portugal) for the individual contract (CEECIND/00648/2017). D.T. thanks the Calouste Gulbekian Foundation for Gulbenkian New Talents 2022 Scholarship in Chemistry.

References
1. G. Pedro, F. Duarte, D. A. Cheptsov, N. Y. Volodin, I. V. Ivanov, H. M. Santos, J. L. Capelo-Martinez, C. Cuerva, E. Oliveira, V. F. Traven and C. Lodeiro, *Sensors*, 2023, **23**, DOI:10.3390/s23031689.
2. G. A. Marcelo, J. Galhano, M. P. Duarte, A. Kurutos, J. L. Capelo-Martínez, C. Lodeiro and E. Oliveira, *Macromol. Biosci.*, 2023, **22**, DOI:10.1002/mabi.202200244.
3. F. Duarte, G. Dobrikov, A. Kurutos, H. M. Santos, J. Fernández-Lodeiro, J. L. Capelo-Martinez, E. Oliveira and C. Lodeiro, *Dyes Pigm.*, in press. DOI:10.1016/j.dyepig.2023.111428.

P182

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Wild endogenous mushroom: chemical characterization to hypocholesterolemic properties

Helena Laronha[1,*], Maria Inês Arranca[1], João Teixeira[1], Filipe Coreta-Gomes[1,2], Manuel A. Coimbra[1], Elisabete Coelho[1]

[1]LAQV-REQUIMTE, Chemistry Department,University of Aveiro, 3810-193 Aveiro, Portugal; [2]Coimbra Chemistry Center-Institute of Molecular Sciences (CQC-IMS), Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal
**h.laronha@ua.pt*

Mushrooms, highly appreciated in traditional cuisine, are described as functional foods, since their chemical composition present several compounds[1], for example polysaccharides, which have been described with bioactive properties, such as hypocholesterolemic properties[2] - hypercholesterolemia being one of the causes of cardiovascular diseases. The search for functional foods with these properties[3] has increased due to several side effects caused by synthetic drugs, to control cholesterol levels.

In this work, chemical characterization of ethanolic and aqueous extracts of two edible Portuguese endogenous mushroom species – *Fistulina hepatica* and *Lactarius deliciosus* – and a medicinal mushroom species – *Ganoderma lucidum* (brown) – were studied. The free sugars were measured by gas chromatography, concluding that the *Lactarius deliciosus* and *Fistulina hepatica* have a higher mannitol (30%) and arabinitol (65%) content, respectively. The aqueous extracts from all mushroom species presented polysaccharides (27 – 66%), mainly monosaccharides residues of glucose, galactose, and mannose. The aqueous extract of *Lactarius deliciosus* was further fractionated with gradual ethanol precipitation, obtaining a rich fraction in glucose (81 % mol) and galactose (8 % mol) with 50% of ethanol (Et50). The glycosidic linkage analysis of Et50, determined by gas chromatography and mass spectrometry of the partially methylated alditol acetates, showed the presence of linear (1→4)-linked glucose (62%), terminally-linked glucose (13%) and (1→4,6)-linked glucose (9%), indicative of glycogen-like structure. Also, it was observed the presence of (1→6)-liked galactose (6%), (1→2,6)-linked galactose (4%) and (1→3)-linked galactose (3%), indicative of the presence of a galactan.

The cholesterol accessibility and bile salt binding of the aqueous extract of *Fistulina hepatica* and *Lactarius deliciosus* and the fraction Et50 of *Lactarius deliciosus* were tested, using an *in vitro* intestinal simplified model. Cholesterol film solubilization was quantified by a commercially available kit and was shown a cholesterol accessibility decreased 41% for *Fistulina hepatica* and 7% for *Lactarius deliciosus*. Bile salts sequestration were quantified by ^{1}H RMN using trimethylsylilpropionic acid, as internal standard, and was shown a bile salts sequestration between 73 - 63%. Preliminary results showed that these samples have cholesterol-lowering properties, probably due to the bile salts sequestration capacity of polysaccharides present in these samples. This work highlights the hypocholesterolemic properties of polysaccharides present in mushrooms, strengthening the comprehension of their structure-function relationships.

Acknowledgements
The authors thanks to the project Safe2Taste (MTS/BRB/0056/2020). Helena Laronha thanks FCT/MCTES (Fundação para a Ciência e Tecnologia and Ministério de Ciência, Tecnologia e Ensino Superior) and ESF (European Social Fund) through NORTE 2020 (Programa Operacional Região Norte) for her PhD grant (Ref. 2022.13262.BD). Maria Inês Arranca thanks to the project "Safe2Taste" for the research grant (MTS/BRB/0056/2020). Elisabete Coelho thanks Portuguese national funds (OE), through FCT, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19 (CDL-CTTRI-88-ARH/2018 - REF. 049-88-ARH/2018). Filipe Coreta-Gomes acknowledge the research contract funding due to LAQV-REQUIMTE (UIDB/50006/2020) project.

Funding
This work was financially supported by Safe2Taste (MTS/BRB/0056/2020), FightSterol (PTDC/QUI-OUT/29373/2017) funded by FCT/MCTES through national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement and Compete 2020. The authors also acknowledge the funding through LAQV/REQUIMTE (UIDB/50006/2020 & UIDP/50006/2020).

References
1. I. C. Ferreira, J. A. Vaz, M. H. Vasconcelos and A. Martins, *Anticancer Agents Med Chem*, 2010, **10**, 424-436.
2. I. M. V. Silva, F. Machado, M. J. Moreno, C. Nunes, M. A. Coimbra and F. Coreta-Gomes, *Molecules*, 2021, **26**.
3. A. Gil-Ramírez, D. Morales and C. Soler-Rivas, *Food Funct*, 2018, **9**, 53-69.

Integrated extraction, purification and preservation of DNA with ionic liquid-based aqueous biphasic systems

Ana I. Valente[1], Teresa B. V. Dinis[2], Ana P. M. Tavares[1], Fani Sousa[3], Mara G. Freire[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]LSRE-LCM - Laboratory of Separation and Reaction Engineering-Laboratory of Catalysis and Materials, Department of Chemical Engineering at Faculty of Engineering, University of Porto, Rua Dr Roberto Frias s/n, 4200-465 Porto, Portugal; [3]CICS-UBI – Health Sciences Research Center, University of Beira Interior, Av. Infante D. Henrique, 6200-506 Covilhã, Portugal
**anaivalente@ua.pt*

The production of deoxyribonucleic acid (DNA) in large-scale for therapeutic purposes presents several challenges. An effective downstream process is highly demanding, as it should be capable of extracting, purifying, and preserving DNA integrity, by reducing its degradation by endonucleases.1,2 A technique that allows the integration of several downstream steps is aqueous biphasic systems (ABS). Through the alignment of ABS with ionic liquids (ILs), IL-based ABS can be a possible platform to be included in DNA production when properly designed. Nonetheless, until our work3 , no attempt had been made to apply an IL-based ABS with DNA, particularly an ABS capable of separating endonucleases from nucleic acids. In this work, doublestranded DNA (dsDNA) was separated from deoxyribonuclease I (DNase I) endonuclease through the application of a three-phase partitioning system (TPP) formed by an ABS composed of biocompatible cholinium-based ILs. Taking advantage of the customized properties of ILs, dsDNA was completely extracted to the IL-rich phase, while DNase I was precipitated at the ABS interface. The system composed of [Ch][Gly] and PEG 400 demonstrated that an optimized ABS/TPP allows the dsDNA simultaneous extraction, purification, and preservation in the long term, paving the way for their application in the bioprocessing of DNAbased therapy products.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia for the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC) and CICS-UBI projects UIDB/00709/2020 & UIDP/00709/2020 financed by national funds through the FCT/MCTES. This work was developed within the scope of the project PureDNA (2022.03394.PTDC, Development of cost-effective platforms based on ionic liquids for the purification of p53-minicircle DNA biopharmaceuticals with application in oncology), financially supported by national funds (OE), through FCT/MCTES. Ana P.M. Tavares acknowledges the FCT for the research contract CEECIND/2020/01867 and Ana I. Valente acknowledges the FCT PhD grant (SFRH/BD/08352/2021).

References
1. J. Stadler, R. Lemmens, T. Nyhammar, Journal of Gene Medicine, 2004, 6, S54-S66.
2. D. R. Gill, I. A. Pringle, S. C. Hyde, Gene Therapy, 2009, 16(2), 165-171.
3. T. B. V. Dinis, A. I. Valente, A. P. M. Tavares, F. Sousa, M. G. Freire, Separation and Purification Technology, 2023, DOI: 10.1016/j.seppur.2023.123646

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development and electrochemical studies of Diphenoquinones and Hydrodiphenoquinones as new Organic Redox Mediators

Daniel Galrito*, Flávia Leitão, Hugo Cruz, Luís C. Branco, Paula S. Branco

LAQV-REQUIMTE, Chemistry Department, NOVA School of Science and Technology, Caparica, Portugal
**d.galrito@campus.fct.unl.pt*

The need to decrease our dependency on fossil fuels requires alternative renewable energy sources, such as solar and wind energy. However, the intermittent nature of these energy sources proves to be a challenge and reveals the importance of developing energy storage systems with higher efficiency.[1,2]
Some batteries are dependent on scarce or toxic elements, such as lithium or cobalt, which increases the difficulty in their deployment on large scale.[1] Replacing these with organic redox mediators, ORMs, would prove to have lower costs and be a highly tunable alternative.[3]
This work aims to study potential new ORMs from the classes of compounds diphenoquinone and hydrodiphenoquinone. Diphenoquinones were synthesized from commercially available phenols, through oxidation with ceric ammonium nitrate (CAN). Hydrodiphenoquinones were then produced through the reduction of diphenoquinones with zinc in acetic acid. The electrochemical properties of these compounds were studied by cyclic voltammetry (Figure 1), to access their future applicability as organic redox mediators. The diphenoquinones revealed two reversible electron transfers, however the hydrodiphenoquinones showed chemical irreversible electron transfers.

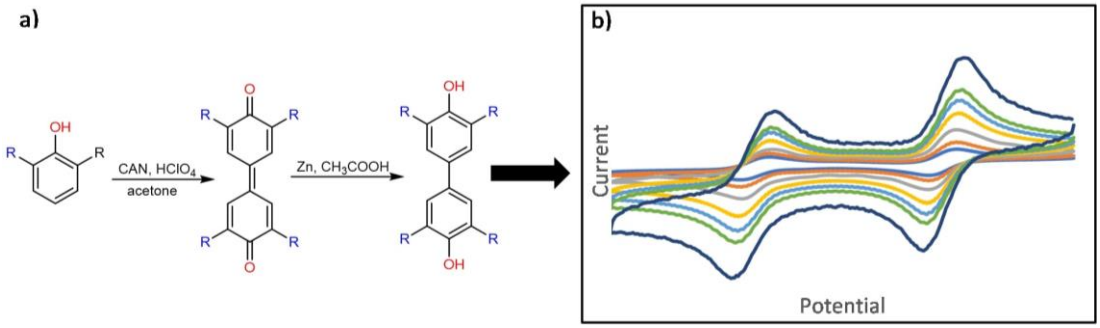


Figure 1: a) Synthetic pathway to target compounds and b) Cyclic Voltammetry studies of tetra-*t*-butyl diphenoquinone (1 mM) in DMF +0.1M $TBAPF_6$, using as a working electrode a glassy carbon disk (d=3mm), a platinum wire as a counter electrode and as reference a SCE.

Acknowledgements
We thank FCT – Fundação para a Ciência e a Tecnologia I. P, this work was performed under the project PTDC/QUI-QOR/7450/2020 "Organic Redox Mediators for Energy Conversion". This work was supported by the Associate Laboratory for Green Chemistry - LAQV financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). FCT/MCTES is also acknowledged for the National NMR Facility Network (ROTEIRO/0031/2013-PINFRA/22161/2016, co-financed by FEDER through COMPETE 2020, POCI, PORL, and FCT through PIDDAC).

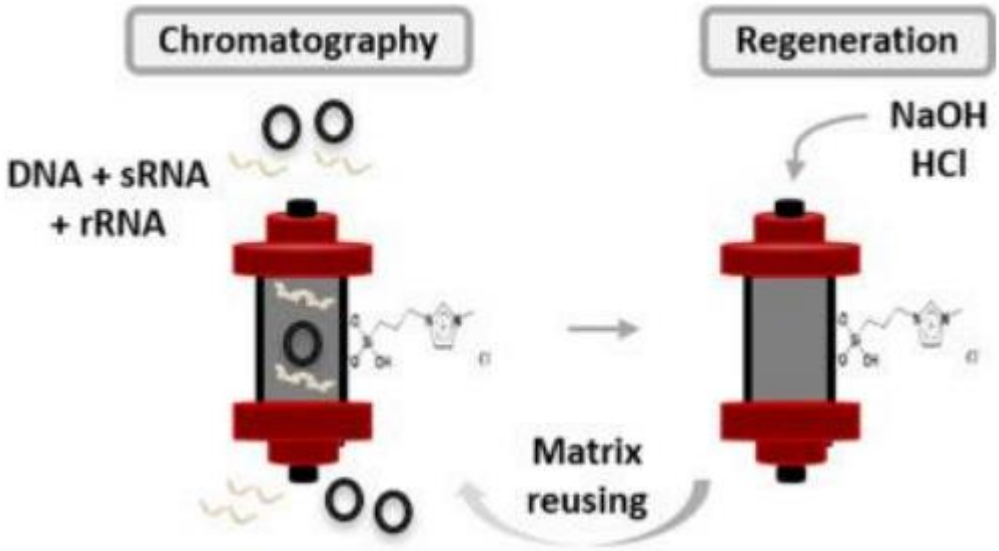
References
1. E. Sánchez-Díez, E. Ventosa, M. Guarnieri, A. Trovò, C. Flox, R. Marcilla, F. Soavi, P. Mazur, E. Aranzabe and R. Ferret, *J Power Sources*, , DOI:10.1016/j.jpowsour.2020.228804.
2. G. L. Soloveichik, *Chem Rev*, 2015, **115**, 11533–11558.
3. R. Chen, S. Kim and Z. Chang, in *Redox - Principles and Advanced Applications*, InTech, 2017.

Ionic liquids immobilized in macroporous supports as synthetic chromatographic ligands for the separation of nucleic acids

M. C. Neves[1], P. Pereira[2], A. Q. Pedro[1,*], J. Martins[2], T. Trindade[1], J. A. Queiroz[2], M. G. Freire[1], F. Sousa[2]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; [2]CICS-UBI – Health Sciences Research Centre, University of Beira Interior, Av. Infante D. Henrique, 6200-506 Covilhã, Portugal
**apedro@ua.pt*

Nucleic acids are relevant biomolecules in therapy and diagnosis, for which their purity and biological activity are of crucial relevance. Particularly, the traditional RNA extraction techniques are time-consuming and require highly toxic reagents, demanding improved technologies able to provide this biomolecule with high integrity, purity, and biological activity.1 With this challenge in mind, this work reports the functionalization of a macroporous chromatographic support with ionic liquids (ILs), and their remarkable performance to purify nucleic acids.2 An initial screening with distinct IL chemical structures supported in silica was carried out, allowing the identification of the IL 1-methyl-3-propylimidazolium chloride as the most promising ligand. This IL was then immobilized in a commercial methacrylic polymeric resin feasible for application in preparative liquid chromatography on the separation of bacterial nucleic acids. It was found that the IL 1-methyl-3-propylimidazolium chloride acts as a multimodal ligand with a remarkable dynamic binding capacity, allowing the (one-step) purification of nucleic acids, namely small RNAs, ribosomal RNAs, and genomic DNA, from a bacterial lysate. Furthermore, this support can be regenerated and reused without compromising its separation performance.



Scheme 1: Proposed application of ionic liquid-immobilized supports for the separation of nucleic acids.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). This work was additionally supported by the CICS-UBI project UIDB/00709/2020, financed by national funds through FCT/MCTES, and the EIC-Pathfinder Yscript project with reference 101047214, supported by the budgets of the Horizon Europe Program. The NMR spectrometers used in this work are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC). Augusto Q. Pedro and Márcia C. Neves acknowledge FCT respectively, for the research contracts CEECIND/02599/2020 and CEECIND/00383/2017 under the Scientific Stimulus – Individual Call.

References
1. 1 M. V. Quental, A. Q. Pedro, P. Pereira, M. Sharma, J. A. Queiroz, J. A. P. Coutinho, F. Sousa, M. G. Freire, ACS. Sustain. Chem. Eng., 2019, 7, 9439-9448.
2. 2 M. C. Neves, P. Pereira, A. Q. Pedro, J. C. Martins, T. Trindade, J. A. Queiroz, M. G. Freire, F. Sousa, Mater. Today Bio., 2020, 8, 100086

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Di-anchoring thieno[3,4-*b*]thiophene-based sensitizers for DSSC applications

A. L. Silva*, G. Malta, J. C. Lima, J. Parola, P. Branco

LAQV-REQUIMTE, Departament of Chemistry, NOVA School of Science and Technology, FCT NOVA, Universidade NOVA de Lisboa, 2829-516, Caparica, Portugal
** aal.silva@campus.fct.unl.pt*

The environmental and energy issues are ranked first among the challenges we will face into the next fifty years. The world's oil reserves are being used up faster now due to rising energy consumption, and the burning of fossil fuels has polluted the environment and played a role to the worldwide greenhouse effect.[1] Among various renewable energy sources, solar energy presents several promising advantages and great potential for power generation. Regarding already established solar cells, dye-sensitized solar cells (DSSCs) are one of the most promising alternatives to silicon cells.[2] Despite recent advancements, their efficiencies remain lower than other competing technologies, so the development of dyes with higher performance in DSSCs is of great interest.[3]

Fused thiophenes represent a promising class of π-bridge due to their extended molecular conjugation, high stability, ring planarity and S-S interactions.[4] Due to their properties, fused thiophenes have aroused much interest in the fields of organic photovoltaic cells (OPVs), organic field-effect transistors (OFETs) and DSSCs in these last case interesting conversion efficiencies were achived.[5] Considering the promising properties of these dyes, two compounds containing a thieno[3,4-b]thiophene nucleus in their π-bridge and two different anchoring groups are being developed The dye synthesis involved the construction of the thieno[3,4-b]thiophene nucleus followed by Sonogashira and Heck palladium catalysed reaction to add the anchor and donor parts of the dye and increase the conjugated system.

One of the compounds was applied in DSSC devices and by measuring the current-voltage curves their efficiency was obtained as also the emission and absorption spectra.

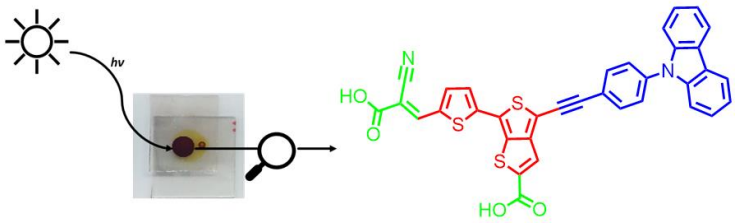


Figure 1: Schematic representation of the synthesized thieno[3,4-b]thiophene-based organic dyes.

Acknowledgements

Thanks to FCT – Fundação para a Ciência e a Tecnologia I. P, this work was performed under the project PTDC/QUI-QOR/7450/2020 "ORGANIC REDOX MEDIATORS FOR ENERGY CONVERSION/FCT/UNL". This work was also supported by the Associate Laboratory for Green Chemistry - LAQV which is financed by national funds from FCT/MCTES (UIDB/50006/2020 and UIDP/50006/2020). FCT/MCTES is also acknowledged for the National NMR Facility Network (ROTEIRO/0031/2013-PINFRA/22161/2016, cofinanced by FEDER through COMPETE 2020, POCI, PORL, and FCT through PIDDAC) and PhD grant PD/BD/145324/2019/ (G.M.).

References

1. Gong, J., Liang, J. and Sumathy, K. Renewable and Sustainable Energy Reviews 2012, 16(8), 5848–5860.
2. Gratzel, M., Acc Chem Res 2009, 42 (11), 1788-98.
3. Ye, M.; Wen, X.; Wang, M.; Locozzia, J.; Zhang, N.; Lin, C.; Lin, Z., Materials Today 2015, 18 (3), 155-162.
4. Kumaresan, P.; Vegiraju, S.; Ezhumalai, Y.; Yau, S.; Kim, C.; Lee, W.-H.; Chen, M.-C., Polymers 2014, 6 (10), 2645-2669.
5. Chen, Y. C.; Chou, H. H.; Tsai, M. C.; Chen, S. Y.; Lin, J. T.; Yao, C. F.; Chen, K., Chemistry 2012, 18 (17), 5430-7.

Polysaccharides-based bionanocomposites as sustainable materials for active food packaging

Cláudia Nunes*, Zélia Alves, Ana Barra, Paula Ferreira

Department of Materials and Ceramic Engineering, CICECO – Aveiro Institute of Materials, University of Aveiro
3810-193 Aveiro, Portugal
**claudianunes@ua.pt*

Biodegradable biopolymers are sustainable alternatives to conventional plastics for food packaging applications. To compete with synthetic polymers, biopolymers need to meet the requirements of cost-effective materials ensuring the mechanical and gas barrier characteristics of food packaging. Additionally, it is demanded to step towards active packaging, which means that packaging material need to interact with the food product to enhance its shelf life, contributing to reduce food waste. In this context, polysaccharides have been exploited to develop biodegradable films due to their functional and sustainable characteristics. The incorporation of fillers, such as clays, metal oxide particles, calcium carbonate, and graphene derivatives, has been a strategy to ensure the mechanical and gas barrier characteristics required for food packaging, to compete with synthetic polymers, while providing the bioactive properties.[1] On the other hand, the pulsed electric field (PEF) is a promising non-thermal food processing technique that preserves the nutritional and organoleptic food properties, meeting the high demand for minimally processed food. Currently the food is processed into a treatment chamber before packaging, which represents a risk of recontamination. The use of an electrically conductive food packaging to sterilize food in-pack may overcome this drawback. In this regard, electrically conductive biocomposites are promising materials for this application due to their non-toxic nature. In this work, the combination of different fillers, namely graphene derivatives, clays, and zinc oxide, to design new formulations based on polysaccharides (starch, alginate and chitosan) allows the production of biomaterials with enhanced mechanical and barrier properties, conferring functional properties as antioxidant capacity, antimicrobial activity and/or electrical conductivity.[1-4] Electrical conductivity is a required property for the processing of food at low temperature using electric fields (Figure 1).

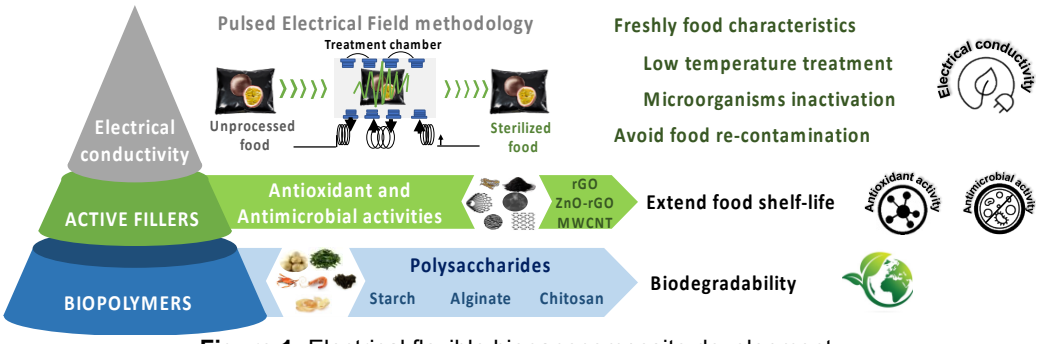


Figure 1: Electrical flexible bionanocomposite development.

This strategy represents an excellent way to enlarge the biobased film properties for food packaging application, thus being biodegradable and renewable alternatives to replace the petroleum-based plastics. Therefore, these bionanocomposites have a great potential as innovative and active food packaging.

Acknowledgements
This work was developed within the scope of projects CICECO (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) and BIOFOODPACK (M-ERA-NET2/0021/2016). ZA, AB, and PF thank FCT for grants PD/BD/117457/2016, SFRH/BD/148856/2019 and IF/300/2015, respectively. CN is grateful to national funds (OE), through FCT, I.P., for framework contract foreseen in numbers 4, 5 and 6 of the article 23, of the D-L 57/2016, of August 29, changed by Law 57/2017, of July 19.

References

1. A. Barra, J. Santos, M. Silva, C. Nunes, E. Ruiz-Hitzky, I. Gonçalves, S. Yildirim, P. Ferreira, P Marques, Nanomaterials, 10 (2020) 2077.
2. A. Barra, N. M. Ferreira, M. Martins, O. Lazar, A. Pantazi, A.A. Jderu, S. Neumayer, B. J. Rodriguez, M. Enăchescu, P. Ferreira, C. Nunes, Compos Sci Technol, 173 (2019) 53–60.
3. Z. Alves, B. Abreu, N.M. Ferreira, E.F. Marques, C. Nunes, P. Ferreira, Carbohydrate Polymers, 273 (2021) 118531.
4. Z. Alves, C. Nunes, P. Ferreira, Nanomaterials, 11(8) (2021) 2149.
5. Z. Alves, N. M. Ferreira, S. Mendo, P. Ferreira, C. Nunes, International Journal of Molecular Sciences, 22 (2021) 9943.

P188

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Interaction of acetylcholine-binding protein from *Aplysia californica* with Imidacloprid: a computational investigation

J. R. C. Santos*, P. E. Abreu, J. M. C. Marques

CQC-IMS, Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal
**joanarcs95@gmail.com*

Pesticides have been formulated with the purpose of effectively managing pests or regulating plant growth, nevertheless, their extensive utilization has resulted in significant environmental issues, particularly water contamination. To address this matter, biological, chemical, and physical methodologies have been employed for water treatment. In such manner, insightful knowledge of the physicochemical properties of pesticides and the elucidation of their interaction with live-organisms target-proteins may be relevant for the design of new materials for its remediation from water.[1] Imidacloprid is an insecticide belonging to the family of neonicotinoids, which are among the most used pesticides, consequently, they are currently found in high concentrations in water ecosystems. Previous works have already reported the imidacloprid mode of action as an insecticide, which is based on the interaction of the nicotinoid with the nicotinic acetylcholine receptor (nAChRs) of several insects, interfering with the transmission of stimuli in the insect nervous system.[2] Acetylcholine-Binding Protein from sea hares *Aplysia californica* (Ac-AChBP) is frequently used as model of the ligand-binding domain of the nAChRs, since it has similar pharmacological properties, residues, and it can bind to the known nAChRs agonists and compete with antagonists such as acetylcholine and nicotine.[3]
In this work, we employed docking, electronic structure calculations and molecular dynamics simulations to explore the interaction of the imidacloprid with the Acetylcholine-Binding Protein from *Aplysia californica* in water.[4] To characterize de imidacloprid-protein interactions, the simulations were analyzed with several techniques, such as radial distribution functions, number of hydrogen bonds, representation of the intermolecular interactions, solvent accessible surface area, number of contacts, distances, interaction energies, and visual inspection. The results allowed the identification of several interaction sites and the aminoacids directly involved. The knowledge coming from this investigation may be relevant to the design of new materials for the removal of pesticides from water.

Acknowledgements
We thank the support from the Coimbra Chemistry Centre (CQC-IMS), which is financed by the Portuguese “Fundação para a Ciência e a Tecnologia” (FCT) through the Project UIDB/00313/2020, co-funded by COMPETE2020-UE. FCT is also gratefully acknowledged for a PhD grant to J.R.C. Santos – 2022.12451.BD. This publication is also based upon work of COST Action CA21101 "Confined molecular systems: from a new generation of materials to the stars" (COSY) supported by COST (European Cooperation in Science and Technology).

References
1. Iman A. Saleh, Nabil Zouari and Mohammad A. Al-Ghouti, Environmental Technology & Innovation, 2020, 19, 101026
2. B. Selvam, J. Graton, A. D. Laurent, Z. Alamiddine, M. Mathé-Allainmat, J. Lebreton, O. Coqueret, C. Olivier, S. H. Thany, and J.-Y. Le Questel, Journal of Molecular Graphics and Modelling, 2015, 55, 1
3. Lin B, Meng H, Bing H, Zhangsun D and Luo S., BioMed Research International, 2014, 691480.
4. R. P. D. Bank, https://www.rcsb.org/structure/3C79, (accessed June 2023)

Could the "eternal fountain of youth" be found in oenological waste? A case study of *Região Demarcada do Douro*

Rui Dias Costa[1,*], Raúl Domínguez-Perles[2], Irene Gouvinhas[1], Ana Novo Barros[1,*]

[1]*Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB)/Institute for Innovation, Capacity Building and Sustainability of Agri-Food Production (Inov4Agro), University of Trás-os-Montes e Alto Douro, Quinta de Prados, 5000-801 Vila Real, Portugal;* [2]*Phytochemistry and Healthy Foods Lab (LabFAS), CEBAS-CSIC (Consejo Superior de Investigaciones Científicas), Campus Universitario de Espinardo, Edif. 25, 30100 Murcia, Spain*
** ruiacosta@utad.pt; abarros@utad.pt*

Wine production is currently regarded as one of the most significant agricultural activities. This practice yields Winery By-Products (WBPs), including Grape Stems (GSt), Grape Pomace (GP), Grape Seeds (GSe), Wine Lees (WL), and Grapevine Shoots (GVS), among others [1]. Several studies have already demonstrated that WBPs can serve as a valuable source of natural antioxidants, primarily due to their abundance in bioactive phytochemicals, particularly phenolic compounds [2]. Phenolic compounds derived from WBPs have been associated with various noteworthy biological activities, such as antioxidant, anti-aging, cardioprotective, antibacterial, anti-inflammatory, and anticancer properties [3]. Recent research indicates an increasing significance of tyrosinase and elastase inhibitors in the fields of cosmetics and pharmaceuticals [4]. The objective of this study was to explore the potential application of GSt, GP, GSe, WL, and GVS from the Douro Region in the cosmetic industry. To accomplish this aim, several methodologies were employed, including the assessment of Total Phenols Content (TPC), Flavonoids Content (FC) [4], enzymatic inhibitory activity through tyrosinase and elastase inhibition assays [5], and antioxidant capacity determination using 2,2-diphenyl-1-picrylhydrazyl (DPPH), Ferric Reducing Antioxidant Power (FRAP), and 2,2-azino-bis (3-ethylbenzothiazoline-6- sulfonic acid) diammonium salt (ABTS) assays [4,6,7]. A solid-liquid extraction method employing a mixture of ethanol and water (50:50, v/v) was utilized to extract phenolic compounds from the WBPs. TPC exhibited a significant correlation with FC (r=0.837) and FRAP (r=0.952), while a positive correlation was observed between FC and FRAP (r=0.909). Additionally, ODC displayed correlations with DPPH (r=0.946) and ABTS (r=0.898). Among the various WBPs investigated, Grape Seeds (Viosinho, Malvasia Fina, and Fernão Pires) demonstrated the highest values of TPC, FC, FRAP, as well as anti-elastase and anti-tyrosinase activities compared to other WBPs. Overall, the WBPs examined exhibited promising properties as compounds with anti-elastase activity, suggesting their potential use as cosmetic ingredients. However, the GSe (Viosinho, Malvasia Fina, and Fernão Pires) displayed moderate anti-tyrosinase activity (36.57%).

Acknowledgements
Rui Dias Costa acknowledges the financial support provided by National Funds by FCT - Portuguese Foundation for Science and Technology PhD grant: 2021.07571.BD. Irene Gouvinhas thanks to FCT (Fundação para a Ciência e Tecnologia) for funding through the Scientific Employment Stimulus - Individual Call (2022.00498.CEECIND). We also acknowledge Rozés, Adega de Vila Real, and Daniel António Mesquita Fernandes – Unipessoal de Viticultura for the samples provided.

References

1. F. J. Barba, Z. Zhu, M. Koubaa, A. S. Sant'Ana and V. Orlien, Green alternative methods for the extraction of antioxidant bioactive compounds from winery wastes and by-products: A review, *Trends Food Sci. Technol.*, 2016, **49**, 96–109.
2. P. S. Melo, A. P. Massarioli, C. Denny, L. F. Dos Santos, M. Franchin, G. E. Pereira, T. M. F. D. S. Vieira, P. L. Rosalen and S. M. De Alencar, Winery by-products: Extraction optimization, phenolic composition and cytotoxic evaluation to act as a new source of scavenging of reactive oxygen species, *Food Chem.*, 2015, **181**, 160–169.
3. A. K. Chakka and A. S. Babu, Bioactive Compounds of Winery by-products : Extraction Techniques and their Potential Health Benefits, *Appl. Food Res.*, 2022, **2**, 100058.
4. S. Santos, M. Maia, A. Barros and I. Gouvinhas, Assessment of Phenolic Content, Antioxidant and Anti-Aging Activities of Honey from Pittosporum undulatum Vent. Naturalized in the Azores Archipelago (Portugal), *Appl. Sci.*, 2023, **13**, 1–13.
5. C. Leal, I. Gouvinhas, R. A. Santos, E. Rosa, A. M. Silva, M. J. Saavedra and A. I. R. N. A. Barros, Potential application of grape (Vitis vinifera L.) stem extracts in the cosmetic and pharmaceutical industries: Valorization of a by-product, *Ind. Crops Prod.*, 2020, **154**, 112675.
6. I. Gouvinhas, R. Pinto, R. Santos, M. J. Saavedra and A. I. Barros, Enhanced phytochemical composition and biological activities of grape (Vitis vinifera L.) Stems growing in low altitude regions, *Sci. Hortic. (Amsterdam).*, 2020, **265**, 109248.
7. A. S. Abraão, N. Fernandes, A. M. Silva, R. Domínguez-Perles and A. Barros, Prunus lusitanica L. Fruits as a Novel Source of Bioactive Compounds with Antioxidant Potential: Exploring the Unknown, *Antioxidants*, 2022, **11**, 1738.

P190

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The combination of high-pressure and pullulanase to improve starch-based films

Renata A. Amaral,[1] Ana P. Martins,[1,2] Carlos A. Pinto,[1] José Lopes da Silva,[1] Jorge A. Saraiva[1*]

[1]LAQV-REQUIMTE, Chemistry department, Aveiro University, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal;
[2]CICECO, Chemistry department, Aveiro University, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal;
**jorgesaraiva@ua.pt*

Thermoplastics are part of our daily lives and although synthetic non-biodegradable polymers have several advantages, such as low prices and simple industrial processing, they raise considerable environmental issues as they generate vast quantities of non-biodegradable waste. A high demand of green consumerism and the introduction and implementation of specific legislation heavily regulating single-use plastics and plastic bags has led to the quest and development of biodegradable biopolymer-based materials as environment-friendly alternative, being starch one of the options [1,2]. Starch is an essential biopolymer being renewable, cheap, and widely available. In addition, multiple studies have demonstrated that starch-based films are appropriate because they are odorless, colorless, visually attractive, can act as an antioxidant and antimicrobial carrier, and are edible[3]. However, high hydrophilicity and retrodegradation can hinder these films, as well as poor mechanical properties[4]. Physical, chemical, and enzymatic techniques can be used to modify starch so that its properties better suit food and industrial applications[5]. Some alternative processing techniques, such as high-pressure processing (HPP) and enzymatic debranching by pullulanase, can induce substantial changes in the physical, chemical, and functional properties of starches[6,7]. In this sense, HPP can be used as a physical technique since it can break or rearrange non-covalent chemical linkages of starch, while pullulanase can hydrolyze the α-1,6 glycosidic bonds of amylopectin molecules generating more linear starch chains and increasing amylose content [6,7].

For so, in this study the effect of HPP (500 MPa for 15 minutes or 350 for 5 minutes) as a starch pre-treatment, either alone or in combination with pullulanase incubation for 165 minutes was studied. Mechanical properties (elongation at break, tensile strength, young's modulus), hydrophobicity, color, transparency, moisture, water solubility, water vapor permeability (WVP) and FTIR, XRD, TGA, DSC, SEM, were used to compare the treated and untreated films.

All the developed films presented a good transparency, however the combination of pressure and pullulanase enabled films to become significantly more transparent and smoother. Films obtained from a 350 MPa/5-minute starch pre-treatment exhibited a greater hydrophobicity and a reduction by a half of WVP. On the other hand, an increase of 285% in elongation at break and a lower tensile strength were observed on HP treatments of 500 MPa during 15 min. When HPP is combined with pullulanase, there is an increase of tensile strength up to 75% more when compared to control and up to 170% more when compared to the respective HPP treatment, while the elongation at break is diminished. Besides, the combination of HPP with pullulanase increases the crystallinity of the films as well as their WVP but decreases its hydrophobicity.

It can be concluded that HPP and its combination with pullulanase as starch pre-treatments, are effective to modify starch-based films enhancing and tailoring their properties and therefore might be a promising approach towards sustainability and eco-friendly packaging.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCT for the financial support to the LAQV-REQUIMTE research Unit (UIDB/50006/2020 & UIDP/50006/2020) through national founds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement. Renata Amaral also acknowledges FCT/MCT for the PhD grant reference SFRH/BD/146009/2019

References

1. S. Agarwal, *Eur Polym J*, 2021, **160**, 110788.
2. J. Nilsen-Nygaard, E. N. Fernández, T. Radusin, B. T. Rotabakk, J. Sarfraz, N. Sharmin, M. Sivertsvik, I. Sone and M. K. Pettersen, *Compr Rev Food Sci Food Saf*, 2021, 1–48.
3. S. Kim, S. Y. Yang, H. H. Chun and K. Bin Song, *Food Hydrocoll*, 2018, **81**, 71–76.
4. R. Thakur, P. Pristijono, C. J. Scarlett, M. Bowyer, S. P. Sing and Q. V. Vuong, *Int J Biol Macromol*, 2019, **132**, 1079–1089.
5. P. Li, X. He, S. Dhital, B. Zhang and Q. Huang, *Carbohydr Polym*, 2017, **169**, 351–356.
6. E. Thomas, N. R. Panjagari, A. K. Singh, L. Sabikhi and G. K. Deshwal, *J Food Sci Technol*, 2022, **1**, 1–20.
7. P. Liu, W. Gao, X. Zhang, Z. Wu, B. Yu and B. Cui, *Carbohydr Polym*, 2020, **242**, 116332.

Food preservation by hyperbaric storage: a study with *Saccharomyces cerevisiae*

V. Lima*, J. Saraiva

LAQV-REQUIMTE, Chemistry Department, University of Aveiro, Portugal
*vasco.lima@ua.pt

Appropriate storage conditions are required to preserve food products, in order to prevent or delay microbial deterioration or quality problems. Cold storage is the most prevalent method employed for food preservation and is used globally. However, it has a great energy consumption and high emissions of global greenhouse gases, which are environmentally unsustainable. Recently, hyperbaric storage (HS), a novel food storage under mild pressures, has been proposed as an alternative to conventional refrigeration that can be used at room temperature (RT). This is a significant benefit as it allows for virtually no energy costs and substantially lower greenhouse gas emissions and has been demonstrated to preserve food products as well as or better than refrigeration. 1 Watermelon juice is known for having an interesting nutritional composition, associated with health benefits, namely vitamins (A, B, C and E), minerals (K, Mg, Ca and Fe), functionally important amino acids (citrulline and arginine) and antioxidants such as carotenoids and phenolic compounds. However, watermelon juice is highly perishable, since it has a high pH (5.2–6.7) and high water activity (0.97–0.99), making it more susceptible to microbial growth and enzymatic activity, leading to a short shelf-life. 2 For the first time, the impact of pH on a food (watermelon juice) preserved by HS at RT was studied with a focus on the behaviour of Saccharomyces cerevisiae inoculated in the juice, adjusted to different pH levels (4.0 and 6.5), and stored at pressures up to 100 MPa up to 21 days, along with controls stored at atmospheric pressure (AP) under refrigerated or RT conditions. The results showed that storage under pressure allowed for the inactivation of S. cerevisiae, often with reductions over 4 log CFU/g to levels below the detection limit, which was not the case for the AP juice samples. While increasing the pressure level had the effect of accelerating inactivation, varying the juice's pH was not as impactful, although juice stored at pH 6.5 seemed to have a slightly quicker inactivation at higher pressure levels. Considering these findings, variables like the juice's pH and the storage pressure level should be further studied to select the most appropriate HS preservation conditions. Additionally, it was noted that while the juice is preserved, not only the growth of S. cerevisiae can be controlled but its inactivation can also reach considerable levels, indicating that hyperbaric storage can also have great potential as a novel nonthermal pasteurization technique at room temperature with quasi no energetic costs.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCTES for the financial support for the LAQV research Unit (FCT UIDB/50006/2020 and UIDP/50006/2020) through national funds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement. Vasco Lima would like to thank also FCT/MCTES for the PhD grants SFRH/BD/146080/2019.

References
1. M. D. Santos, L. G. Fidalgo, C. A. Pinto, R. V. Duarte, A. T. Lemos, I. Delgadillo and J. A. Saraiva, Crit Rev Food Sci Nutr, 2021, 61, 2078-2089.
2. A. T. Lemos, A. C. Ribeiro, L. G. Fidalgo, I. Delgadillo and J. A. Saraiva, Food Chem, 2017, 231, 61- 69

P192

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

New fluorescent probes based on gallium(III) corrole complexes for the recognition of hydrogen sulfide

C. I. M. Santos[1,2,*], A. M. Santigo[2], A. R. Araújo[1], M. A. F. Faustino[2], I. M. Araújo[3], M. G. P. M. S Neves[2], J. M. G. Martinho[1], E.M.S.Maçôas[1]

[1]*Centro de Química Estrutural, Institute of Molecular Sciences and Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa, 1049–001 Lisboa, Portugal.*
[2]*LAQV–REQUIMTE and Department of Chemistry, University of Aveiro, 3810–193 Aveiro, Portugal.*
[3]*Algarve Biomedical Center Research Institute (ABC-RI), University of Algarve, 8005-139, Faro, Portugal.*
**Carla.Santos@tecnico.ulisboa.pt*

Hydrogen sulfide (H_2S) is a toxic gas with a foul-smelling, which has been recently recognized as an endogenous gaseous transmitter such as nitric oxide (NO) and carbon monoxide (CO). In the human body this gas, endogenously produced through enzymatic processes, performs essential biological functions, and is associated with various diseases. Unregular levels of H_2S are associated with Alzheimer´s disease, Down´s syndrome and diabetes.[1] Thus, from physiological and pathological point of view, it is important to develop sensitive and specific techniques for the detection of this gasotransmitter. Fluorescence imaging is the best technique for non-invasive in situ detection and mapping of H_2S in different media.
Corroles, the porphyrins analogues bearing a direct pyrrole-pyrrole linkage, are very promising as fluorescent chemosensors. Here we present fluorescent probes for detection of H_2S based on gallium(III) corrole complexes bearing nitro groups at β-pyrrolic positions. The response of the corroles to H_2S in solution and in intracellular medium is discussed.[2]

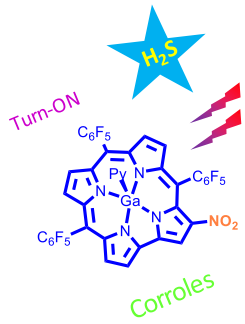


Figure 1: Illustration of a gallium (III) corrole complex bearing a nitro group at β-pyrrolic position.

Acknowledgements
We thank the Fundação para a Ciência e a Tecnologia (FCT) for Financial Support (Projects: UIDB/00100/2020, UIDP/00100/2020,LA/P/0056/2020, PTDC/NAN-MAT/29317/2017, PTDC/QUI-QFI/29319/2017, LISBOA-01-0145-FEDER-029319, UIDB/50006/2020, UIDP/50006/2020, 2020.01763.CEECIND and REF.IST-ID/95/201) where applicable, co-financed by the FEDER and COMPETE2020, within the PT2020 Partnership Agreement.

References

1. H. Li., Y.Fang, J. Yan, X. Ren, C. Zheng, B. Wu, S. Wang, Z. Li, H. Hua, P. Wang, D. Li; Trac-*Trends Anal Chem,* **2021**, 134, 116117.
2. C. Santos, A. Santiago, A. Araújo, S. Pinto, R. R. Agostinho, S. Simão, T. P. Azevedo, C. Antunes, M. A. F. Faustino, I. M. Araújo, M. G. P.M.S. Neves, J.M.G. Martinho, E. M.S. Maçôas; *Dyes and Pigments,* **2023**,216, 111304.

Development of phenanthroline-based derivatives as telomeric G-quadruplex binders: synthesis and *in vitro* evaluation

Joana Figueiredo[1,*], Israel Carreira-Barral[2], Roberto Quesada[2], Jean-Louis Mergny[3], Carla Cruz[1,4,*]

[1]CICS-UBI - Centro de Investigação em Ciências da Saúde, Universidade da Beira Interior, Av. Infante D. Henrique, 6200-506 Covilhã, Portugal;
[2]Departamento de Química, Facultad de Ciencias, Universidad de Burgos, 09001 Burgos, Spain;
[3]Laboratoire d'Optique et Biosciences, Institut Polytechnique de Paris, CNRS, INSERM, Université Paris-Saclay, 91120 Palaiseau cedex, France.
[4]Department of Chemistry, University of Beira Interior, Rua Marquês D'Ávila e Bolama, Covilhã 6201-001, Portugal
**figueiredo_joana@hotmail.com; carlacruz@fcsaude.ubi.pt*

G-quadruplexes (G4) are non-canonical secondary structures formed by G-rich DNA or RNA sequences that have been identified in a wide range of genomic regions and play an important role in carcinogenesis and tumor development. G4 are therefore considered important drug targets, leading to the development of G4 stabilizing small molecules. Telomeric regions have received special attention since they can fold into several distinct intramolecular G4 topologies. These structures contribute to the protection, regulation, accessibility and stability of telomeres, influencing critical cellular processes. Herein, we report the synthesis and *in vitro* evaluation of phenanthroline-based derivatives and their ability to stabilize different intramolecular telomeric G4 sequences. We evaluated ligand-induced stabilization, selectivity, and specificity of ligands using different biophysical techniques such as Förster Resonance Energy Transfer (FRET) melting experiments and circular dichroism (CD). In addition, we assessed the cytotoxicity of these ligands against two cancer cell lines (A549 and H1299) and one healthy cell line (NHDF). All synthesized compounds showed selectivity towards G4 over duplexes. The most promising ligands in terms of thermal stabilization were ligands **2b**, **3a,** and **5b**. Compounds **3a** and **5b** contain ethane-aminium substituents linked to the phenanthroline core through amine or amide groups, whereas ligand **2b** is equipped with methoxyaniline moieties in the lateral chains. Overall, the ligands presented an adequate cytotoxic profile in cancer cell lines, being more effective against A549 than H1299 cells. Ligand **5b** proved to be the best ligand in terms of cytotoxicity against A549 cells. This study provides invaluable information about the structure-activity relationship for this kind of compounds. However, further studies are required to reveal the complete mechanism of action of these derivatives.

Acknowledgements
Joana Figueiredo acknowledges doctoral fellowship grant from Fundação para a Ciência e a Tecnologia ref. SFRH/BD/145106/2019.

References
J. Figueiredo, I-C. Barral, R. Quesada, J-L. Mergny and C. Cruz, *Bioorg. Med. Chem.* 2022, 73, 116971.

P194

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Exploring the volatile profile of purple passion fruit: from consumer perception of fruit to thermal and high-pressure pasteurized juice.

A. M. A. Fonseca[1,2,*], C. A. Pinto[1], J. A. Saraiva[1], A. J. D. Silvestre[2], S. M. Rocha[1]

[1]*LAQV/REQUIMTE, Departamento de Química, Universidade de Aveiro, 3810-193 Aveiro, Portugal*
[2]*CICECO-Aveiro Institute of Materials, Departamento de Química, Universidade de Aveiro, 3810-193 Aveiro, Portugal*
**alexandrefonseca@ua.pt*

Passion fruit has an average global production of 1.5 million tons, most of which is consumed fresh or processed into juice [1]. Its purple variety (*Passiflora edulis* f. *edulis*) is considered more palatable due to its higher sweetness and lower acidity [2]. When consumed fresh, the fruit is cut into halves and the pulp is spooned out and eaten directly. Alternatively, the fruit is submitted to a juice extraction procedure and then thermally processed to improve its shelf-life [3]. Aroma perception of fresh fruits and juices is considered among the most relevant factors that influence the consumer's preferences and it is determined by the emitted volatile compounds.

The objective of this work is: a) to identify key markers in whole and halved fruits that potentially impact on consumer aroma perception; and b) to evaluate the impact of juice pasteurization (thermal (TP) and high-pressure (HPP) pasteurization) on passion fruit key aroma compounds. The volatile compounds released from whole (WF), halved fruit (HF) and juice (fresh and thermal and high-pressure pasteurized) were analyzed by headspace solid-phase microextraction (HS-SPME) combined with comprehensive two-dimensional gas chromatography coupled with time-of-flight mass spectrometry (GC×GC-ToFMS). Brix°, pH, acidity, total phenolic content, and antioxidant activity were also quantified and chemometric tools were used to combine all domains of information to correlate the volatile compounds profile and physicochemical parameters.

Esters and terpenoids (with higher abundance in HF) were found to be the chemical families that contribute the most to distinguish WF from HF and different key markers were identified for each sample. They have mostly citric, earthy, and fermented notes in the case of WF, and fruity and floral notes in HF. For juice, it was evaluated the effect of each pasteurization method on the key aroma compounds of passion fruit and thus, which one best preserves its aroma.

Acknowledgements

This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the Associate Laboratories LAQV-REQUIMTE (UIDB/50006/2020 and UIDP/50006/2020) and CICECO-Aveiro Institute of Materials (UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020). A.M.A. Fonseca also thanks FCT (Fundação para a Ciência e Tecnologia) and ESF (European Social Fund) through POCH (Programa Operacional Capital Humano) for his PhD grant [SFRH/BD/146391/2019]. A.M.A. Fonseca and S.M. Rocha thank Sociedade Portuguesa de Química (Portuguese Society of Chemistry, Portugal) for supporting their participation in this conference.

References

1. FAO, *Food Outlook: Biannual Report on Global Food Markets*, 2018.
2. M. Pontes, J. C. Marques and J. S. Câmara, *Microchemical Journal*, 2009, **93**, 1–11.
3. A. M. A. Fonseca, M. V. Geraldi, M. R. M. Junior, A. J. D. Silvestre and S. M. Rocha, *Food Research International*, 2022, **160**, 111665.

Reaction induced self-separating catalysts - Wonder catalytic systems

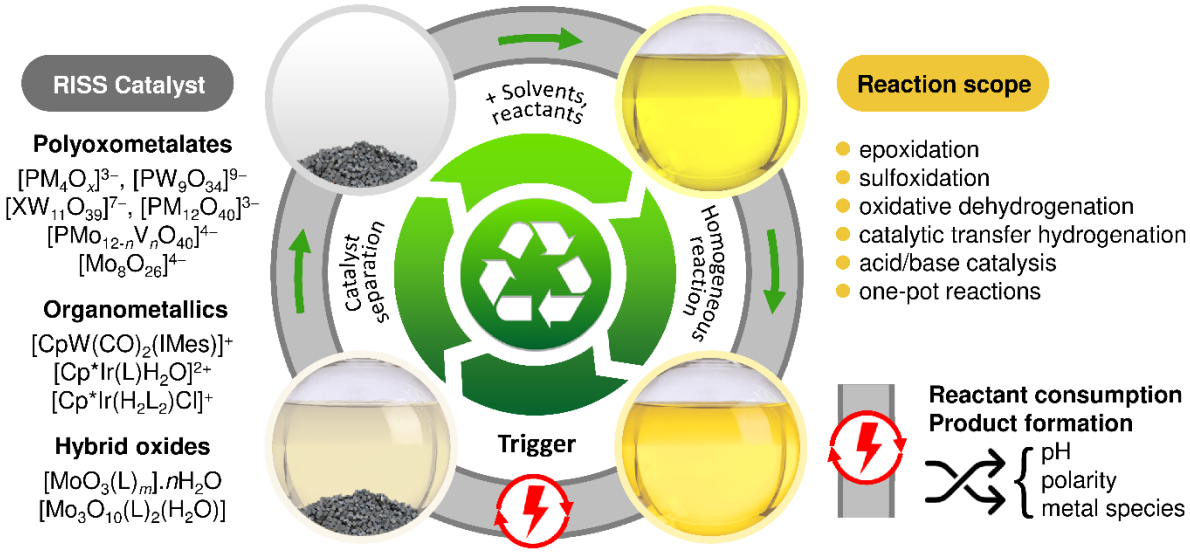
P. Neves*, D. M. Gomes, I. S. Gonçalves, M. Pillinger, A. A. Valente

CICECO, Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal
E-mail: pneves@ua.pt

A discovery of the 21st century is reaction-controlled or reaction-induced self-separating (RISS) metal-based catalytic systems, which combine features of the two hemispheres of Catalysis, i.e. homogeneous and heterogeneous catalysis (Scheme 1). Specifically, RISS catalytic systems involve homogeneous catalysis with facilitated mass transfer phenomena, and catalyst self-precipitation under ambient conditions, enabling its easy separation and reuse, without requiring energy intensive downstream processes (e.g., cooling bellow ambient temperature or use of precipitation agents to separate metal catalysts).

RISS metal-based catalytic features were discovered for various compounds/materials, ranging from neutral to ionic coordination compounds possessing different types of metals, organic components (ligands or cations) and structural dimensionalities (0D, 1D, 2D), which could be easily recovered in high yields via simple operation units (at ambient temperature) such as filtration or centrifugation, and reused, enhancing catalyst productivity.

The wonders of RISS metal-based catalytic systems and their application in important chemical transformations, how these systems operate (e.g., factors triggering the transition between homogeneous and heterogeneous catalytic features), the types of soluble active metal species formed, and relevant aspects from a practical point of view, such as catalyst recovery yield and reuse, will be summarized.[1]



Scheme 1: Reaction-controlled or reaction-induced self-separating (RISS) catalysts.

Acknowledgements
This work was developed within the scope of the project CICECO Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC), and the COMPETE 2020 Operational Thematic Program for Competitiveness and Internationalization (POCI-01-0145-FEDER-030075), co-financed by national funds through the FCT/MCTES (Ministério da Educação e Ciência) and the European Union through the European Regional Development Fund under the Portugal 2020 Partnership Agreement. D.M.G. (grant ref. 2021.04756.BD) acknowledges the FCT for a PhD grant (State Budget, European Social Fund (ESF) within the framework of Portugal 2020, namely through the Centro 2020 Regional Operational Program).

References
1. P. Neves, D. M. Gomes, I. S. Gonçalves, M. Pillinger and A. A. Valente, Coord. Chem. Rev., 2023, **491**, 215-229.

P196

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Potential of deep eutectic solvents to improve the conformational and colloidal stability of biopharmaceuticals

Ana S. C. Marques[1,*], Diksha Dhiman[2], Meena Bisht[2], Ana P. M. Tavares[1], Pannuru Venkatesu[2], Mara G. Freire[1]

[1]CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal;
[2]Department of Chemistry, University of Delhi, Delhi-110 007, India
**anascm10@ua.pt*

Currently, the number of biopharmaceuticals available for clinical use has increased rapidly due to the growing interest of the pharmaceutical industry in these products. Antibodies are the best-selling class on the market, due to their specific action and reduced immunogenicity. 1,2 Immunoglobulin G (IgG), have a pivotal role as biopharmaceuticals capable of treating a wide variety of diseases. However, IgG is a protein, hence, it can easily lose stability (forming aggregates) and therapeutic efficiency during its handling, transportation and preservation, which is not desirable from a clinical point of view since they can lead to serious and fatal health effects. 3,4 To overcome these drawbacks, in this work positive effect of deep eutectic solvents (DESs) was investigated, for the first time, on the conformational and colloidal stability of IgG antibodies, thus opening the door for their use as novel solvents in IgG formulations.5 Here, aqueous solutions of cholinium-based DESs were applied to enhance the conformational and colloidal stability of IgG, with no need to add excipients. A series of DESs were prepared through the combination of cholinium chloride ([Ch]Cl), as a hydrogen-bond acceptor (HBA), and various hydrogen-bond donors (HBD), such as urea, glycerol (Gly) and ethylene glycol (EG) and investigated in detail. The effect of [Ch]Cl–urea at different molar ratios (1 : 1, 1 : 2, 1 : 3 and 2 : 1) was also analysed. Conformational stability was checked by thermal fluorescence spectrometry, and it was found that selected DESs allowed increasing the transition temperature (Tm) of IgG by ca. 4 °C. The observed increase in the conformational stability of IgG in the presence of DESs was in agreement with the results of other spectroscopic studies, including FTIR and Raman spectroscopies.5 In the presence of DESs, there was a minimum exposed surface of IgG with water molecules, thereby improving its stability. Dynamic light scattering (DLS), size-exclusion high-pressure liquid chromatography (SE-HPLC) and sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) experiments were additionally performed to analyse the aggregation rate of IgG, which was found to decrease in the presence of appropriate DESs.5 Finally, the long-term stability of IgG in the presence of DESs was investigated at room temperature. All the results obtained from the conformational and colloidal studies of IgG demonstrated the outstanding potential of cholinium-based DESs as novel solvents for IgG formulations, with the DESs comprising [Ch]Cl–urea or [Ch]Cl–Gly noted as the most promising candidates. All the described studies were also performed with the DESs' individual components, demonstrating that the full DESs (HBD + HDA) are needed to improve the stability of IgG.5.

Acknowledgements
P. V. gratefully acknowledge the Council of Scientific & Industrial Research (CSIR), New Delhi, India through Grant No. 01/3016/21/EMR-II for their financial support. D. D. thanks the Council of Scientific and Industrial Research (CSIR), New Delhi for providing JRF (Junior Research Fellowship). This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC) and within the scope of the EIC-Pathfinder YSCRIPT project with reference 101047214, supported by the budgets of the Horizon Europe Program. Ana P. M. Tavares acknowledges the FCT for the research contract CEECIND/2020/01867.

References

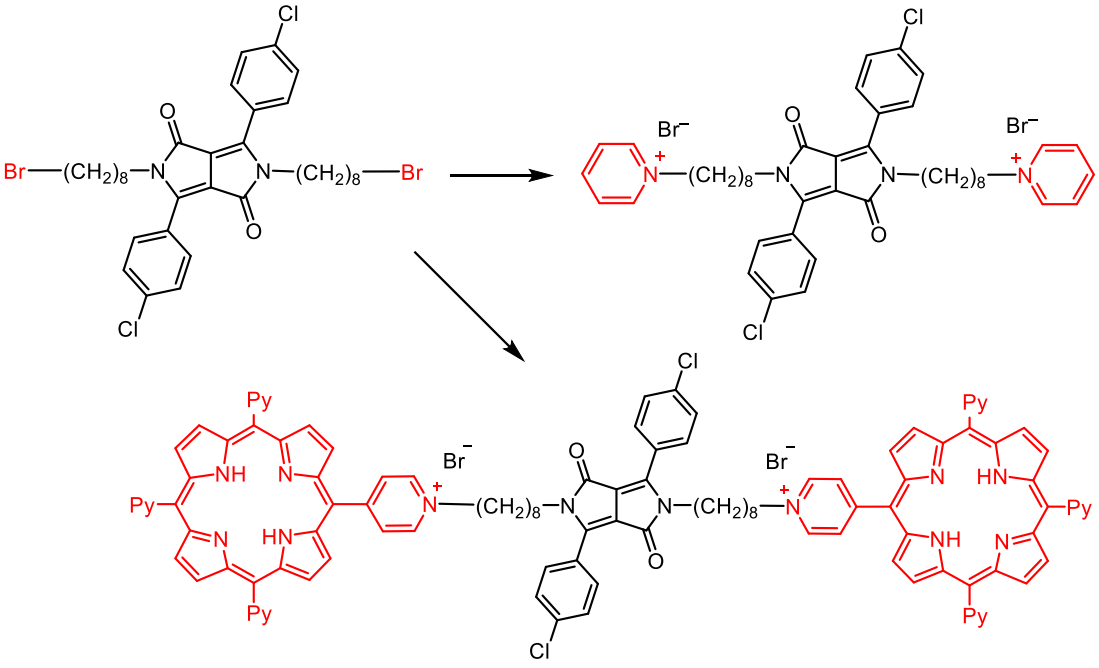
1. M. S. Hong, K. A. Severson, M. Jiang, A. E. Lu, J. C. Love and R. D. Braatz, Comput. Chem. Eng., 2018, 110, 106–114.
2. Fortune Business Insights, Monoclonal Antibody Therapy Market Size, https://www.globenewswire.com/newsrelease/2021/08/30/2288101/0/en/Monoclonal-Antibody-Therapy-Market-Size-Is-Projected-to-Grow-USD-451- 89-billion-in-2028-at-a-CAGR-of-14-1.html, (accessed 25 November 2021).
3. M. Vázquez-Rey and D. A. Lang, Biotechnol. Bioeng., 2011, 108, 1494–1508.
4. M. Bjelošević, A. Z. Pobirk, O. Planinšek and P. A. Grabnar, Int. J. Pharm., 2020, 576, 119029.
5. D. Dhiman, A. S. C. Marques, M. Bisht, A. P. M. Tavares, M. G. Freire and P. Venkatesu, Green Chem., 2023, 25, 650–660

Synthesis of cationic diketopyrrolopyrroles for the photodynamic inactivation of pathogenic microorganisms

Vasco M. S. Castanheira*, Vítor A. S. Almodôvar, Augusto C. Tomé

LAQV-Requimte, Department of Chemistry, University of Aveiro, 3010-193, Aveiro, Portugal
**vasco.castanheira@ua.pt*

Diketopyrrolopyrroles (DPPs) are a family of organic pigments that have fascinating optical properties. Discovered in the 1970s, DPPs were initially used as paints and dyes for plastics, but nowadays they are used as fluorescent probes or in photodynamic therapy, for example.[1,2,3]
In this communication, we present different ways to synthesize cationic DPP that can be used for the photodynamic inactivation of pathogenic microorganisms. The first step involves N-alkylation with a dibrominated alkylating agent to introduce porphyrin or pyridine groups into the structure (Scheme 1).
To understand whether these compounds can be used as photosensitizing molecules for photodynamic inactivation, the photophysical properties of the molecules, such as the fluorescence quantum yield and their capacity to produce reactive oxidative species, were evaluated.



Scheme 1: Synthesis of cationic DPP.

Acknowledgments:
Thanks are due to the University of Aveiro and Fundação para a Ciência e a Tecnologia (FCT) for the financial support to the LAQV-REQUIMTE. Thanks are also due to the Portuguese NMR and Mass Networks Partnership Agreement.

Funding:
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through projects UIDB/50006/2020 and UIDP/50006/2020. Vítor A. S. Almodovar thanks FCT/MCTES for his PhD grant ref. SFRH/BD/135598/2018.

References

1 M. Grzybowski and D. T. Gryko, *Adv Opt Mater*, 2015, **3**, 280–320.
2 M. A. Auwalu and S. Cheng, *Chemosensors*, 2021, **9**, 44.
3 V. A. S. Almodôvar and A. C. Tomé, *Molecules*, DOI:10.3390/molecules26164758.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Quality improvement of blood under pressure – Hyperbaric storage as a preservation methodology

A. P. Martins[1,2,*], Á. T. Lemos[1], T. R. Correia[2], B. J. Goodfellow[2], J. F. Mano[2], J. A. Saraiva[1]

[1]LAQV-REQUIMTE, Chemistry Department, Aveiro University, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[2]CICECO, Chemistry Department, Aveiro University, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
**ana.patricia.martins@ua.pt*

Extend blood preservation for transfusion remains a challenge, however, blood quality is also an important field of study since several storage damages can be a matter of concern for blood transfusion.[1]
Hyperbaric storage is a new preservation methodology that allows the storage of products under pressure (up to 100 MPa) for variable time periods and has been studied almost exclusively for food products in the last decade.[2]
In this study, the possibility to use hyperbaric storage as a new blood preservation method for blood quality improvement was evaluated. Swine blood with citrate-phosphate-dextrose-adenine (CPDA-1) was stored for 35 days under pressure (25 – 50 MPa) at refrigeration temperatures (5 °C) and compared to the standard blood preservation method (refrigeration). Quality parameters of whole blood during storage were assessed, namely, the quantification of hemolysis, pH measurement, and a multivariate and metabolic composition analysis by ^{1}H NMR spectroscopy.
The results demonstrate that pressures up to 40 MPa are suitable for whole blood preservation, maintaining the hemolysis below the allowed limit for transfusion (0.8 %) and, when compared to the conventional method (refrigeration), the values were similar. Regarding pH, the blood kept under pressure at refrigeration temperatures revealed a lower decrease of pH than that at atmospheric pressure and refrigeration temperatures (conventional refrigeration). To understand the difference on pH, a metabolic composition analysis by ^{1}H NMR spectroscopy was performed, where the results showed a lower lactate and a higher glucose concentration in blood stored under pressure, which may indicate a decrease in red blood cell metabolic rates when pressure and refrigeration temperatures are combined showing promising preliminary results.
The present work provides a global perspective on the viability of using hyperbaric storage as a whole blood preservation technique to improve blood quality. Not withstand, to have a deeper insight, additional analyses are required, regarding red blood cells function assessment by ATP and 2,3-DPG quantification, flow cytometry for microvesicles detection, viability after storage and microscopy for morphological characterization.

Acknowledgements
Thanks are due to University of Aveiro and FCT/MCT for the financial support to LAQV-REQUIMTE research Unit (UIDB/50006/2020 & UIDP/50006/2020) through national founds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement. This work was also developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). Ana P. Martins also acknowledges FCT/MCT for the PhD grant reference SFRH/BD/146369/2019 and Álvaro T. Lemos for the PhD grant reference SFRH/BD/129848/2017

References

1. M. García-Roa, M. Del, C. Vicente-Ayuso, A. M. Bobes, A. C. Pedraza, A. González-Fernández, M. P. Martín, I. Sáez, J. Seghatchian and L. Gutiérrez, *Blood Transfus*, 2017, **15**, 222–253.
2. Á. T. Lemos, A. C. Ribeiro, L. G. Fidalgo, I. Delgadillo and J. A. Saraiva, *Food Chem*, 2017, **231**, 61–69.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

P199

Isolation of anthocyanins from natural sources using sustainable, simple and affordable methodologies

C. I. Sampaio[1,*], M. A. Cerqueira[2], A. M. Dias[1]

[1]*Chemistry Research Centre, Department of Chemistry, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal*
[2]*International Iberian Nanotechnology Laboratory, Av. Mestre José Veiga s/n, 4715-330, Braga, Portugal*
**catia.ibs@hotmail.com*

Natural pigments have been receiving high attention as they are safe, healthy, ecologic, and consumers are demanding clean label products. One of the most important groups of natural dyes are anthocyanins (ACNs) belonging to the flavonoid family that originate red, blue and purple colours of fruits, vegetables and flowers, and are also found in grape pomace waste. Besides their coloring applications, ACNs have significant antioxidant activity, making a diet rich in these compounds a great way to retard and prevent oxidative damage.[1]

Another current and important concept is the circular economy, with the consequent reduction of wastes. Large amounts of residues are generated every year in the production of wine, which is one of the most important agricultural activities in the world. These pomaces, resulting from fermentation, have low pH and are rich in organic matter, constituting an environmental hazard if they are discharged in crops or wet-lands. These wastes are rich in anthocyanins and, therefore, grape pomaces can be used as a source of natural colourants. Likewise, old roses, which were not sold while they were fresh, are usually discarded by florists, as consumers do not want to buy degraded flowers. Petals from these old red roses are rich in anthocyanins and, consequently, could also be used as natural source for these pigments.[2,3]

Therefore, in this work, the anthocyanins were extracted and isolated from two natural sources: red grape skin and red rose petals. Once the crude extracts were obtained, it was necessary to proceed with the purification/isolation of the ACNs and, for this, sustainable, simple, and affordable methods were used, namely liquid-liquid extraction techniques and column chromatography (normal, reverse and/or vacuum), using potato starch as adsorbent and “green” solvents.

Since these isolation methods produced partially purified samples, as observed by colorimetric tests, TLC, and NMR, the strategy was changed to ACNs isolation/precipitation from the crude extract. Through this new approach, it was possible to obtain a pure anthocyanin from old red roses, using a simple and affordable method. After optimization and scaling up of the process, cyanidin-3,5-diglucoside was fully characterized using data obtained from ESI-MS, NMR techniques (^{1}H, ^{13}C, DEPT, HSQC, HMBC and COSY) and TLC.

Further studies will be performed considering its use as a colored antioxidant additive in foods.

Acknowledgements

The authors acknowledge the financial support by Foundation for Science and Technology (FCT) and FEDER-COMPETE through the Chemical Research Centre of the University of Minho (UID/QUI/00686/2018, UID/QUI/00686/2020) and Rede Nacional de RMN (PINFRA/22161/2016). C. I. Sampaio acknowledges FCT and Fundo Social Europeu (FSE) through “Programa Operacional Regional Norte” for funding the PhD grant with the reference 2021.08622.BD.

References

1. L. Cruz, N. Basílio, N. Mateus, V. de Freitas and F. Pina, *Chem. Rev.*, 2022, **122**, 1416–1481.
2. X. Zhao, S.-S. Zhang, X.-K. Zhang, F. He and C.-Q. Duan, *Food Chem.*, 2020, **310**, 125830.
3. H. Wan, C. Yu, Y. Han, X. Guo, L. Luo, H. Pan, T. Zheng, J. Wang, T. Cheng and Q. Zhang, *Front. Plant Sci.*, 2019, **10**, 1–14.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

The influence of *Salicornia ramosissima* ingestion by shrimp on their GC-MS biochemical profile: analysis optimization

Ana C. S. Veríssimo[1,*], Benjamin Costas[2], Rui Rocha[3], Raquel Marçal[4], Sofia Guilherme[4], Mário Pacheco[4], Artur M. S. Silva[1], Diana C. G. A. Pinto[1]

[1]*LAQV/REQUIMTE, Departament of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*CIIMAR-Interdisciplinary Centre of Marine and Environmental Research, 4450-208 Matosinhos, Portugal.*
[3]*Riasearch Unipessoal Lda., 3880-394 Murtosa, Portugal*
[4]*CESAM and Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal*
**carolinaana@ua.pt*

The Aquacombine project centres on cultivating and biorefining a salt-tolerant plant that can produce more food and plant material for bioenergy and biochemicals on marginal land 1. Among these plants are species of the Salicornia genus, halophytes that can grow on saline lands without freshwater for irrigation 2. When grown as a vegetable, only the fresh tips are used, while the woody part of the plant is considered a residue. Thus, the need to value these residues and minimize their environmental impacts becomes evident through their use in different aquaculture applications, such as health, food, and feed production. The present work focuses on this last topic. It evaluates the effect of ingestion of *Salicornia ramosissima* at different percentages on the profile of secondary metabolites produced by aquaculture shrimp (*Litopenaeus vannamei*). To guarantee a complete analysis possible, in this work, 4 different methods were tested, with the final objective of choosing the method that provided a complete characterization of the samples. For this, the extract in hexane (EXT), direct silylation of the biomass (DS), alkaline hydrolysis (AH) of the biomass, and the new method (NM) 3 were tested (this method presents the possibility of identifying compounds with a simpler and faster method) and analyzed by GC-MS. It was verified that the different analyses allow the detailed identification of different classes of compounds according to the properties/characteristics of the method used. The methods that presented the highest number of identified compounds are EXT and DS, followed by NM and AH. Thus, EXT and DS allow targeted identification for different classes of compounds; in the case of DS, there is a more targeted identification for amino acids, while in the case of EXT, it is more targeted for families such as fatty acids, alcohols, and sterols. Performing the statistical analysis, it is verified that the EXT is the method that allows a more robust analysis since all the compounds with significant differences identified in the SD are also identified in the EXT, also presenting significant differences. In addition, other compounds are identified in the EXT, in addition to these, which present significant differences. In this way, it is concluded that the EXT is the method that provides a complete characterization of the samples and is the most robust method for evaluating the influence of *Salicornia* ingestion by shrimp.

Funding: This work was supported by the European Union's Horizon 2020 research and innovation program under grant agreement No. 862834 (project AQUACOMBINE). This output reflects the views only of the authors, and the European Union cannot be held responsible for any use which may be made of the information contained therein. Also received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020.

Acknowledgements: The work was supported through the AQUACOMBINE project and the DBIO-AQUA-COMBINE / 2020 research grant. Also, thanks projects UIDB/50006/2020 and UIDP/50006/2020, funded by FCT/MCTES through national funds.

References

1. M. H. Thomsen, The AQUACOMBINE Project., https://www.aquacombine.eu/, (accessed 10 November 2021).
2. T. J. Flowers and T. D. Colmer, Salinity tolerance in halophytes*, *New Phytol.*, 2008, **179**, 945–963.
3. D. M. Pereira, P. Valentão, N. Teixeira and P. B. Andrade, Amino acids, fatty acids and sterols profile of some marine organisms from Portuguese waters, *Food Chem.*, 2013, **141**, 2412–2417.

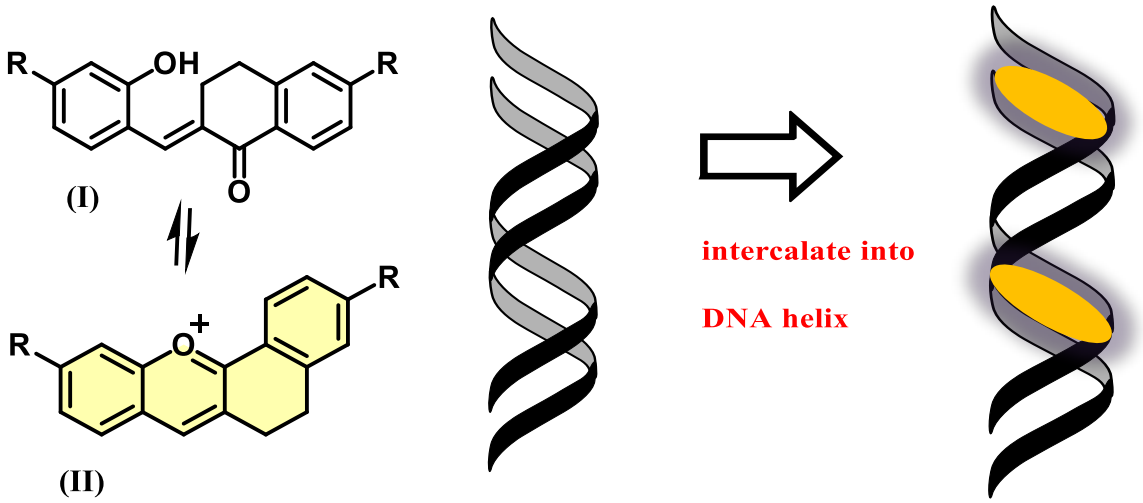
Interaction between flavylium derivatives and ds-DNA

H. Mahmoodi*, A. J. Parola, N. Basílio

LAQV-REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
**h.mahmoodi@campus.fct.unl.pt*

Flavylium cations are renowned for their ability to establish supramolecular interactions with synthetic and natural receptors, being good candidates to bind nucleic acids, specifically DNA.[1] This study focused on exploring the binding affinities and modes of interaction between flavylium cations and DNA utilizing UV-VIS spectroscopic techniques. The switchable nature of the flavylium-chalcones system, coupled with its fluorescence properties and specific interactions with DNA, make it a promising candidate for various biochemical applications. The results support the notion that flavylium cations establish strong interactions with the DNA double helix.

Different flavylium derivatives have been synthesized and their interaction with calf thymus ds-DNA were investigated by UV-Vis spectroscopy in phosphate buffer at pH 7. Additionally, the influence of DNA on the flavylium-chalcone equilibrium was investigated in order to evaluate the potential of these compounds to develop stimuli-responsive small molecule DNA-binders for biological applications.



Scheme1: Interaction between flavylium and DNA. (I) trans-chalcone; (II) flavylium.

Acknowledgements
This work was supported by the Associate Laboratory for Green Chemistry-LAQV (projects UIDB/50006/2020 and UIDP/50006/2020), which is financed by national funds from FCT/MCTES.

Reference
1. I. Crnolatac, L. Giestas, G. Horvat, A. J. Parola and I. Piantanida, *Chemosensors*, 2020, **8**, 1–10.

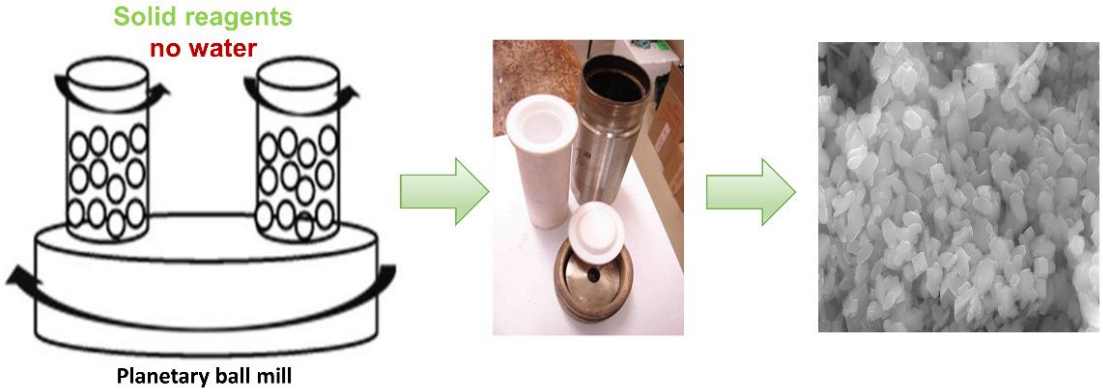
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Towards the sustainable synthesis of microporous titanosilicates: mechanochemical pre-treatment reduces the water amount

Isabel C. M. S. Santos-Vieira*, Zhi Lin, João Rocha

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal
**ivieira@ua.pt*

There is a growing recognition of the significance of developing environmentally friendly chemical processes.[1,2] In this regard, the synthesis of materials through mechanical grinding or milling holds great potential.[3] Microporous zeolitic materials are widely recognized for their importance as catalysts, ion exchangers, and in applications such as gas separation and storage.[4] This study demonstrates the incorporation of a mechanosynthesis (ball milling) step in the production of a crucial class of zeolite-type materials called microporous titanosilicates. It reveals that this method significantly reduces the amount of water used compared to conventional hydrothermal synthesis, typically by one to two orders of magnitude. For instance, in the synthesis of the small-pore synthetic analogs of sitinakite ($Na_2Ti_2O_3SiO_4 \cdot 2H_2O$) and ivanyukite-K (also known as GTS-1, $HK_3Ti_4O_4(SiO_4) \cdot 4H_2O$), no water was added to the reagents. Similarly, the preparation of other important microporous titanosilicates like ETS-10 ($(Na,K)_2TiSi_5O_{13} \cdot nH_2O$), microporous AM-2 ($K_2TiSi_3O_9 \cdot H_2O$), and the analog of the layered mineral natisite ($Na_2TiO(SiO_4)$) only required a very small amount of water. The improved reactivity observed in the ball-milled reaction mixtures can be attributed to the reduction in particle size of precipitated silica (in ETS-10 synthesis) and the increased number of silica nanoparticle silanol groups (in ETS-10 and sitinakite synthesis). Additionally, the ball milling step significantly reduces the synthesis time, leading to notable energy savings ranging from 3 to 34 times compared to conventional hydrothermal synthesis.[5] This research demonstrates that mechanosynthesis offers a more sustainable alternative to conventional hydrothermal synthesis for the preparation of microporous titanosilicates (including layered ones) and can be easily scaled up for industrial applications.



Scheme 1: Schematic representation of the preparation of microporous titanosilicates *via mechanochemical pre-treatment*

Acknowledgements
This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior (PIDDAC)) through the CICECO-Aveiro Institute of Materials (UIDB/50011/ 2020, UIDP/50011/2020 and LA/P/0006/2020). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project No. 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC. The position held by I. C. M. S. S. V. (Ref. 197_97_ARH-2018) was funded by national funds (OE), through FCT, I. P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of article 23 of the Decree-Law 57/2016 of 29 August, changed by Law 57/2017 of 19 July.

References
1. P. T. Anastas and J. B. Zimmerman, Curr. Opin. Green Sustainable Chem., 2018, **13**, 150–153.
2. T. Friščić, C. Mottillo and H. M. Titi, Angew. Chem., Int. Ed., 2020, **59**, 1018–1029.
3. C. F. Burmeister and A. Kwade, Chem. Soc. Rev., 2013, **42**, 7660–7667.
4. L. Bacakova, M. Vandrovcova, I. Kopova and I. Jirka, Biomater. Sci., 2018, **6**, 974–989.
5. I. C. M. S. Santos-Vieira, Z. Lin and J. Rocha, Green Chem., 2022, **24**, 5088-5096.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

P203

Metallodrugs as therapeutic agents: Interaction with biomolecules, antibacterial activity, and incorporation into biopolymeric systems

A. C. C. Gomes[1,*], C. Pereira[2], R. Mendes[1], F. Paz[1], T. Santos[1], J. Rocha[1], A. Almeida[2], C. S. R. Freire[1], B. J. M. Leite Ferreira[1]

[1]*CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal*
[2]*CESAM, Department of Biology, University of Aveiro, 3810-193, Aveiro, Portugal*
**adrianagomes@ua.pt*

The current healthcare landscape is characterized by significant challenges in several areas, such as antibiotic resistance and oncology. Antibiotic resistance, for example, is one of the greatest threats to global health. It is assuming dangerous proportions worldwide, and new resistance mechanisms are emerging, spreading around the globe and threatening the ability to treat common infectious diseases.[1] Today, 700 thousand people die each year from antimicrobial resistance, a number that could rise to 10 million by 2050.[2] On the other hand, cancer is one of the leading causes of death worldwide, and was responsible for nearly 10 million deaths in 2020.[3] Thus, there is an urgent need to develop innovative and efficient therapeutic agents that can address these healthcare challenges.

Metallodrugs are pharmacologically active metal complexes composed of ligands coordinated to a metallic center. The discovery of their potential for therapeutic applications began in the early 20th century, when an arsenic compound, salvarsan, became the first effective treatment for syphilis.[4] Years later, the discovery and clinical development of cisplatin, a platinum complex, was a milestone in the history of chemotherapeutic metal complexes. However, cisplatin caused various side effects, and some cancers developed resistance to this metallodrug.[5] These findings motivated the exploitation of different approaches to develop metallodrugs that are more suitable for specific therapeutic applications.[6] Due to the synergistic combination between the ligands and the metal, metallodrugs may exhibit novel structures and improved biological activities, such as anticancer, anti-inflammatory, and antibacterial activities.[7,8,9] Compared to therapeutic organic molecules, metallodrugs have several advantages, as they present mechanisms of action that cannot be achieved with organic molecules alone, as well as unique electronic, magnetic, and spectroscopic properties. In addition, their diverse geometries and three-dimensionality are generally associated with high clinical success rates.[4]

In this work, we present the synthesis and characterization of metallodrugs composed of transition metals and commercial pharmaceutical agents, namely antibiotics and non-steroidal anti-inflammatory drugs. To understand the potential of these metallodrugs as therapeutic agents, their interaction with biomolecules, in particular DNA and BSA, as well as their antibacterial activity against *Staphylococcus aureus* and their ability to be incorporated into (and released from) bacterial nanocellulose (BNC) membranes, which are well-known biopolymeric delivery systems, were evaluated. The results showed that these metallodrugs are able to interact with biomolecules, with some of them even exhibiting stronger antibacterial activity than the parent antibiotic, and that they can be successfully incorporated into and released from BNC membranes, increasing their thermal stability and exhibiting a rapid release profile, suitable for topical delivery. Therefore, these metallodrugs have potential as therapeutic agents that could potentially address some of the current challenges in healthcare.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC), and CESAM-Centre for Environmental and Marine Studies (UIDP/50017/2020+UIDB/50017/2020+LA/P/0094/2020). We also thank FCT for the research grant 2022.10449.BD.

References
1. WHO, “Antibiotic resistance,” 2020 [Online].
2. WHO, “New report calls for urgent action to avert antimicrobial resistance crisis,” 2019 [Online].
3. WHO, “Cancer”, 2022 [Online].
4. A. Frei, *Antibiotics*, 2020, **9**, 90-113.
5. M. Zaki, F. Arjmand, and S. Tabassum, *Inorganica Chim. Acta*, 2016, **444**,1–22.
6. M. Varol, *J. Appl. Pharm.*, 2016, **8**, 107–109.
7. L. Viganor, O. Howe, P. McCarron, M. McCann, and M. Devereux, *Curr. Top. Med. Chem.*, 2017, **17**, 1280–1302.
8. G. Psomas and D. P. Kessissoglou, *Dalt. Trans.*, 2013, **42**, 6252–6276.
9. U. Ndagi, M. Ndumiso, and M. E. Soliman, *Drug Des. Devel. Ther.*, 2017, **1**, 599–616.

P204

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Solvothermal synthesis of Zn(II), Cu(II) and Co(II)-flavonoid complexes with anti-diabetic potential

Diogo Marinheiro[1,2,*], Nelson Andrade[2,3,4], Ricardo F. Mendes[1], Filipe A. Almeida Paz[1], João Rocha[1], Fátima Martel[2,3], Ana L. Daniel-da-Silva[1], Bárbara J. M. L. Ferreira[1]

[1]*Department of Chemistry & CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Biomedicine Department, Biochemistry Unit, Faculty of Medicine, University of Porto, 4200-319 Porto, Portugal*
[3]*I3S—Institute of Research and innovation in Health, University of Porto, 4200-135 Porto, Portugal*
[4]*REQUIMTE/LAQV, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal*
**diogomarinheiro@ua.pt*

Diabetes mellitus is a widespread chronic metabolic disease with a significantly high global occurrence, posing substantial health risks, including an increased susceptibility to cardiovascular diseases.[1] Despite the existence of various treatments, their limitations and drawbacks emphasize the urgent need for novel therapeutic strategies. In this context, flavonoids have emerged as promising candidates due to their reported anti-diabetic properties, making them attractive for the development of new drugs with anti-diabetic effects.[2,3] The focus of this study is the synthesis and characterization of novel metal complexes comprising zinc (Zn(II)), copper (Cu(II)), and cobalt (Co(II)) ions combined with flavonoids such as chrysin, morin, and quercetin. These metal-flavonoid complexes were synthesized using solvothermal synthesis technique. The complexes underwent comprehensive characterization, including X-ray diffraction, FTIR and FT-Raman spectroscopy, UV-VIS spectroscopy, elemental analysis, and thermogravimetric analysis. Based on these techniques the following coordination compounds were proposed: **1** [Cu(chrysin)$_2$], **2** [Co(chrysin)$_2$]·4H$_2$O, **3** [Zn[quercetin)(2,2'-dipy)(acetate)], and **4** [Zn(morin)(H$_2$O)$_2$]·2H$_2$O. These complexes are currently undergoing screening assays and evaluations to assess their efficacy in mitigating key factors associated with diabetes.

Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020, and LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). The position held by B.J.M.L.F. was funded by national funds (OE), through FCT-Fundação para a Ciência e Tecnologia, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of Article 23 of the Decreet-Law 57/2016, of 29 August, changed by Law 57/2017 of 19 July. D.M. acknowledges FCT for the PhD grant (2021.05673.BD). The technical assistance of Dr. Ilda Rodrigues is acknowledged.

References
1. X. Lin, Y. Xu, X. Pan, J. Xu, Y. Ding, X. Sun, X. Song, Y. Ren and P.-F. Shan, *Sci Rep*, 2020, **10**, 14790.
2. AL-Ishaq, Abotaleb, Kubatka, Kajo, and Büsselberg, *Biomolecules*, 2019, **9**, 430.
3. J. Xiao, *Current Opinion in Food Science*, 2022, **44**, 100806.

Volatility and solubility properties of the herbicide dichlobenil

B. D. A. Pinheiro*, A. R. R. P. Almeida, M. J. S. Monte

Research Center in Chemistry of University of Porto (CIQUP), Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry (DQB), Faculty of Sciences of University of Porto (FCUP), Rua do Campo Alegre, P-4169-007 Porto, Portugal
**up201100352@edu.fc.up.pt*

Pesticides play a significant role in agriculture and pest management practices. These chemical substances are designed to control or eliminate pests that can adversely impact crop yields, damage structures, and pose threats to human health. Pesticides encompass a wide range of products, including herbicides to control weeds, insecticides to combat insects, fungicides to prevent fungal diseases, and rodenticides to manage rodents. While pesticides provide valuable benefits, their usage raises concerns regarding potential environmental and human health impacts. Ongoing research and knowledge of important properties of pesticides aim to develop safer and more sustainable solutions for pest management, fostering a balanced approach that ensures both agricultural productivity and environmental stewardship. In this sense, this work aims to provide essential information on the experimental determination of relevant physical-chemical properties that help to assess mobility properties and the environmental fate of the Dichlobenil. The study includes the volatility (vapor pressure) and phase transitions of this compound as well as the determination of its solubility in water (Sw) at 298.15 K. The sublimation properties derived through vapor pressure measurements[1,2] were combined with those obtained through solubility experiments,[3] yielding other crucial properties such as solvation (hydration) and Henry's constants. Dichlobenil is widely used as a versatile direct-action herbicide, finding extensive application in agricultural, industrial, and residential environments. Additionally, it is employed to eliminate tree roots and prevent their growth in sewer systems. Moreover, this herbicide operates in a selective and systemic manner, blocking cellulose production while having no impact on photosynthesis or cellular respiration. It effectively inhibits meristem cell division and seed germination, making it particularly prevalent in plant nurseries, fruit orchards, public green areas, and private gardens.[4-6]

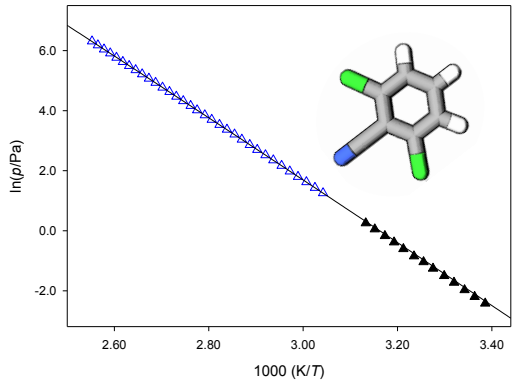


Figure 1: Sublimation vapor pressures of Dichlobenil at different temperatures.

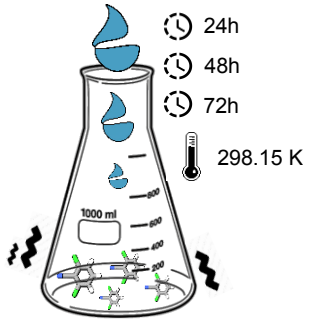


Figure 2: Aqueous solubility of Dichlobenil at 298.15 K determined by the shake-flask method.

Acknowledgements
Acknowledgements: This work was supported by the Fundacão para a Ciência e Tecnologia (FCT) (funded by national funds through the FCT/MCTES (PIDDAC)) to CIQUP, Faculty of Science, University of Porto (Project UIDB/00081/2020), IMS-Institute of Molecular Sciences (LA/P/0056/2020)). ARRPA is financed by national funds through the FCT-I.P., in the framework of the execution of the program contract provided in paragraphs 4, 5 and 6 of art. 23 of Law no. 57/2016 of 29 August, as amended by Law no. 57/2017 of 19 July.

References
1. M. A. V. Ribeiro da Silva, M. J. S. Monte and L. M. N. B. F. Santos, *J. Chem. Thermodyn.*, 2006, **38**, 778.
2. M. J. S. Monte, L. M. N. B. F. Santos, M. Fulem, J. M. S. Fonseca and C. A. D. Sousa, *J. Chem. Eng. Data* 2006, **51**, 757.
3. A. Veseli, S. Žakelj and A. Kristl, *Drug Dev. Ind. Pharm.*, 2019, **45**, 1717.
4. M. S. Holtze, S. R. Sørensen, J. Sørensen and J. Aamand, *Environ. Pollut.*, 2008, **154**, 155–168.
5. Z. Frková, N. Badawi, A. Johansen, N. Schultz-Jensen, K. Bester, S. Reinhold Sørensen and U.G. Karlson, *Pest. Manag. Sci.*, 2014, **70**, 1291–1298.
6. W.-K. Li, H.-X. Zhang and Y.-P. Shi, *Anal. Chim. Acta.*, 2018, **1011**, 40–49.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Bromine/iodine halogen bond synthons for co-crystalization

Guilherme D. Serrão[1,*], Joana F. C. Silva[1], Pedro S. Pereira Silva[2], Manuela Ramos Silva[2], M. Ermelinda S. Eusébio[1], Mário T. S. Rosado[1]

[1]CQC-IMS, Departamento de Química, Universidade de Coimbra, 3004-535 Coimbra, Portugal
[2]CFisUC, Departamento de Física, Universidade de Coimbra, 3000-370 Coimbra, Portugal
**gds@student.uc.pt*

Halogen bond (XB) synthons have emerged as alternatives to supramolecular synthesis based on hydrogen bonding, since XB acceptors are generally, also, hydrogen bond (HB) acceptors. While the physical nature of XB synthon is mostly electrostatic, it is also explained in a smaller degree by a combination of charge transfer, exchange-repulsion, induction, and dispersion effects.[1] In this work, the XB donor strength of bromine vs. iodine and the induction effect of fluorine was investigated, comparing the co-crystallization ability of 1-bromo-4-iodobenzene (BrIB) with 1,4-diiodo-2,3,5,6-tetrafluorobenzene (IFB). Three new co-crystals of BrIB were synthesized, using 4,4-bipyridyl (bP), 1,2-bis(4-pyridyl)ethane (bPa) and 1,2-bis(4-pyridyl)ethene (bPe), a series of bis-pyridines with wide application as HB (and XB) co-formers, despite the lack of fluorine induction and weaker polarization and σ-hole in bromine. Experimental characterization was performed by Differential Scanning Calorimetry (DSC), FTIR-ATR and Powder X-Ray Diffraction (PXRD). The intermolecular interactions in the molecular aggregates were analyzed by several electronic structure methods (MESP, IGM,[2] NBO[3]) based on DFT calculations (Figure 1).

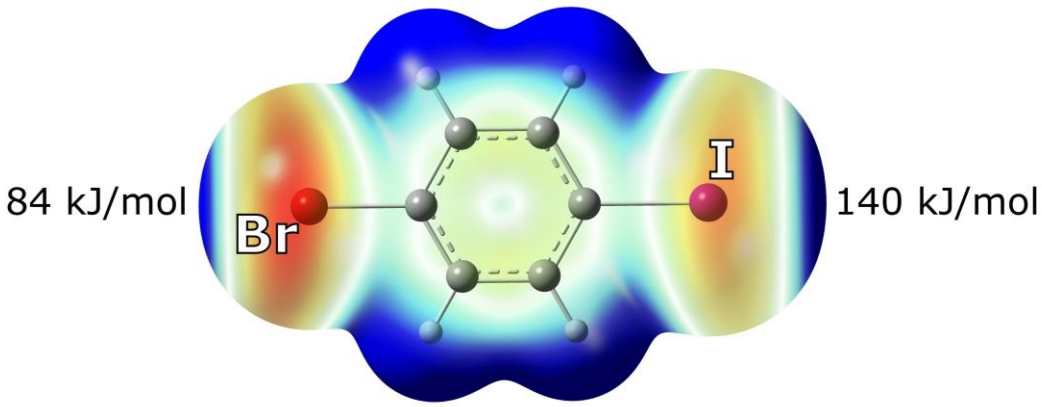


Figure 1: Molecular electrostatic potential (MESP) of BrIB plotted on the 0.002 a.u. isosurface of the total electron density computed at def2TZVP / ωB97X-D level of theory.

Acknowledgements
CQC-IMS is funded by the Fundação para a Ciência e a Tecnologia (FCT) project UIDB/00313/2020, also co-funded by FEDER/COMPETE 2020-EU. CFisUC is funded by the FCT project UID/FIS/04564/2020. Access to TAIL-UC facility funded under QREN-Mais Centro is gratefully acknowledged.

References

1. G. Cavallo, P. Metrangolo, R. Milani, T. Pilati, A. Priimagi, G. Resnati and G. Terraneo, Chem. Rev., 2016, **116**, 2478–2601.
2. C. Lefebvre, J. Klein, H. Khartabil, J.-C. Boisson and E. Hénon, J. Comput. Chem., 2023, **44**, 1750–1766.
3. E. D. Glendening, C. R. Landis and F. Weinhold, J. Comput. Chem., 2013, **34**, 1429–1437.

Targeting mutant p53 using indole-based small molecules

R. J. F. Ferreira, A. P. Leandro, M. M. M. Santos*

Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa. Lisboa, Portugal
**mariasantos@ff.ulisboa.pt*

Mutations in the *TP53* gene are observed in almost 50% of human cancers, being extremely important to develop mutant (mut-) p53 reactivators. However, the development of mut-p53 reactivators is highly challenging due to the diversity of p53 mutants. To date, two small molecules R175H mut-p53 have reached clinical trials: APR-246 and COTI-2. APR-246 is converted into its active metabolite methylene quinuclidinone (MQ) after administration. COTI-2 binds to mutant p53. leading to regain of p53 DNA-binding properties.[1] Among the mutants with clinical relevance and less studied by the scientific community are R280K and R273H mut-p53, for which crystallographic structures are available. Previously, our research group developed novel tryptophanol-derived oxazoloisoindolinones that act as wild-type (wt-) and mut- p53 reactivators[2-3]
In this communication, we will present our latest results on the evaluation of these tryptophanol-derived oxazoloisoindolinones against wt-p53 DNA binding domain using a differential scanning fluorimetry (DSF) assay. The target compounds were obtained by reacting (*R)*- or (*S)*-tryptophanol with oxo-acids in toluene under reflux using a Dean-Stark apparatus. Bromine-enriched compounds were synthesized by reacting the tryptophanol-derived oxazoloisoindolinones with pyridinium tribromide. The optimization process on p53 expression and cleavage of the protein histidine-tag with thrombin will also be addressed. Finally, the development of a new DSF assay for the two specific mut- forms of p53 (R273H and R280K) with clinical relevance will also be shown (**Figure 1**).

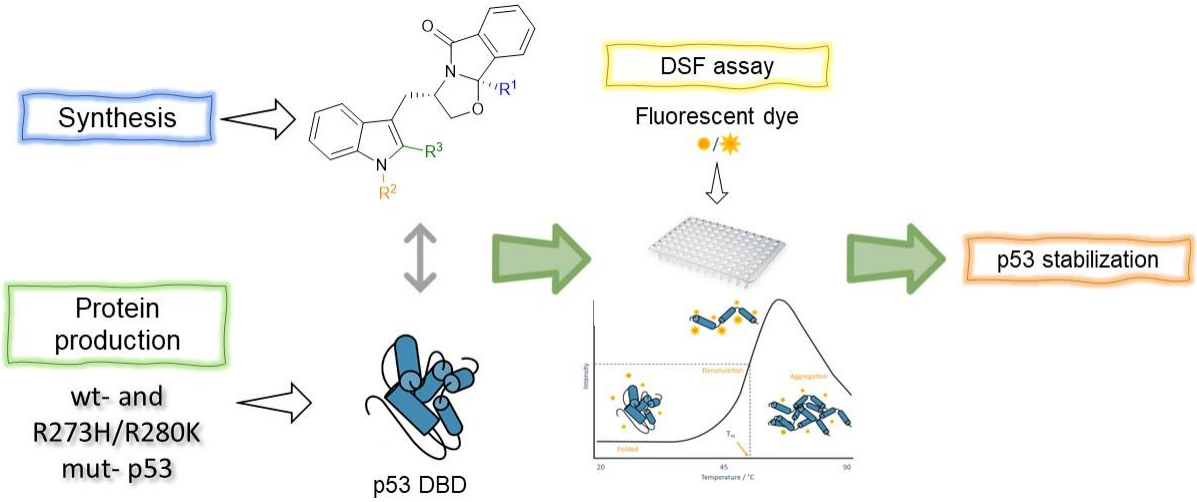


Figure 1: Overview of the project.

Acknowledgements
This work was supported by National Funds (Fundação para a Ciência e a Tecnologia) through iMed.ULisboa (UIDB/04138/2020), project PTDC/QUI-QOR/1304/2020 and PhD fellowship 2022.11539.BD (R. Ferreira). We also acknowledge the financial support from FCT and Portugal 2020 to the Portuguese Mass Spectrometry Network (Rede Nacional de Espectrometria de Massa – RNEM; LISBOA-01-0145-FEDER-402-022125). The NMR spectrometers are part of the National NMR Network (PTNMR) and are partially supported by Infrastructure Project Nº 022161 (co-financed by FEDER through COMPETE 2020, POCI and PORL and FCT through PIDDAC).

References

1. O. Hassin and M. Oren,Nat Rev Drug Discov. 2023, 22(2), 127-144.
2. V. Barcherini, J. Almeida, EA Lopes, M. Wang, D. Magalhães E Silva, M. Mori, S. Wang, L. Saraiva and M. M. M. Santos, *ChemMedChem* 2021,16(1), 250-258.
3. V. Barcherini, J. B. Loureiro, A. Sena, C. Madeira, A. P. Leandro, L. Saraiva, A. M. M. Antunes and M. M. M. Santos, *Pharmaceuticals* 2023, 16(2), 146.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of novel dual p53-MDM2/4 protein-protein interactions inhibitors

Elizabeth A. Lopes,[1,*] Margarida Espadinha,[1] Vanda Marques,[1] Joana D. Amaral,[1] Daniel J. V. A. dos Santos,[2] Mattia Mori,[3] Rebecca Piccarducci,[4] Elisa Zappelli,[4] Simona Daniele,[4] Claudia Martini,[4] Cecília M. P. Rodrigues,[1] Maria M. M. Santos[1,*]

[1]Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Av. Prof Gama Pinto 1649-003, Lisbon, Portugal; [2]CBIOS – Research Center for Biosciences & Health technologies, Universidade Lusófona de Humanidades e Tecnologias, Campo Grande 376, 1749–024 Lisboa, Portugal; [3]Department of Biotechnology, Chemistry and Pharmacy, University of Siena, Via Aldo Moro 2, 53100 Siena, Italy; [4]Department of Pharmacy, University of Pisa, 56126, Pisa, Italy
ed.lopes@ff.ulisboa.pt/ mariasantos@ff.ulisboa.pt

p53, Eencoded by the tumor suppressor gene *TP53*, is one of the most important tumor suppressor factors. This protein can be negatively regulated by MDM2 and MDM4. Dual inhibition of p53-MDM2/4 protein-protein interactions (PPIs) to restore p53 function is considered as a promising anticancer approach. p53-MDMs small molecule inhibitors mimic the p53 key amino acids (Phe19, Leu22, Trp23, and Leu26) involved in the interaction of p53 with MDMs. Although several MDM2 antagonists have reached clinical trials, none is used in the clinic, mostly due to the development of chemoresistance Targeting p53-MDM4 PPI is important to overcome this chemoresistance, and to activate p53 in cancers with MDM4 overexpression. Moreover, the development of novel chemical entities that disrupt p53-MDM4 and p53-MDM2/4 PPIs has been very demanding, mostly due to the rigidity of MDM4 and its conformational differences with MDM2.[1,2]

In this communication, we report the structural optimization of a previously identified hit spiropyrazoline oxindole as dual inhibitor of p53-MDM2/4 PPIs. Although this derivative was identified as p53 pathway activator in HCT116 cells, inducing cell cycle arrest at G0/G1 phase and apoptosis, it didn't bind extensively to MDM2.[3] Consequently, we have designed new derivatives able to reactivate p53 by targeting MDM2 and MDM4. Compounds with higher scores and best visual fitting were synthesized. Twenty-seven spiropyrazoline oxindole derivatives were prepared and evaluated in four cancer cell lines harboring wild-type p53. The most active compounds were evaluated in an enzyme immunoassay for heterocomplexes p53-MDM2 and p53-MDM4. Three compounds inhibited MDM2/4-p53 PPIs with IC_{50} values in the nM range, while one compound inhibited more selectively the MDM2-p53 PPI over the MDM4-p53 PPI. These results show spiropyrazoline oxindoles may serve as valuable leads for obtaining dual MDM2/4 inhibitors and more effective p53 activators.[4]

Acknowledgments
This work was supported by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the project PTDC/QUI-QOR/29664/2017, iMed.ULisboa (UIDB/04138/2020) and fellowships SFRH/BD/137544/2018 (E. A. Lopes), SFRH/BD/117931/2016 (M. Espadinha) and PD/BD/135467/2017 (V. Marques).

References

1. M. N. Saleh et al., Clin. Cancer Res. 27 (2021) 5236;
2. M. M. M. Santos *et al.*, Curr. Top. Med. Chem. 18 (2018) 647;
3. M. M. M. Santos *et al.*, Eur. J. Med. Chem. 139 (2017) 168;
4. M. M. M. Santos *et al.*, Eur. J. Med. Chem. 241 (2022) 114637.

ChemiOMICS – identifying fingerprints on food safety, authenticity and traceability

José S. Câmara[1,2,*], Jorge A. M. Pereira[1], Rosa Perestrelo[1]

[1]CQM – Centro de Química da Madeira, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal;
[2]Departamento de Química, Faculdade de Ciências Exatas e Engenharia, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal;
**jsc@staff.uma.pt*

Currently, research in food chemistry and food science is boosted thanks to the great potential offered by the OMICS platforms in unravelling the huge complexity of food metabolome at the genetic and molecular levels, through the employment of advanced OMICS tools, namely metabolomics, lipidomics, proteomics and genomics.[1,2] The main demands are directed towards food origin, shelf life, adulterations and food composition related to potential health benefits.[3] Unfortunately, food adulteration and contamination events seem to occur with some regularity, which requires continued efficient vigilance accomplished by the development of rapid analytical and detection techniques for the identification and/or quantification of characteristic components, adulterants and/or contaminants of food.

The OMICS platforms combined with chemiOMICS, assuming an increasing centrality on the systematic establishment of volatilomes, proteomes, lipidomes, and genomes, are emerging as self-standing research fields relying on well-established and recognized analytical methods such as mass spectrometry techniques (GC-MS and LC-MS/MS), in addition to modern spectroscopic approaches based on NMR (1H; 13C), IR and sensor technologies, to better characterize food matrices, identifying their components and defining nutritional properties. This comprehensive approach based on the integration of ChemiOMICS platforms combined with high-resolution analytical methodologies and data processing, seems to be a promising strategy for food fingerprinting, in a non-selective way, as a tool to establish its composition, certify its integrity and elucidate some critical issues related with food safety, food quality, food traceability and food authenticity, constituting useful support on detection adulterations and contaminations. In turn, this will progress our understanding of the biochemical, molecular, and cellular mechanisms related to the health benefits of bioactive food components.

Acknowledgements
This research was funded by FCT-Fundação para a Ciência e a Tecnologia through the CQM Base Fund - UIDB/00674/2020, and Programmatic Fund - UIDP/00674/2020, and by ARDITI-Agência Regional para o Desenvolvimento da Investigação Tecnologia e Inovação, through the project M1420-01-0145-FEDER-000005 - Centro de Química da Madeira - CQM+ (Madeira 14-20 Program) and the Post-Doctoral fellowship given to JAMP (Project M1420–09–5369-FSE-000001). The authors also acknowledge FCT and Madeira 14-2020 program for the Portuguese Mass Spectrometry Network (RNEM) through the PROEQUIPRAM program, M14-20 M1420-01-0145-FEDER-000008).

References
1. Y. Rodríguez-Carrasco, Foods, 2022, **11**(9), 1238.
2. U. Andjelković, M. S. Gajdošik, D. Gašo-Sokač, T. Martinović, D. Josić, Food Technol Biotechnol., 2017, **55**(3), 290-307.
3. D. Braconi, G. Bernardini, L. Millucci, A. Santucci, Expert Rev Proteomics. 2018, **15**(2), 153-164.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Neurotoxic effects of synthetic cathinones and its metabolites: the role of metabolism

R. P. Lopes[1,2,4,*], C. C. Miranda[3,4,5], H. Gaspar[2], A. M. M. Antunes[1]

[1]*Centro de Química Estrutural – Institute of Molecular Sciences, Instituto Superior Técnico, Universidade de Lisboa, Portugal.*
[2]*BioISI – BioSystems and Integrative Sciences Institute, Faculdade de Ciências, Universidade de Lisboa, Portugal.*
[3]*AccelBio – Collaborative Laboratory to Foster Translation and Drug Discovery, Cantanhede, Portugal.*
[4]*iBB – Institute of Bioengineering and Biosciences, Instituto Superior Técnico, Universidade de Lisboa, Portugal.*
[5]*Associate Laboratory i4HB – Institute for Health and Bioeconomy, Instituto Superior Técnico, Universidade de Lisboa, Portugal.*
**rita.padinha.lopes@tecnico.ulisboa.pt*

Synthetic cathinones represent the first largest group of new psychoactive substances (NPS) seized in Europe and the second largest group reported to EMCDDA, in terms of the number of controlled substances.[1]
Due to their potential toxicity, the recreational use of these NPS constitute a serious worldwide public health problem and difficults the update of cathinone's information by legal authorities. The metabolic degradation of these compounds adds one additional layer of difficulty for the clinical/ legal control of these NPS. However, metabolites can act as consumption biomarkers, extending the detection window beyond that allowed by the parent drug. Additionally, the metabolite profile can also shed some light on the molecular mechanism underlying the toxicity and open avenues for new effective therapeutic options for the management of non-fatal intoxication cases.[2,3]
With the ultimate goal of contributing for a proactive response in tackling the NPS problem, we have already successfully synthesized and characterized ten cathinones standards and, their reduced metabolites. Currently, all synthesized target compounds are undergoing neurotoxicity evaluation in the SH-SY5Y cell line (**Figure 1**). Preliminary results revealed that these metabolites show a higher cytotoxicity than the parent cathinone, thereby suggesting that metabolism can have a key role in the onset of the adverse effects induced by this class of NPS.

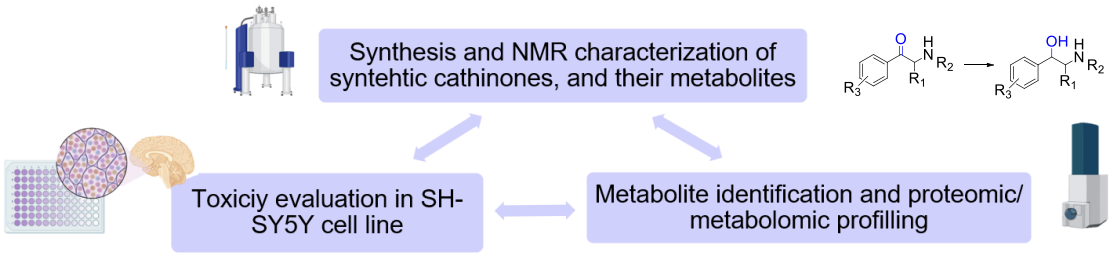


Figure 1: Metabolic profiling and toxicity evaluation of synthetic cathinones standards, and of their reduced metabolites.

Acknowledgements
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. FCT is also acknowledged for the PhD grant 2022.04738 to RPL and for support to BioISI-Biosystems & Integrative Sciences Institute (thought projects UIDB/04046/2020 and UIDP/04046/2020. Joint funding from FCT and the COMPETE Program through grant RNEM-LISBOA-01-0145-FEDER-022125 funding are also gratefully acknowledged. We acknowledge funding received from FCT, through Institute for Bioengineering and Biosciences (UIDB/04565/2020 and UIDP/04565/2020), through Associate Laboratory Institute for Health and Bioeconomy (LA/P/0140/2020), and through Investimento RE-C05-i02 –Missão Interface N.o01/C05-i02/22.

References
1. EMCDDA (2022a). European drug report 2022: Trends and developments. Available at: https://www.emcdda.europa.eu/publications/edr/trends-developments/2022_en (Acessed June 14, 2023).
2. R. P. Lopes, R. A. Ferro, M. Milhazes, M. Figueira, M. J. Caldeira, A. M. M. Antunes, H. Gaspar, *Front. Pharmacol*. 2023, 14, 1-14.
3. B. T. Lopes, M. J. Caldeira, H. Gaspar, A. M. M. Antunes, Front. Chem. 2021, 8, 1-13.

Unleashing the potential of incense honey from Azores: Invasive tree, profitable product!

Soraia Santos[1,*], Miguel Maia[2], Irene Gouvinhas[1], Ana Barros[1]

[1]*Centre for the Research and Technology of Agro-Environment and Biological Sciences (CITAB)/Inov4Agro (Institute for Innovation, Capacity Building and Sustainability of Agri-Food Production), University of Trás-os-Montes and Alto Douro (UTAD), Quinta de Prados, 5000-801 Vila Real, Portugal*
[2]*APISMAIA, Produtos & Serviços, Rua Almirante Reis, 91-A-2, 4490-463 Póvoa de Varzim, Portugal*
**soraiamsantos98@gmail.com*

Azores Islands are commonly known for their rich biodiversity due to the soil and climatic conditions, which also leads to the establishment of non-indigenous invasive species, such as *Pittosporum undulatum* Vent. with the common name of incense. However, this tree poses significant challenges and costs for control and the honey derived from it could hold the key to turning profit [1,2]. Indeed, this botanical source significantly influences the organoleptic and pharmacological characteristics of the honey, which are intricately linked to its chemical composition, including phenolic compounds. Consequently, this influence and enhances its commercial value and stimulates heightened consumer demand [3].

Our work aims to evaluate the incense honey from Azores focusing on its phenolic content and biological capacities, such as antioxidant and anti-aging properties. By doing so, we aim to augment its value and explore potential applications in several industries, including food, cosmetics, and pharmaceuticals. To achieve this objective, the phenolic content was determined through total phenols, *ortho*-diphenols, and flavonoids content assays, while the biological properties were analysed through ABTS•$^{+}$, DPPH•, and FRAP methodologies, for antioxidant capacity and through elastase and tyrosinase inhibition assays, for anti-aging capacity.

The outcomes of this study reveal highly favourable findings. Notably, the total phenolic content ranged from 20.82 to 112.13 mg of GA/100 g, *ortho*-diphenols ranged from 10.25 to 103.26 mg of GA/100 g, and flavonoid content varied between 2.94 and 40.96 mg of CAT/100 g. Regarding antioxidant capacity, the measured values ranged from 0.06 to 2.27 mmol Trolox/100g for DPPH, 0.04 to 0.45 mmol Trolox/100 g for ABTS, and 0.05 to 0.69 mmol Trolox/100 g for FRAP. In terms of anti-aging capacity, the honey exhibited a higher elastase enzyme inhibition capacity (ranging from 37.52% to 45.88%) compared to the tyrosinase enzyme inhibition capacity (4.36% to 9.37%) [2].

To the best of our knowledge this study is pioneering in incense honey phytochemical and biological properties analysis. In this sense, our research not only highlights its potential health benefits but also its significance as a national food product, along with its prospective applications in diverse industries, and simultaneously taking profit from a tree that has been considered a problem in the Islands.

Acknowledgements
We would like to thank to Apismaia for providing the samples. Soraia Santos received a grant from CITAB - BII/UTAD/11/2021. This work was supported by National Funds by the FCT – Portuguese Foundation for Science and Technology under the project I&D Centre for the Research and Technology of Agro-Environmental and Biological Sciences - CITAB (UIDB/AGR/04033/2020), with the reference BII/UTAD/11/2021.

References

1. M. D. Mendes, A. S. Lima, H. Trindade, A. I. D. Correia, J. G. Barroso, L. G. Pedro and A. C. Figueiredo, ISSR molecular characterization and leaf volatiles analysis of Pittosporum undulatum Vent. naturalized in the Azores archipelago (Portugal), Ind. Crops Prod., 2011, 33, 710–719.
2. S. Santos, M. Maia, A. Barros and I. Gouvinhas, Assessment of Phenolic Content, Antioxidant and Anti-Aging Activities of Honey from Pittosporum undulatum Vent. Naturalized in the Azores Archipelago (Portugal), Appl. Sci., 2023, 13, 1788.
3. L. R. Silva, R. Videira, A. P. Monteiro, P. Valentão and P. B. Andrade, Honey from Luso region (Portugal): Physicochemical characteristics and mineral contents, Microchem. J., 2009, 93, 73–77.

P212

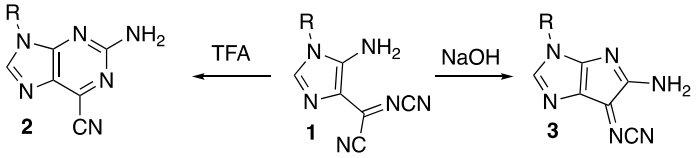
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis of novel 5-aminopyrrolo[2,3-*d*]imidazoles from 5-aminoimidazole precursors

B. Leite, N. Senhorães, A. M. Dias*

Chemistry Research Centre, Department of Chemistry, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
**ad@quimica.uminho.pt*

Nitrogen-containing heterocycles have received major attention because of their biological and pharmacological significance. Pyrrole is an important scaffold present in co-factors and natural products such as vitamin B12, bile pigments, chlorophyll, cytochrome, myoglobin and hemoglobin. In addition, several pyrrole-containing secondary metabolites isolated from natural sources also exhibit potential biological activity. Apart from this, synthetic pyrrole analogs have found diverse therapeutic applications like fungicides, antibiotics, anti-inflammatory drugs, cholesterol-reducing drugs, as well as anti-tubercular, antiviral, and antitumor agents.[1] In comparison to pyrrole, the imidazole scaffold shows additional binding potential to a variety of enzymes, proteins, and receptors. As a result, the development of the imidazole-based medicinal chemistry is in rapid expansion, not only because it is found in several naturally derived compounds (histamine, histidine, biotin, alkaloids, and nucleic acid, etc.), but it is also a part of multiple classes of approved drugs.[2] Even though many fused pyrrole analogs have been prepared to further increase biological activities toward various diseases,[1] as far as we know the synthesis of pyrroloimidazole compounds has not yet been achieved. In our research group, a number of substituted purines have been obtained from a 5-amino-4-cyanoformimidoyl imidazole. As part of a research program aiming to develop new imidazole and purine derivatives from this imidazole precursor, a synthetic strategy that enables the preparation of a diversity of 2-aminopurines trough the imidazole intermediate **1** had been planned. By combining the 5-amino-4-cyanoformimidoyl imidazole precursor with cyanamide, a series of compounds **1** were obtained in very good yield. Then, it was found that this intermediate easily undergo nucleophilic substitution of the cyano group as well as intramolecular cyclization, both facilitated in presence of acids or bases. Thus, a comprehensive study on the reactivity of intermediates **1** under different conditions was carried out, enabling the synthesis of a diversity of products. In particular, a series of highly fluorescent 2-amino-6-cyanopurines **2** were obtained by refluxing compounds **1** in the presence of trifluoracetic acid.[3]



Scheme 1: Synthesis of 2-amino-6-cyanopurines **2** and *N*-(5-amino-3-methylpyrrolo[2,3-*d*]imidazol-6(3*H*)-ylidene)cyanamide **3** from imidazole intermediates **1.**

Then, it was also established that similar results may be obtained in the presence of DBU, which prompted us to investigate the reaction of imidazoles **1** in the presence of different bases. When imidazoles **1** were combined with NaOH, a different intramolecular cyclization reaction of **1** occurred, giving the unexpected 5-aminopyrrolo[2,3-*d*]imidazoles **3.** These new compounds **3** were fully characterized on the basis of Mass, IR and NMR spectroscopy, including ^{13}C and 2D techniques. The detailed experimental data will be presented and discussed.

Acknowledgements
The authors acknowledge the financial support by Foundation for Science and Technology (FCT) and FEDER-COMPETE through the Chemical Research Centre of the University of Minho (UID/QUI/00686/2018, UID/QUI/00686/2020) and Rede Nacional de RMN (PINFRA/22161/2016).

References

1. N.J. Basha, S.M. Basavarajaiah, K. Shyamsunder, *Mol Divers, 2022,* **26**, 2915–2937.
2. S.S. Alghamdi, R.S. Suliman, K. Almutairi, K. Kahtani, D. Aljatli, *Drug Des. Devel. Ther.*, 2021, **15**, 3289–3312.
3. J.M. Gonçalves, J.N. Gonçalves, A.S. Pêra, N. R. Senhorães, A.R. Rodrigues, R. Oliveira, P.J. Coutinho, E.M. Castanheira, A. M. Dias, *Eur. J. Org. Chem.*, 2023, **26,** e202300176.

Chelerythrine – promising agent towards cancer treatment

A. Petrosian*, P. Pinheiro, G. Justino

Centro de Química Estrutural - Institute of Molecular Sciences, IST, Universidade de Lisboa, 1049-001 Lisboa, Portugal.
*artem.petrosian@tecnico.ulisboa.pt

In 2020, an estimated 4 million people were diagnosed with cancer, and 1.9 million deaths were reported.[1] Despite all the advances in treatment and the increased survival rate in past decades, cancer still remains one of the leading causes of death worldwide.

The natural alkaloid chelerythrine can be used as a promising agent towards a cancer treatment.[2] This compound is already known to have an anti-proliferative effect on some cancer cell lines, inhibiting their growth and division. In this study, we tested the anticancer activity of chelerythrine on prostate (LNCap), T-cell leukemia (Jurkat) and multiple myeloma (MM.1S) cell lines. Cell viability was measured by the resazurin assay in 96-well plate with a cell suspension at a density of 5×10^5 cells/mL for Jurkat and MM.1S and 2×10^5 cells/cm^2 for LNCap (Figure 1). Chelerythrine exhibits an anti-cancer effect with IC_{50} values lower than 20 μM for the chosen cell lines, which is comparable to some anticancer drugs (Figure 1A).[3]

To elucidate the mechanisms behind the anti-cancer effects of chelerythrine, a proteomics analysis of MM.1S cells exposed to two different concentrations (IC_{10}, IC_{50}) for 48 hours was performed. The initial analysis revealed that this alkaloid affects the pathways related with formation, folding, targeting, transporting and stability of proteins as well as the control of cellular metabolic function and death (Figure 1B).

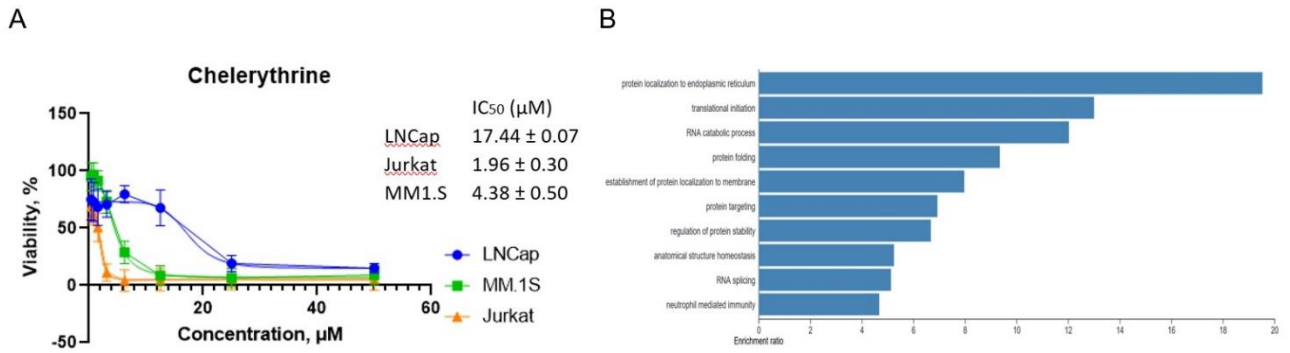


Figure 1: A - Dose response curves of chelerythrine for LNCap, Jurkat and MM.1S cell lines. **B -** Enrichment analysis of significantly changed proteins.

This possibility is now being further explored, combining our proteomics approach with conventional cell-based assays namely viability and migration assays.

Acknowledgements
Centro de Química Estrutural is a Research Unit funded by Fundação para a Ciência e Tecnologia through projects UIDB/00100/2020 and UIDP/00100/2020. Institute of Molecular Sciences is an Associate Laboratory funded by FCT through project LA/P/0056/2020. This work was partially funded through RNEM-LISBOA-01-0145-FEDER-022125 (RNEM—Portuguese Mass Spectrometry Network).

References
1. ECIS - European Cancer Information System. Available at: https://ecis.jrc.ec.europa.eu (Last accessed on 2 April 2023). 2. K. Kang, H. Jiang, S. Zhang, B. Cheng, Natural Product Communications. **2022**;17(6).
2. P. Larsson, H. Engqvist, J. Biermann, et al. Sci Rep. **2020**; 10, 5798.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

In chemico greener technologies in grape pomace valorization. Towards a circular bio-economy model

Teresa Abreu[1], José S. Câmara[1,2], JuanTeixeira[3], Rosa Perestrelo[1,*]

[1]*CQM – Centro de Química da Madeira, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal;*
[2]*Departamento de Química, Faculdade de Ciências Exatas e Engenharia, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal;*
[3]*Justino´s Madeira Wines, S.A., Parque Industrial Da Cancela, Caniço, 9125-042 Santa Cruz, Portugal;*
**rmp@staff.uma.pt*

Agri-food waste is a worldwide concern which continuously creates problems for society, the environment, human health, and the economy. To help reduce and minimize these concerns, it is necessary to implement transformation strategies that allow the conversion of agricultural waste into a variety of marketable added-value end products including bioactive compounds, biobased chemicals, biofuels, food additives, among others, to functionalize sustainable bio-economy model.[1,2] Within this context, the aim of this research was to establish the volatilomic fingerprint of grape pomace (GP) obtained from different Vitis vinifera L. grape varieties cultivated at Madeira Island, using solid phase microextraction (HS-SPME) coupled to gas chromatography-mass spectrometry (GC-MS), to unveil the properties of most dominant volatile organic metabolites (VOMs) in a context of its application on marketable products, in food, pharmaceutical and cosmetic industries. The obtained results revealed the potential of some GP VOMs in replacing synthetic antioxidants, \ anti-inflammatory, and antimicrobials with great potential for industrial applications, meeting the increasing consumer demand for natural alternative compounds. A total of 52 VOMs belong to different chemical families. Alcohols, carbonyl compounds, and esters are the most dominant chemical groups. Explored the signalling pathways involved in 1-octen-3-ol-mediated dopamine neurotoxicity; carbonyl compounds, special attention has been devoted to hexanal and benzaldehyde, which are powerful antimicrobials; and esters (isoamyl acetate, hexyl acetate, ethyl hexanoate) and alcohols (benzyl alcohol, 2-phenethyl alcohol) are commonly used as flavouring agents in various food products.

Acknowledgements
This work was supported by FCT-Fundação para a Ciência e a Tecnologia through the CQM Base Fund - UIDB/00674/2020, and Programmatic Fund - UIDP/00674/2020, , by Interreg MAC 2014–2020 Cooperacion territorial through AD4MAC project (MAC2/1.1b/350),by Madeira 14–20 Program, project PROEQUIPRAM - Reforço do Investimento em Equipamentos e Infraestruturas Científicas na RAM (M1420-01-0145-FEDER-000008), and by ARDITI - Agência Regional para o Desenvolvimento da Investigação Tecnologia e Inovação, through the projects M1420-01-0145-FEDER-000005 - Centro de Química da Madeira - CQM+ (Madeira 14–20 Program). Teresa Abreu acknowledges FCT for her PhD funding with the reference 2022.11323.BDANA.

References

1. A. Székács, J. Agric. Environ. Ethics, 2017, **30**, 153-170.
2. L.M. de Souza Mesquita, M. Martins, L.P. Pisani, S.P.M. Ventura, V.V. de Rosso, Compr. Rev. Food Sci. Food Saf., 2021, **20**, 787-818.

Centesimal and chemical characterization of Brazilian spinach (*Alternanthera sessilis* (L.) DC)

Matheus Matos do Nascimento[1,2], Joana Rodrigues[2], Ângela Fernandes[2,*], Lillian Barros[2], Almecina Balbino Ferreira[1,*], Joana S. Amaral[2]

[1]*Universidade Federal do Acre (UFAC), Rio Branco, Acre, Brazil*
[2]*Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Bragança and Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Portugal*
**afeitor@ipb.pt, almecina.ferreira@ufac.br*

Many plant species consumed as foods in the past have fallen into disuse and are scarcely or no longer used. However, in the last decade, these species are increasingly returning to the population's table, being generally known as unconventional food plants (UFP). UFPs grow spontaneously and often present higher nutritional value compared to some conventional food plants. In addition, they are sources of antioxidants and are often used as medicines with anti-inflammatory and antimicrobial potential[1]. *Alternanthera sessilis*, also known as Brazilian spinach or spinach from the Amazon, stands out as a South American UFP. It originates from the northern region of Brazil and is consumed by local communities and sold at fairs in the region. However, the information about the chemical composition of this UFP and on how cultivation practices can impact its composition is still very scarce. Thus, the objective of this work was to evaluate the centesimal and chemical composition of Brazilian spinach cultivated under different fertilization practices.

A. sessilis plants were cultivated in a greenhouse in the north region of Brazil (Acre) under 50% luminosity, using different fertilization treatments: T1- control; T2- synthetic fertilizer composed of a source of nitrogen (45% N urea), phosphorus (20% P_2O_5 simple super phosphate), and potassium (60% K_2O potassium chloride); T3 - organic fertilization using poultry manure; and T4- organomineral fertilization, a combination of synthetic and organic fertilization in a 50:50 ratio. The cultivation was carried out for 90 days from July to October 2022. The plants were harvested and dried in greenhouses at a constant temperature of 35 ºC. The leaves were separated from the stems and ground separately for subsequent analysis. The centesimal characterization followed the procedures described by the AOAC. Free sugars were determined by high-performance liquid chromatography (HPLC) coupled with a refractive index (RI) detector, organic acids by ultrafast liquid chromatography coupled with a diode array detector (UPLC-DAD), fatty acids by gas chromatography with flame ionization detection (GC-FID), and tocopherols by HPLC coupled with a fluorescence detector (HPLC-FL).

The lipid content in *A. sessilis* samples was higher in the leaves of plants grown with organic fertilization (3.4 ± 0.1 g/100g dried weight, d.w.). However, for proteins and ash, the contents were higher in plants grown with organomineral fertilization. Of particular note is the protein content in this treatment, which was 21.3 ± 0.2 g/100 d.w., significantly higher than that of many conventional vegetables. Regardless of the treatment, carbohydrates were relatively higher in the stems as compared to the leaves. Regarding the chemical characterization, two free sugars, fructose and sucrose, were identified in both the stems and leaves. The stems of plant received synthetic fertilization contained the highest amount of fructose, while sucrose was predominant in the stems of plants treated with organomineral fertilization. Among the organic acids, the highest concentration was found for oxalic acid in the leaves of plants cultivated with organomineral fertilization (6.83 ± 0.08 g/100 g d.w.), followed by succinic acid in those cultivated with synthetic fertilization (6.24 ± 0.06 g/100 g d.w.), while malic and citric acids were observed in lower concentrations (ranging from 2.0 to 3.1 g/100g d.w). Regarding fatty acids, there was a predominance of polyunsaturated fatty acids, with linoleic and α-linolenic acids being the main compounds. For vitamin E, α-, γ-, and β-tocopherols were identified, with particular emphasis on α-tocopherol, which was present in higher amounts in the leaves of plants cultivated with synthetic fertilization (9.3± 0.9 g/100g d.w).

The results showed that Brazilian spinach is a nutritious food with a high content of protein and interesting fatty acids profile. Organomineral fertilization resulted in higher protein, sucrose, and organic acids content. Therefore, further efforts should be pursued to cultivate this species and promote greater food diversification.

Acknowledgements
The authors thank the Coordination for the Improvement of Higher Education Personnel (Capes, Brazil) for the financial support through the resources made available by the public notice Procad-Amazônia 21/2018, and the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CIMO (UIDB/00690/2020 and UIDP/00690/2020) and SusTEC (LA/P/0007/2020), and national funding by FCT, P.I., through the institutional scientific employment program-contract for L. Barros and A. Fernandes

References

1. V.F. Kinupp, H. Lorenzi, Non-Conventional Food Plants (PANC) in the Brazil: identification guide, nutritional aspects and illustrated recipes. São Paulo, Publisher Plantarum, 2014.

P216

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Chemical composition of *Ruscus aculeatus L.* – Preliminary studies

Y. Dulyanska[1,2*], L. Cruz-Lopes[1], B. Esteves[1], M. J. Barroca[2], L. A. E. Batista de Carvalho[2], F. J. Gonçalves[1], I. Domingos[1], J. V. Ferreira[1], R. P. F. Guiné[1]

[1]*CERNAS-IPV, Instituto Politécnico de Viseu, Portugal*
[2] *Unidade de I&D Química-Física Molecular, Departamento de Química, Universidade de Coimbra; Portugal*
**ydulyanska@esav.ipv.pt*

Lignocellulosic material has gained considerable attention for presenting several environmental advantages due to its abundance, low price, renewable nature and low energy consumption in production. Nowadays, with a growing environmental awareness, the reassessment of agroforestry residues is one of the challenges of sustainable agriculture to reduce its environmental impacts and give them high added value[1].
The *Ruscus aculeatus L.* plant belongs to the *Liliaceae* family[2]. *Ruscus aculeatus L.* is a sub-shrub with a wide geographic distribution, occurring in more than 700 locations in mainland Portugal. Its high ecological plasticity allows it to colonize different types of habitat, although it shows a preference for forest environments dominated by oak forests. It grows on all types of soil from sea level up to 1400 meters, preferring shaded places with fresh and deep soils[3]. In the *Ruscus aculeatus L*. what appears to be leaves are actually expansions of the stem, called cladodes. It is in these formations that the flowers emerge and the fruits are formed, red globose berries when ripe. It presents pharmacological properties due to the presence of different classes of natural products or active compounds. *Ruscus aculeatus L*. is one of the most used plants in traditional medicine in different parts of the world, namely in Europe and the Iberian Peninsula[4].
The present study aimed to contribute to the development of scientific knowledge regarding the chemical composition of *Ruscus aculeatus L*. for a better understanding of the possible value-added products that can be obtained from this material. For this, the *Ruscus aculeatus L*. samples were characterized for their ash content, extractives (in dichloromethane, ethanol, and hot water), α-cellulose, lignin, and hemicelluloses. The 40–60 mesh fraction was used and prepared for the chemical analyses according to Tappi T 264 om-97. The ash content was determined by the calcination of the material at 525 ºC according to the standard procedure Tappi T 211 om-93. The extractives were determined by extraction with different solvents in sequential order of ascending polarity. The extractive content consisted on the determination of dichloromethane, ethanol, and hot water extractives using Soxhlet extraction according to Tappi T 204 om-88. The lignin content in *Ruscus aculeatus L*. free of extractives was determined by the Klason method with 72% H_2SO_4 (according to Tappi T 204 om-88). The soluble lignin was analyzed through spectrophotometry by measuring the absorption at 205 nm. Holocellulose was determined by the acid chloride method. The hemicellulose content was determined by the difference between holocellulose and α-cellulose.
Preliminary studies on chemical composition revealed that the material is lignocellulosic, presenting approximately 39,3% α-cellulose, followed by hemicellulose 21,2% and lignin 20,8%. However, analyses show a high percentage of hot water extractives of around 7,9%, higher than the extractives in ethanol (6,9%) and dichloromethane (2,1%). In this way, it can be concluded, based on the chemical characterization performed on *Ruscus aculeatus L*., that this material has several components of interest to recover. Additionally, because it is a lignocellulosic material it can also be transformed into a liquefied material that can be further processed to obtain a possible replacement for the polyol in polyurethane foams or that can be used to produce adhesives.

Acknowledgements
This work was supported by Foundation for Science and Technology, I.P. (Ref. UIDB/00681/2020 & UIDB/00070/2020). Y. Dulyanska received support from FCT (UIDP/00681/2020/BD-Alim).

References
1. F. J. Lozano and R. Lozano, Journal of Cleaner Production, 2018, 172, 4162–4169.
2. J. P. B. Rodrigues, Â. Fernandes, M. I. Dias, C. Pereira, T. C. S. P. Pires, R. C. Calhelha, A. M. Carvalho, I. C. F. R. Ferreira and L. Barros, *Molecules*, 2021, **26**, 1882.
3. Flora-On | Flora de Portugal, https://flora-on.pt/?q=Ruscus, (accessed 22 June 2023).
4. M. Masullo, C. Pizza and S. Piacente, *Planta Med*, 2016, **82**, 1513–1524.

Hyperbaric storage of egg white to assure microbiological safety, maintaining functional and quality parameters

Gabriela Matos[1,*], Jéssica Tavares[1], Isabel Ferreira[2], Jorge A. Saraiva[1]

[1]LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal; [2]LAQV-REQUIMTE, Laboratory of Bromatology and Hydrology, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal.
**gabrielamatos@ua.pt*

Egg white (EW) plays an important role in the food industry due to its high protein content, but also for providing desirable functional properties such us foaming and gelling, leading to its use in a vast variety of food products. Nevertheless, EW is highly perishable and usually go through thermal processing that extends shelf-life under refrigeration (RF) but causes considerable detrimental effects of functional properties.1 Moreover, RF is highly reported to have significant economic and environmental impacts. Thus, more efficient food preservation methodologies are needed, without compromising EW functionality and quality, with extended shelf-life as a plus. Hyperbaric storage (HS) is a novel pressure-based food preservation methodology that uses mild pressures (25-150 MPa), being a possible alternative to RF when used at room temperature (RT) since no energy is needed to keep the food products under pressure along storage. This allows reducing the carbon-footprint associated with food preservation, in addition to the longer shelf-life achievable with this methodology.2,3 Therefore, the aim of this study is to evaluate HS/RT as a nonthermal preservation methodology for microbial growth inhibition on EW, to assure its microbial safety, thus, avoiding thermal pasteurization and evaluate at what extent HS/RT can replace RF. HS experiments at different pressure levels (50/75/100 MPa) at RT were carried out up to 60 days in EW. Microbiological evaluation of HS/RT was assessed through counts of inoculated pathogenic microorganisms (≈6.8 log CFU/mL), namely Salmonella Senftenberg, Salmonella Enteritidis, Listeria monocytogenes and Staphylococcus aureus, for the established pressure/time conditions and compared with RF at atmospheric pressure. EW preserved at the optimal conditions of HS/RT for microbial inhibition was evaluated for functional and physicochemical properties, such us pH, color, soluble protein, water holding capacity and foaming capacity and stability. Microbiological results showed that using HS/RT under 75–100 MPa in EW allowed to reduce S. Senftenberg, S. Enteritidis, L. monocytogenes and S. aureus population to counts below 1 log CFU/mL, notably more than 5 log units inactivation, remaining bellow the detection limit up to 60 days. In addition, functional and physicochemical properties measured in EW maintained in most of the cases unchanged, indicating that HS/RT have great potential not just to preserve EW but also to inactivate microbial population to values normally achieved by pasteurization.

Acknowledgements
Thanks are due to the University of Aveiro, University of Porto and FCT/MCTES for the financial support for the LAQV research Unit (projects FCT UIDB/50006/2020 and UIDP/50006/2020) through national founds and, where applicable, cofinanced by the FEDER, within the PT2020 Partnership Agreement. Gabriela Matos also thanks FCT/MCTES and ESF through NORTE 2020 for PhD grant reference 2021.07139.BD.

References

1. Rossi, M., Casiraghi, E., Primavesi, L., Pompei, C. & Hidalgo, A. Functional properties of pasteurised liquid whole egg products as affected by the hygienic quality of the raw eggs. LWT - Food Science and Technology 43, 436–441 (2010).
2. Duarte, R. V., Pinto, C. A., Gomes, A. M., Delgadillo, I. & Saraiva, J. A. A microbiological perspective of raw milk preserved at room temperature using hyperbaric storage compared to refrigerated storage. Innovative Food Science & Emerging Technologies 78, 103019 (2022).
3. Bermejo-prada, A., Colmant, A. & Otero, L. Industrial viability of the hyperbaric method to store perishable foods at room temperature. J Food Eng 193, 76–85 (2017).

P218

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Development of a liposome-based cell membrane mimetic system for the characterization of glucan-receptor interaction studies

Vítor J. Martins[1,2*], Ildefonso Marin-Montesinos[2], Manuel A. Coimbra[1], Elisabete Coelho[1]

[1]LAQV-REQUIMTE, Departamento de Química, Universidade de Aveiro, Campus Universitário de Santiago, 3910-193, Aveiro, Portugal; [2]CICECO – Instituto de Materiais de Aveiro, Departamento de Química, Universidade de Aveiro, Campus Universitário de Santiago, 3910-193, Aveiro, Portugal
**vitorjmartins@ua.pt*

Immune recognition of fungal polysaccharides by the mammalian immune system is mediated by specific receptors, such as Dectin-1, a transmembrane C-type lectin expressed in macrophages which recognizes both linear and branched (β1→3)-glucans. [1] Dectin-1 has two active isoforms (A and B) which exhibit differential interactions with glucan structures, with the canonical A isoform recognizing soluble glucans containing at least 11 monosaccharide units [2], whereas the shorter isoform B recognizes insoluble glucans. Previous studies have primarily focused on the immunological behavior of Dectin-1, and the structural characterization of glucan-receptor interactions has been limited to their carbohydrate recognition domain. [2, 3] Although this provides some structural insights, it overlooks the influence of the transmembrane nature of these receptors on the assessment of glucan-protein interactions. The development of a cell membrane mimetic system in which Dectin-1 or other receptors could be integrated is thus a key step in the proper establishment of glucan-receptor relationships with these receptors.

In this work, dioleoyl- (DOPC) and dipalmitoylphospatidylcholine (DPPC) liposomes were prepared both with and without gramicidin A, a hydrophobic pentadecapeptide with antibiotic activity, as a proof-of-concept model prior to incorporation of Dectin-1 isoforms. These membrane models were characterized on their size using dynamic light scattering and by magic angle spinning (MAS) solid state NMR to assess the peptide insertion in the lipid bilayer.

Dynamic light scattering analysis of the obtained liposomes revealed that the incorporation of gramicidin A resulted in larger vesicles and a more polydisperse vesicle distribution, as compared with the liposomes prepared without peptide. ^{31}P-^{1}H Heteronuclear correlation (HETCOR) spectra of both liposome preparations revealed dipole-dipole interactions between the phosphatidylcholine head group and neighboring protons from the phospholipid head and aliphatic regions. On the sample containing gramicidin A, additional correlations could also be identified, according to literature [4], as belonging to peptidic linkage amide protons and indole protons from tryptophan side chains.

These results show that gramicidin A was successfully incorporated into the lipid bilayer of liposome vesicles, proving the feasibility of this membrane mimetic model for future incorporation of Dectin-1.

Acknowledgements
The work was supported through the projects UIDB/50006/2020 and UIDP/50006/2020 (LAQV-REQUIMTE), UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020 (CICECO - Aveiro Institute of Materials), funded by FCT/MCTES through national funds. Vítor Martins was supported with an individual PhD grant by FCT (2021.08389.BD) and Elisabete Coelho thanks FCT (Fundação para a Ciência e Tecnologia) for funding through program DL 57/2016 – Norma transitória (Ref.049-88-ARH/2018).

References

1. G. D. Brown and S. Gordon, Nature, 2001, 413, 36-37.
2. A. S. Palma, T. Feizi, Y. Zhang, M. S. Stoll, A. M. Lawson, E. Diaz-Rodriguez, M. A. Campanero-Rhodes, J. Costa, S. Gordon, G. D. Brown and W. Chai, J Biol Chem, 2006, 281, 5771-5779.
3. J. Brown, C. A. O'Callaghan, A. S. Marshall, R. J. Gilbert, C. Siebold, S. Gordon, G. D. Brown and E. Y. Jones, Protein Sci, 2007, 16, 1042-1052.
4. S. M. Pascal and T. A. Cross, J Mol Biol, 1992, 226, 1101-1109.

Integrated purification strategies of RNA from recombinant lysates using biobased ionic liquids

Ana F. Pereira[1], Augusto Q. Pedro[1], Leonor S. Castro[1], Maria J. Quental[1], Ana P. M. Tavares[1,*], Luís C. Branco[2], João A. P. Coutinho[1], Fani Sousa[3], Mara G. Freire[1]

[1]CICECO – Instituto de Materiais de Aveiro, Departamento de Química, Universidade de Aveiro, Campus Universitário de Santiago 3810-193, Aveiro, Portugal; [2]LAQV-REQUIMTE, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Lisboa, Portugal; [3]CICS-UBI – Centro de Investigação em Ciências da Saúde, Universidade da Beira Interior, Convento de Sto. António 6201-001, Covilhã, Portugal
**aptavares@ua.pt*

RNA has emerged as a promising biopharmaceutical, paving the way for the development of innovative medicines with broad therapeutic and prophylactic efficiencies. However, the therapeutic efficiency of RNA strongly depends on its integrity, purity and biological activity, which is not easily achievable due to the highly labile nature and intrinsic low stability of RNA, coupled with the laborious and costly current methods for RNA extraction and purification.[1] To surpass the described drawbacks, more competitive, effective and sustainable strategies for purifying RNA are of paramount relevance. To this end and by virtue of the high affinity between amino-acids and RNA, as well as the favourable nucleic acids-stabilization properties exhibited by amino-acid-based ILs (AA-ILs), AA-ILs may play a prominent role on this field.[2] From the exposed, several AA-ILs are being investigated as constituents of aqueous biphasic systems (ABS). ABS are aimed to be used as alternative cost-effective and sustainable purification-stabilization platforms for RNA, taking advantage of the tuneability and designer solvent character of ILs, with the ultimate goal of purifying RNA from a complex recombinant lysate. AA-ILs comprising L-arginine, L-lysine and L-histidine as cations combined with chloride or DL-aspartate, were synthesized and characterized. All AA-ILs in study formed ABS with polypropylene glycol with a molecular weight of 400 $g.mol^{-1}$ (PPG 400), allowing their use in the purification and preservation of RNA. RNA is majorly extracted with high yield either to the IL-rich phase or can be recovered as a precipitate (in the ABS composed of the dicationic AA-ILs), without compromising its structural integrity and thus confirming the versatility and improved selectivity of these systems. New extraction studies were then carried out with a more complex sample containing RNA and genomic DNA, and it was found that two ABS show a preferential partition of gDNA to the precipitate and RNA to the IL-rich phase, thus demonstrating the ability of these systems to act as potential integrated purification-preservation platforms for RNA. Ongoing work is focusing on the application of the most promising IL-based ABS for the separation of RNA from complex recombinant lysates. Overall, the approach herein developed represents a promising strategy to surpass the critical demand of RNA with high integrity, purity, and biological activity, envisaging its potential use as biotherapeutics.

Acknowledgments
This work was developed within the scope of the projects: CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC); EIC-Pathfinder YSCRIPT project with reference 101047214, supported by the budgets of the Horizon Europe Program; and mVACCIL (EXPL/BII-BTI/0731/2021), financially supported by national funds (OE), through FCT/MCTES. Ana Pereira, Leonor Castro, Augusto Pedro and Ana Tavares acknowledge FCT, respectively, for the PhD grants 2022/13247/BD and 2020/05090/BD and the research contracts CEECIND/2020/02599 and CEECIND/2020/01867 under the Scientific Stimulus – Individual Call.

References
1. A. Q. Pedro, P. Pereira, M. J. Quental, A. P. Carvalho, S. M. Santos, J. A. Queiroz, F. Sousa and M. G. Freire, *ACS Sustain Chem Eng*, 2018, **6**, 16645–16656.
2. M. V. Quental, A. Q. Pedro, P. Pereira, M. Sharma, J. A. Queiroz, J. A. P. Coutinho, F. Sousa and M. G. Freire, *ACS Sustain Chem Eng*, 2019, **7**, 9439–9448.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Bioprospecting *Laminaria digitata* as a potential biostimulant and drought stress mitigator in tomato plants

Ana R. Circuncisão[1,*], Mateus Pereira[1], Maria C. Dias[1,2], Artur M. S. Silva[1], Manuel A. Coimbra[1], Susana M. Cardoso[1], Sónia Silva[1]

[1]*LAQV & REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Department of Life Sciences, Centre for Functional Ecology, Faculty of Sciences and Technologies, University of Coimbra, Calçada Martim de Freitas, 3000-456 Coimbra, Portugal*
**anarcircuncisao@ua.pt*

Nowadays, the agrifood sector is dealing with the acceleration of climate change episodes, such as drought with negative consequences on crop growth and yields[1]. In addition to the challenging environmental conditions, substantial increases in food production must be met while decreasing the environmental agriculture footprint[1]. These challenges make imperative the development of new sustainable strategies enabling crops to combine high productivity and tolerance to abiotic stressors. Seaweeds and, particularly seaweeds-rich extracts have been recognized as promising plant biostimulants due to their plethora of bioactive compounds, including polysaccharides, pigments, phenolic compounds, proteins, phytohormones and micro- and macronutrients which have been associated to a wide range of biofunctionalities[2]. In this context, the present work aimed to study the benefits of using brown seaweed *Laminaria digitata* aqueous extract against drought effects and on the improvement of plant performance.

To achieve this, two weeks old *Solanum lycopersicum* (tomato) plants were primed with different concentrations (0, 0.1 and 1 g/L) of *L. digitata* aqueous extract (cold water, 1:70 (w/v), 1h). After 5 foliar applications, plants were divided in two groups differing on their irrigation conditions: water stressed (WS) and well-watered (WW). The WS group was not watered for a week, whereas the WW group received regular irrigation. Following the stress period, the tomato leaves were analysed for their morphological and physiological features. Also, their content in phenolics and flavonoids were determined, as well as their antioxidant activity by $ABTS^{\bullet+}$ radical scavenging assay. The most proeminent phenolic compounds were characterized by UHPLC-DAD-ESI-MS.

In terms of chemical composition, the *L. digitata* aqueous extract contained 27.7% ash, 4.8% protein, and 38.5% of total sugars. Besides, the total phenolic and phlorotannins compounds accounted for 1.3 g and 0.26 g phloroglucinol equivalents/100 g extract. The results showed that the foliar application of the *L. digitata* extract did not affected tomato plant growth, leaf water content, neither proline nor H_2O_2 contents. On the other hand, *L. digitata* treatment led to enhanced gas exchange in the WW group, with the increment of the net CO_2 assimilation rate (P_N), stomatal conductance (g_s), intercellular CO_2 concentration (C_i), and transpiration rate (*E*) in both concentrations. In contrast, the WS group exhibited a trend to increase water use efficiency, concomitant with a decrease in the g_s and *E* parameters. Concerning the fluorescence of Chl *a*, the maximum efficiency of PSII (F_v/F_m) trended to be higher in the WW group, despite a decrease of the effective efficiency of PSII (ΦPSII). At the same dose and in WS, the treatment enhanced the ΦPSII, together with the increase of photochemical quenching (qP). Regarding the antioxidant response, it was observed the decrease of the total flavonoids content in both WW and WS groups at the highest dose, contrasting to a trend to increase the total phenolics in WW. Despite these variations, treatments did not change the total antioxidant activity. Further, UHPLC-MS analysis revealed that water limitation modified the profile of the identified phenolic compounds, and that *L. digitata* treatment modulated phenolics abundance and composition in both groups. In WW, despite some increments (e.g. malic acid), the phenolics abundance decreased, mostly at the highest dose. A similar trend was followed by the WS group, despite less evident. Overall, these results highlight the ability of *L. digitata* extract in modulating photosynthesis and phenolics in tomato, thus pinpointing its potential use as plant biostimulant and as mitigator of drought stress effects.

Acknowledgements and Funding
Sónia Silva and Maria C. Dias thanks FCT (Fundação para a Ciência e Tecnologia) for funding through program DL 57/2016 – Norma transitória (Ref. SFRH/BPD/74299/2010 and SFRH/BPD/100865/2014). Susana M. Cardoso thanks FCT/MCTES for funding through the Individual Call to Scientific Employment Stimulus Ref. 2022.06426.CEECIND. Ana R. Circuncisão thanks FCT/MCTES and ESF (European Social Fund) through Norte20202 (Programa Operacional Região Norte) for her PhD grant Ref. SFRH/147321/2019. This work received financial support from PT national funds (FCT/MCTES, Fundação para a Ciência e Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through the projects UIDB/50006/2020 and UIDP/50006/2020, UIDB/04004/2020 and UIDB/50006/2020.

References

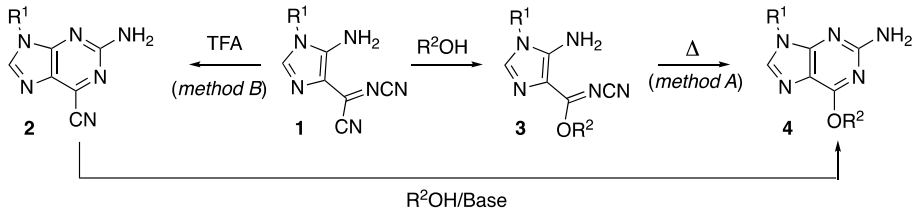
1. M. C. Dias, M. Araújo, S. Silva, C. Santos, *Horticulturae*, 2022, **8(11)**, 1048.
2. M. D. Catarino, A. M. S. Silva, Susana M. Cardoso, *Mar. Drugs*, 2018, **16(8)**, 249.

Two simple and accessible approaches for the synthesis of 2-amino-6-alcoxypurines from 5-aminoimidazole precursors

A. M. Santos, B. Leite, A. M. Dias*

Chemistry Research Centre, Department of Chemistry, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
**ad@quimica.uminho.pt*

Purines are the most abundant nitrogen-heterocycles in nature. This scaffold is present in adenine and guanine, and, therefore, it is part of nucleic acids and nucleotides (AMP, GMP), which play crucial roles in the regulation of cellular energy and in the intracellular signaling processes (ATP, GTP) and enzyme cofactors (NADH, coenzyme A). The biological relevance of this heterocyclic ring makes it an excellent scaffold in drug design. Hence, several purine analogs have been developed for the treatment of different diseases such as leukemias, viral infections, cancer or immune disorders, and many others are currently being studied.[1]
Typically, purine analogs may be obtained by the introduction of substituents at positions C2, C6, C8, and/or N9 using different synthetic methodologies. Considering the C6-substituted purines, the most used methods start from 6-chloropurines or 6-chloro-4,5-diaminopyrimidines, and involve a nucleophilic replacement of the chloro atom at C6-position to introduce the desired substituent. In the purine libraries generated by these methods, C6-aminated analogs are generally predominant while the attachment of an ether group at C6 is a less explored structural feature. However, few examples of 6-alkoxypurines have been obtained and exhibited important anti-cancer and trypanocidal activity.[2]
In our research group, a number of substituted purines have been obtained as part of a research program aiming to develop new imidazole and purine derivatives from a 5-amino-4-cyanoformimidoyl imidazole precursor. A synthetic strategy to the preparation of a diversity of 2-aminopurines involving the key imidazole intermediate (**1**) have been developed. This intermediate, obtained by combining the 5-amino-4-cyanoformimidoyl imidazole precursor with cyanamide, led to a series of 6-cyanopurines **2** (Scheme 1).[3]



Scheme 1: Two alternative methods to obtain 2-amino-6-alkoxipurines **4** from 5-aminoimidazole intermediates **1.**

Here, we report two alternative two-step synthetic pathways for the preparation of 2-amino-6-alkoxypurines **4** from intermediates **1**: nucleophilic addition of a primary alcohol to imidazole **1** followed by elimination of the cyano group affording imidazoles **3**, which were then converted to the desired purines **4** by intramolecular cyclization (method A); or cyclization of compounds **1** followed by SN_{Ar} reaction of the generated purines **2** upon treatment with the same primary alcohols in the presence base (method B). These new compounds **4** were fully characterized on the basis of Mass, IR and NMR spectroscopy, including ^{13}C and 2D techniques. The experimental details of both strategies will be presented and discussed.

Acknowledgements
The authors acknowledge the financial support by Foundation for Science and Technology (FCT) and FEDER-COMPETE through the Chemical Research Centre of the University of Minho (UID/QUI/00686/2018, UID/QUI/00686/2020) and Rede Nacional de RMN (PINFRA/22161/2016).

References

1. M. Pineda de las Infantas y Villatoro, J. Unciti-Broceta, R. Contreras-Montoya, et al. *Sci Rep*, 2015, 5, 9139.
2. Á. Lorente-Macías, I. Iañez, M. C. Jiménez-López, M. Benítez-Quesada, S.Torres-Rusillo, J. J. Díaz-Mochón, I. J. Molina, M.J. Pineda de Las Infantas, *Arch Pharm* (Weinheim), 2021,**354**(10), e2100095.
3. J.M. Gonçalves, J.N. Gonçalves, A.S. Pêra, N.R. Senhorães, A.R. Rodrigues, R. Oliveira, P.J. Coutinho, E.M. Castanheira, A.M. Dias, *Eur. J. Org. Chem*., 2023, **26**, e202300176.

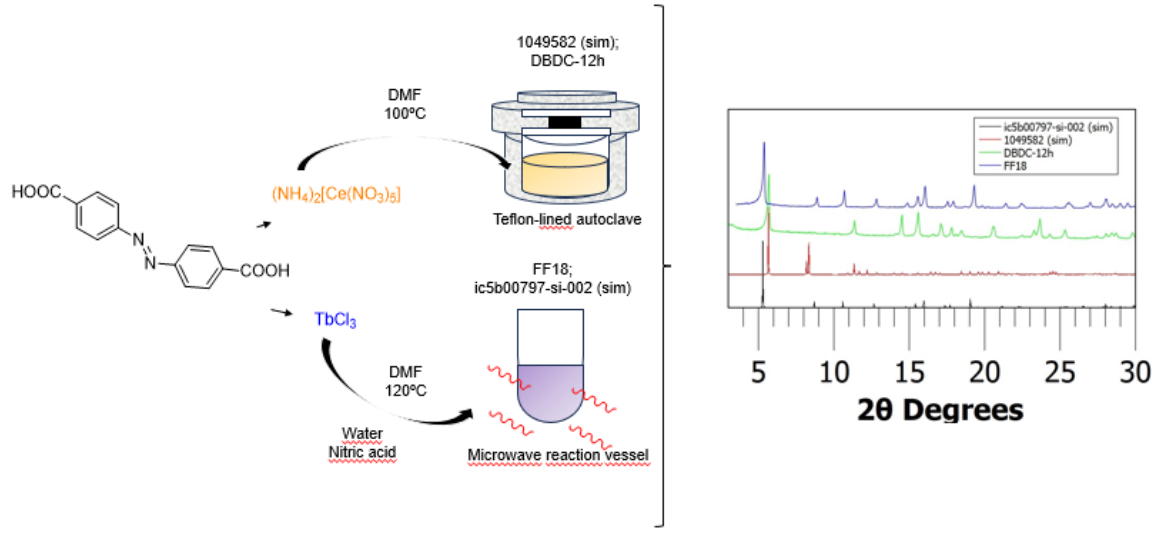
XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

A new cerium-based metal-organic framework with azobenzene-4,4'-dicarboxylic acid as ligand

Nádia E. Santos[1,2*], Ricardo F. Mendes[1], Susana Santos Braga[2], Filipe A. Almeida Paz[1], Flávio Figueira[1]

[1]*CICECO—Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193, Aveiro, Portugal*
**nadiaasantos@ua.pt*

Lanthanide elements are usually considered suitable metal centers, mainly due to their higher coordination numbers and uncontrolled geometries[1]. However, lanthanide-based metal organic-frameworks (MOFs) have been drawing attention, thanks to their interesting structures and potential applications, including biological properties[2]. We report the synthesis of a series of cerium-based and terbium-based MOF using azobenzene-4,4'-dicarboxylic acid (Scheme 1), a versatile organic ligand due its variety of coordination modes, with cerium and terbium, by solvothermal conditions. The obtained material showed, by powder x-ray diffraction, a similar phase resembling a previously reported one[1] but with slight changes that were explored.
Moreover, an important feature to take into consideration when using MOFs for biological applications is their structural integrity and stability under different chemical conditions. Therefore, we report in this work the structural and stability features of these MOFs for future biological application.



Scheme 1: Experimental conditions for the preparation of cerium and terbium-based MOF's, under solvothermal and microwave-assisted synthesis, and respective XRD diffractograms.

Acknowledgements
We acknowledge University of Aveiro and FCT/MCTES (Fundação para a Ciência e a Tecnologia, Ministério da Ciência, da Tecnologia e do Ensino Superior) for financial support to LAQV-REQUIMTE (Ref. UIDB/50006/2020), and to CICECO—Aveiro Institute of Materials (Refs. UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020) through national founds (PIDDAC) and, where applicable, co-financed by the European Regional Development Fund (FEDER), within the PT2020 Partnership Agreement. Nádia E. Santos acknowledge FCT for the financial support under the PhD scholarship 2022.09798.BD. The research contract of FF (REF-168-89-ARH/2018) is funded by national funds (OE), through FCT, in the scope of the framework contract foreseen in Nos. 4, 5 and 6 of article 23 of the Decree-Law 57/2016, of 29 August, changed by Law 57/2017, of 19 July.

References

1. B. Fernández, I. Oyarzabal, J. Seco, E. Sebastián, D. Fairen-Jiménez, S. Gómez-Ruiz, A. Salinas-Castillo, A. Calahorro and A. Rodríguez-Diéguez, *Polymers*, 2016, **8**, 39.
2. D. Briones, B. Fernández, A. J. Calahorro, D. Fairen-Jimenez, R. Sanz, F. Martínez, G. Orcajo, E. San Sebastián, J. M. Seco, C. Sánchez González, J. Llopis, A Rodríguez-Diéguez, *Cryst. Growth Des*, 2016, **16**, 537–540.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

P223

Moderate pressure pasteurization as an alternative to commercial HPP to pasteurize bovine meat without major colour changes

R. Lopes[1,*], A. P. Martins[1,2], S. Casal[3], J. A. Saraiva[1]

[1]*LAQV-REQUIMTE, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*CICECO, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[3]*LAQV-REQUIMTE, Department of Chemical Science, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal*
**lrafaelaa9@gmail.com*

High Pressure Processing, HPP (400 – 600 MPa, over 1 – 10 min, at ≈ 8 – 14º C) is a commercial technique that already showed promising results in the preservation of different food products in solid and liquid state (juices, milk, dressings, ready to eat meals, etc), with the benefit of not requiring any thermal treatment. HPP allows to achieve microbial inactivation above 400 MPa, however at these pressures, some unwanted changes were described in products with high content in proteins like meat[1].The most important changes regard the color and texture of the product and are caused by the desnaturation of proteins[2].

Moderate pressure pasteurization, MPP, has been recently propose as a new slow, pressure-based pasteurization methodology for heat- and pressure-sensible foods, as an alternative to HPP[3]. MPP use moderate pressures (100 – 300 MPa, for a few hours) to successfully inactivate vegetative microorganisms without temperature, like MPP, but with smaller impact on the physicochemical parameters[3]. However, the extent of the effect of MPP in the raw meat colour, the most important parameter evaluated by consumers, is still unknow. Therefore, the aim of this work was to evaluate the impact of MPP on raw bovine meat colour and other physicochemical parameters, while guaranteeing microbial inactivation/pasteurization.

In this regard, bovine meat in pieces was pasteurized using MPP (125 and 200 MPa) at uncontrolled room (≈ 15 to 25 ºC). *Salmonella enterica* and *Staphylococcus aureus*, two of the most common pathogenic bacteria, were the microorganisms tested. Simultaneously, the colour, the texture and the pH were evaluated to determine the optimal conditions that combine high levels of microbial inactivation with minimal physicochemical changes.

Salmonella enterica and *Staphylococcus aureus* were inactivated at 200 MPa/RT after 3 and 24 hours of pressure, up to 5.7 and 3.5 log units, respectively. Under this pressure, the meat's microbial safety was achieved, but with a variation in colour of 9.8 ± 3.98 (ΔE), value that were superior to 3, highest value for undistinguishable changes by human eye[4]. However, at 125 MPa/RT, mild colour changes were observed, with ΔE closed to 3, resulting in a very similar look to fresh raw meat. Meanwhile, a slower microbial reduction was detected, up to 3.5 log units for *Salmonella enterica* and *Staphylococcus aureus after 48 and 72 hours,* respectively, thus, still improving meat microbial safety. The other parameters analysed suffered small alterations. The texture of the samples in both pressures only had an increase of around 3 N of hardness, much less compared to the effect of HPP (around 40 N at 400 MPa)[5].

These results point MPP as a promising methodology for raw bovine meat pasteurization without relevant colour changes, being such a result impossible until now with currently commercial pasteurization techniques. Further studies are so on great interest on the effect of MPP on meat and other proteinaceous foods that are sensible in relation to quality issues to the current pasteurization methodologies, including nonthermal HPP.

Acknowledgements
Thanks are due to the University of Aveiro and FCT/MCT for the financial support to the LAQV-REQUIMTE research Unit (UIDB/50006/2020) through national founds and, where applicable, co-financed by the FEDER, within the PT2020 Partnership Agreement. Rafaela Lopes also acknowledges FCT/MCT for the PhD grant reference UI/BD/151276/2021 and Ana P. Matins for the PhD grant reference SFRH/BD/146369/2019.

References

1. M. Wang, X. Chen, Y. Zou, H. Chen, S. Xue, C. Qian, P. Wang, X. Xu and G. Zhou, *Int J Food Sci Technol*, 2017, 52, 724–732.
2. G. H. Zhou, X. L. Xu and Y. Liu, *Meat Sci*, 2010, 86, 119–128.
3. Á. T. Lemos, A. P. Martins, I. Delgadillo and J. A. Saraiva, *Food Microbiol*, 2022, 105, 104031.
4. P. B. Pathare, U. L. Opara and F. A.-J. Al-Said, *Food Bioproc Tech*, 2013, 6, 36–60.
5. H. J. Ma and D. A. Ledward, *Meat Sci*, 2004, 68, 347–355.

P224

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Technological transposition and scale-up of a method for the recovery of rare earth elements using the macroalgae *Ulva sp.*

Daniel Barros*, Ana Francisca Santos, Daniela S. Tavares, Thainara Viana, João Pinto, Eduarda Pereira, Bruno Henriques

LAQV-REQUIMTE, Departamento de Química, Universidade de Aveiro, 3810-193 Aveiro, Portugal
**barrosdaniel@ua.pt*

In recent years modern societies have seen big technological leaps, which is in part due to increasing use of Rare Earth Elements (REE) [1]. Despite being widely used in supposedly "green alternatives" to typical pollution sources (electric cars, wind turbines, etc.), REE have significant detrimental environmental impacts mainly in the mining process of REE containing ores [2]. Given this negative environmental impact and the criticality of these elements, it becomes clear that alternatives to the production of REE from primary sources are needed [3]. Fluorescent Lamp (FL) waste has been one of the main focuses in terms of REE recovery from secondary sources mainly due to its high availability as well as the large amounts of REE present in this type of waste[4,5]. The usage of living macroalgae to recover REE from aqueous solutions has shown great promise and studies using the macroalgae *Ulva sp* have already successfully recovered REE from FL Waste extracts [2].
The present work evaluated the scalability potential of a methodology where REE are extracted from FL waste using a two-step acid leaching process and, after dilution, the macroalgae *Ulva sp* was used to pre-concentrate REE from the extract. For this purpose, experiments were conducted in tanks with a volume of 20 L and 4 different system configurations were tested. Results showed that a system where the diluted extract is maintained and macroalgae are periodically removed and replaced by a fresh batch, allows for maximum REE recovery from the extract, recovering 48.5 % of Y and 34.3 % of Eu. Additionally, it was found that a system with a continuous flow of extract allows for the maximization of the REE concentration in the macroalgae biomass, achieving a concentration of 12.4 mg/g of Y and 0.71 mg/g of Eu. Considering that the system with periodic macroalgae renewal was the most adequate for an industrial application, experiments in tanks with a volume of 100 L were also performed. The results showed that REE recovery still occurred at this scale in the same order of magnitude as the 20 L volume experiments, which confirms the scalability of this promising methodology.

Figure 1: Scale-up experiment with a volume a 20 L

Acknowledgements
This work was supported by the project Nº46998_N9ve-REE, co-funded by Portugal 2020) program (PT2020), PO Centro and European Regional Development Fund. Bruno Henriques acknowledges FCT for the research contract (ref. CEECIND/03511/2018), while João Pinto and Thainara Viana acknowledge their PhD grant (2020.05323.BD and ref. 2022.13015.BD, respectively).

References
1. C. E. D. Cardoso, J. C. Almeida, C. B. Lopes, T. Trindade, C. Vale and E. Pereira, *Nanomaterials*, 2019, **9**, 814.
2. J. Pinto, J. Colónia, T. Viana, N. Ferreira, D. Tavares, J. Jacinto, A. Abdolvasei, F. LS. Monteiro, B. Henriques and E. Pereira, *J Clean Prod*, 2022, **369**, 133299.
3. Q. Tan, J. Li and X. Zeng, *Crit Rev Environ Sci Technol*, 2015, **45**, 749–776.
4. N. Dhawan and H. Tanvar, *Sustainable Materials and Technologies*, 2022, **32**, e00401.
5. C. Tunsu, C. Ekberg and T. Retegan, *Hydrometallurgy*, 2014, **144–145**, 91–98.

Exploring the synergistic relationship between sugar-based cationic surfactants and commercially accessible eco-friendly surfactants.

Carolina F. Jesus[1,*], Andreia A. S. Alves[2], Filipe E. Antunes[1,2]

[1]*Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal*
[2]*Science351, Instituto Pedro Nunes, Rua Pedro Nunes C, 3030-199 Coimbra, Portugal*
**carolinaajesus@gmail.com*

In recent years, the blending of cationic sugar-based surfactants with other classes of natural surfactants has emerged as a promising area of research with strong implications for surfactant science. The combination of these surfactant classes offers a unique opportunity to harness synergistic effects, leading to enhanced performance and expanded capabilities in formulation design. By blending cationic sugar-based surfactants with other natural surfactant classes, such as nonionic, anionic, or zwitterionic surfactants, researchers aim to unlock novel surfactant systems with superior properties and functionalities.[1] The interaction between different surfactant classes can result in improved surface activity, solubilization capacity, stability, and foamability, among other desirable traits. This synergistic effect arises from the complementary nature of the surfactant molecules, which can lead to optimized packing at interfaces and enhanced interfacial tension reduction.[2] Moreover, the use of natural-based surfactants in these mixed systems addresses the growing demand for environmentally friendly alternatives to synthetic surfactants. Renewable resources-based surfactants exhibit inherent biodegradability, low toxicity, and reduced ecological impact. By incorporating these surfactants into blended systems, the overall environmental footprint of surfactant-based formulations can be significantly reduced, contributing to sustainable practices.[3]

The findings obtained from studying mixed surfactant systems contribute to the advancement of surfactant science and have far-reaching implications across diverse industries. These blended systems offer new avenues for innovation and the development of sustainable solutions in areas such as personal care products, household cleaners, agricultural formulations, and pharmaceutical formulations. By harnessing the potential of mixed surfactant systems, researchers and industries can create formulations with improved performance, reduced environmental impact, and enhanced functionality, ultimately driving the transition towards a more sustainable and eco-conscious future.[4]

The investigation of mixed surfactant systems composed of new sugar-based cationic surfactants and other natural surfactant classes like nonionic (tween 80), anionic (sodium cocoyl glutamate) and zwitterionic (cocamidopropyl betaine) surfactants encompasses various characterization techniques, including measurements of critical micelle concentration, aggregate size, zeta potential, and pH, that provide valuable insights into the behavior and performance of the hybrid systems. In all mixtures was observed a synergistic behavior like lower CMC and smaller aggregates in the case of mixtures of cationic-nonionic and cationic-zwitterionic surfactants and the possibility of the presence of catanionic vesicles in a hybrid mixture of cationic-anionic surfactants.

Acknowledgements
Thanks are due to Coimbra Chemistry Centre (CQC-IMS), supported by the Portuguese Agency for Scientific Research and PT2020 – Sistema de Incentivos à Investigação e Desenvolvimento Tecnológico (SI I&DT), AVISO 13/SI/2020.

References

1. H. Hoffmann and G. Pössnecker, *Langmuir*, 1994, **10**, 381-389.
2. M. J. Rosen, Z. H. Zhu and T. Gao, *Journal of colloid and interface science*, 1993, **157**, 254-259.
3. C. C. Ruiz, *Sugar-based surfactants: fundamentals and applications*, CRC Press, 2008.
4. K. P. Sekhar, V. Solanki, D. Patel, S. A. Holey and R. R. Nayak, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 2020, **601**, 125008.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis and activation studies of light-controllable PROteolysis-TArgeting Chimeras (PROTACs)

A. Voloshchuk[1], M. Serafini[2], R. Moreira[2]

[1]*Faculdade de Farmácia da Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisboa, Portugal;*
[2]*Research Institute for Medicines (iMed.ULisboa), Faculdade de Farmácia da Universidade de Lisboa, Av. Prof. Gama Pinto, 1649-003 Lisboa, Portugal*
avoloshchuk@edu.lisboa.pt

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by motor (ex. slowness, tremors, balance and coordination difficulties) and nonmotor symptoms (ex. cognitive decline, depression, and dementia) that which severely compromise an individual's quality of life. Despite its initial description nearly 200 years ago, PD cure remains elusive, and current treatments only provide symptomatic relief. As a rapidly growing neurological disease, ongoing research has identified the LRRK2 gene mutation as a significant contributor to PD progression since the increased activity of LRRK2 leads to neuronal cell death, protein aggregate phosphorylation, and disrupted dopamine regulation. To address the limitations of existing LRRK2 inhibitors, which can inadvertently alter LRRK2 behaviour and cause adverse effects on the kidneys and lungs (1), targeted protein degradation using PROTACs has emerged as a promising therapeutic approach. These synthetic molecules leverage the cellular Ubiquitin-Proteasome degradation system, connecting, through a linker, the target protein and an E3 ligase enzyme to label it for degradation (2). In previous research, Liu et al. (1) developed a PROTAC to efficiently and selectively degrade the LRRK2 kinase using the VHL E3 enzyme with good oral bioavailability and blood-brain barrier permeability in mice (1). However, like other PROTACs, cytotoxicity may arise from the uncontrollable degrading the target and impairing its function in any accessible cell (3). This project envisions further structural optimization of this VHL-based PROTAC, along with a new CRBN-based PROTAC, to minimize its on-target toxicity. To achieve its precise distribution within the body, photocaging, a photopharmacological approach, will be employed. By incorporating a photocleavable cage group on the E3 moiety, the formation of the PROTAC's active complex will be blocked. Once it is irradiated with a specific wavelength of light (3), at a chosen moment and location, however, the cage group will be cleaved, allowing the release of the bioactive molecule to degrade LRRK2. This research aims to address the selectivity issues encountered in conventional LRRK2 inhibitors by optimizing the spatial and temporal distribution of two LRRK2-targeting PROTAC-based therapies. By complementing the reported pharmacokinetic properties of these models, this will allow a selective and efficient mitigation of the pathological effects of the LRRK2 mutation in PD.

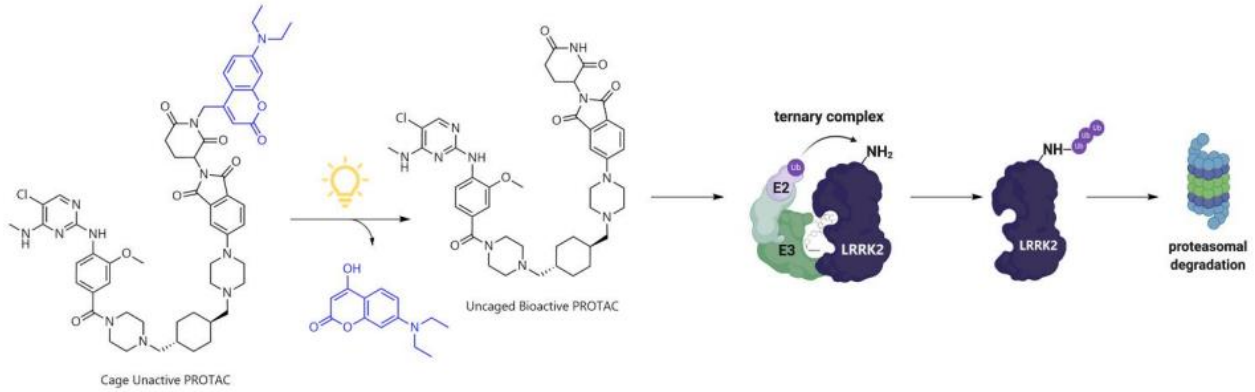


Figure 1: Mechanism of photo-dependent PROTAC uncaging; Since the CRBN-based PhotoPROTAC is caged at the E3 ligase recruiting moiety, the protein of interest is not degraded via the UPS. Once it is irradiated with light of a specific wavelength, the coumarin photocage is cleave releasing the bioactive PROTAC to induce UPS-dependent target proteolysis

References

1. Liu X, Kalogeropulou AF, Domingos S, Makukhin N, Nirujogi RS, Singh F, et al. Discovery of XL01126: A Potent, Fast, Cooperative, Selective, Orally Bioavailable, and Blood-Brain Barrier Penetrant PROTAC Degrader of Leucine-Rich Repeat Kinase 2. J Am Chem Soc [Internet]. 2022 Sep 21 [cited 2023 Jun 6];144(37):16930–52. Available from: https://pubs.acs.org/doi/full/10.1021/jacs.2c05499
2. Békés M, Langley DR, Crews CM. PROTAC targeted protein degraders: the past is prologue. Nat Rev Drug Discov [Internet]. 2022 Mar 18;21(3):181–200. Available from: https://www.nature.com/articles/s41573-021-00371-6
3. Salerno A, Seghetti F, Caciolla J, Uliassi E, Testi E, Guardigni M, et al. Enriching Proteolysis Targeting Chimeras with a Second Modality: When Two Are Better Than One. J Med Chem. 2022 Jul 28;65(14):9507–30.

Design and synthesis of a novel class of thiazole-based necroptosis inhibitors

Inês L. Roque*, Lara Fidalgo, Ana S. Ressurreição

iMed.ULisboa, Faculdade de Farmácia, Universidade de Lisboa, Av. Professor Gama Pinto, 1649-003 Lisboa, Portugal.
**miroque@edu.ulisboa.pt*

Necroptosis is a programmed necrosis cell death that is dependent on the kinase activity of RIPK1 and its downstream mediators RIPK3 and MLKL. Not only necroptosis is regulated by a variety of genes and has a specific death signaling pathway (like apoptosis) but also has the same morphological features as necrosis including the release of damage-associated molecular patterns (DAMPs). DAMPs will provoke a strong pro-inflammatory immune response which eventually will create a fatal systemic hyperinflammation associated with a wide range of human diseases[1,2]. The majority of RIPK1 inhibitors show limited bioavailability, absence of inter-species cross-activity, poor specificity, and off-target effects. Therefore, new chemotypes with improved modes of action are urgently needed to target RIPK1[3].
A phenotypic high-throughput screen of over 250,000 small molecules identified 356 compounds that inhibited necroptosis[4] across multiple pharmacophores, including a family of 2,5-disubstituted 1,3-thiazole-based compounds, with promising anti-necroptotic activity. Based on the initial structure-activity relationships (SAR) studies we have design a new library of analogues containing electron-donating groups (EDGs) and increased sp^3 character (**Figure 1)**. Here we report a successful and optimized synthesis of more than 20 new analogues based on the 2,5-disubstituted thiazole scaffold and will discuss the impact that these structural modifications have in RIPK1's inhibition.

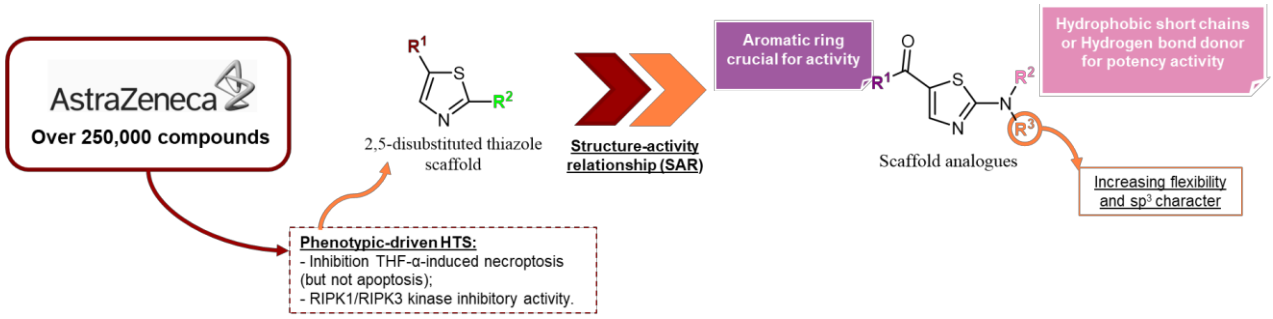


Figure 1: General strategy for obtaining 2,5-disubstituted thiazole analogues with EDG substituents.

Acknowledgements
This research was funded by projects UIDB/04138/2020 and UIDP/04138/2020 (Fundação para a Ciência e Tecnologia (FCT), Portugal). We thank the Fundação para a Ciência e a Tecnologia for financial support through the PhD fellowship grant PD/BD/143157/2019 awarded to Lara Fidalgo.

References
1. J. Seo, Y. W. Nam, S. Kim, D.-B. Oh and J. Song, Necroptosis molecular mechanisms: Recent findings regarding novel necroptosis regulators, *Exp Mol Med*, 2021, **53**, 1007–1017.
2. E. H. Kim, S.-W. Wong and J. Martinez, Programmed Necrosis and Disease:We interrupt your regular programming to bring you necroinflammation, *Cell Death Differ*, 2019, **26**, 25–40.
3. A. Degterev, D. Ofengeim and J. Yuan, Targeting RIPK1 for the treatment of human diseases, *Proc. Natl. Acad. Sci. U.S.A.*, 2019, **116**, 9714–9722.
4. H. Brito, V. Marques, M. B. Afonso, D. G. Brown, U. Börjesson, N. Selmi, D. M. Smith, I. O. Roberts, M. Fitzek, N. Aniceto, R. C. Guedes, R. Moreira and C. M. P. Rodrigues, Phenotypic high-throughput screening platform identifies novel chemotypes for necroptosis inhibition, *Cell Death Discov.*, 2020, **6**, 6.

P228

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

MALDI-TOF mass spectrometry of molecules, cells and tissues: applications for agricultural and food chemistry

Newton Valério Verbisck

EMBRAPA, Brasil
newton.verbisck@embrapa.br

Introduction: MALDI-TOF (Matrix Assisted Laser Desorption Ionization-Time-Of-Flight) mass spectrometry is an analytical methodology for mass based molecular identification, characterized by very high sensitivity, resolution and accuracy, high throughput, ease of execution and relative low cost. Currently, MALDI-TOF methodologies have been used in the laboratory routine worldwide for the identification and molecular characterization of bacterial and fungal species, in a fast and reliable way. More recently, the practical potential of using MALDI-TOF has been demonstrated for biotyping plants and animals, including mammals, as well as processed foods, such as meat, based on analysis of protein mass profiles. Here we show our recent achievements of high resolving power MALDI-TOF analysis of either single molecules or complex samples such as cells and tissues with utility for the field of agriculture and food chemistry.
Methods: Different chromatographic separation methods were used to purify recombinant proteins from *Mycobacterium bovis*, seed plant inhibitors and enzymes from fungus and snake venom. Bacterial isolation from bovine tissue and lesions followed microbiological standard methods. Protein extraction methods and reference spectra libraries were improved for development of accurate identification of pathogens such as *Salmonella*, *Mycobacterium tuberculosis*, *Mycobacterium bovis*, *Brucella abortus* and *Staphylococcus* spp. Bovine meat profiling is an ongoing project (grant number FUNDECT 322/2022). Mass spectra were acquired on an Autoflex III Smartbeam (Bruker Daltonics). Microbial profiling and biotyping were carried out with MALDI Biotyper software (Bruker Daltonics).
Results: MALDI-TOF analysis improved molecular characterization of: i) *Mycobacterium bovis* recombinant proteins used for an immunoenzimatic method for bovine tuberculosis diagnosis;[1] ii) plant seed Kunitz type inhibitors with activity against a pest insect[2] and *Candida* spp. Fungi;[3] iii) an *Aspergillus* xylanase for fruit peel and juice processing;[4] and iv) a snake venom phospholipase with *Acinetobacter baumannii* antibiofilm activity.[5] Bovine carcass isolates were biochemically tested for *Salmonella* and species were identified by MALDI-TOF with gains in speed of identification analysis.[6] Microbial protein profiling with MALDI-TOF enabled for accurate identification of *Mycobacterium bovis* bovine clinical isolates.[7] Also, an enhanced method for cell disruption and protein extraction of *Mycobacterium tuberculosis* was described.[8] *Brucella* spp. mass spectra profiles were generated as reference and enabled distinction of vaccinal and wild-type strains of *Brucella abortus*. Additionally, MALDI-TOF allowed identification of antimicrobial resistant *Staphylococcus* spp.[9]
Conclusions: MALDI-TOF methodology significantly contributed to the biochemical characterization of diverse molecules with utility in agricultural and food chemistry field. Novel aspects of our results were regarded to zoonotic pathogens, with distinction of Mycobacterium Tuberculosis Complex members and detection of *Brucella* vaccinal strains.

References

1. Melo, E.S.P., Souza, I.I.F., Ramos, C.A.N., Osório, A.L.A.R., Verbisck, N.V., Araújo, F.R. (2015) Archivos de Medicina Veterinaria, 47 (3), pp. 273-280. DOI: 10.4067/S0301-732X2015000300003
2. Ramalho, S.R., Bezerra, C.D.S., Lourenço De Oliveira, D.G., Souza Lima, L., Maria Neto, S., Ramalho De Oliveira, C.F.,Valério Verbisck, N., Rodrigues Macedo, M.L. (2018) Journal of Agricultural and Food Chemistry, 66 (6), pp. 1349-1358. DOI: 10.1021/acs.jafc.7b04159 PubMed ID: 29239611
3. Dib, H.X., de Oliveira, D.G.L., de Oliveira, C.F.R., Taveira, G.B., de Oliveira Mello, E., Verbisk, N.V., Chang, M.R., Corrêa Junior, D., Gomes, V.M., Macedo, M.L.R. (2019) Archives of Microbiology, 201 (2), pp. 223-233. DOI: 10.1007/s00203-018-1598-8 PubMed ID: 30483842
4. da Silva, P.O., de Alencar Guimarães, N.C., Serpa, J.D.M., Masui, D.C., Marchetti, C.R., Verbisck, N.V., Zanoelo, F.F., Ruller, R., Giannesi, G.C. (2019) Biocatalysis and Agricultural Biotechnology, 21, 101312. DOI: 10.1016/j.bcab.2019.101312
5. Nunes, E., Frihling, B., Barros, E., de Oliveira, C., Verbisck, N., Flores, T., de Freitas, A., Jr., Franco, O., de Macedo, M.,Migliolo, L., Luna, K. (2020) Toxins, 12 (9), 606. DOI: 10.3390/toxins12090606 PubMed ID: 32962193
6. Bier, D., Tutija, J.F., Pasquatti, T.N., Oliveira, T.L., Araújo, F.R., Verbisck, N.V. (2017) Pesquisa Veterinaria Brasileira, 37 (12), pp. 1373-1379. DOI: 10.1590/S0100-736X2017001200003
7. Bacanelli, G., Olarte, L.C., Silva, M.R., Rodrigues, R.A., Carneiro, P.A.M., Kaneene, J.B., Pasquatti, T.N., Takatani, H.,Zumárraga, M.J., Etges, R.N., Araújo, F.R., Verbisck, N.V. (2019) Journal of Veterinary Medical Science, 81 (10), pp. 1400-1408. DOI: 10.1292/jvms.19-0214 PubMed ID: 31462609
8. Bacanelli, G., Araujo, F.R., Verbisck, N.V. (2023) Microorganisms, 11 (7), 1692. DOI: 10.3390/microorganisms11071692
9. Silva, V., Caniça, M., Manageiro, V., Verbisck, N., Tejedor-Junco, M.T., González-Martin, M., Corbera, J.A., Poeta, P.,Igrejas, G (2022) Animals, 12 (10), 1255. DOI: 10.3390/ani12101255 PubMed ID: 35625101

Wet peroxide oxidation of paracetamol from real wastewaters using multi-core shell magnetic nanoparticles as catalyst

Adriano S. Silva,[1,2,*] Fernanda F. Roman,[1,2] Arnaldo V. Dias,[3] Jose L. Diaz de Tuesta,[4] Ana Paula F. da Silva,[1] Ana M. Ferrari Lima,[3] Adrián M. T. Silva,[2] Joaquim L. Faria,[2] Helder T. Gomes[1]

[1]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança (IPB), Bragança, Portugal and Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), IPB, Bragança, Portugal; [2]LSRE-LCM – Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Porto, Portugal and ALiCE – Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Porto, Portugal; [3]Universidade Tecnológica Federal do Paraná, Campus Apucarama, Apucarana, Brasil; [4]Department of Chemical and Environmental Technology, ESCET, Rey Juan Carlos University, Spain;
**adriano.santossilva@ipb.pt*

Increasing consumption of pharmaceutical compounds by humans and animals has led to alarming amounts of these compounds in water bodies. Among pharmaceuticals, paracetamol (PCM) has been recently identified in quantities ranging from 0.1 to 300 mg L^{-1} in effluents worldwide.[1] The conventional treatments used in wastewater treatment plants are inefficient for removing PCM from wastewater. On the other hand, advanced oxidation processes, such as catalytic wet peroxide oxidation (CWPO), have demonstrated to be a promising application to degrade organic micropollutants from simulated aqueous matrixes.[2] However, the use of simulated matrixes should be surpassed to evaluate the feasibility of CWPO to treat real wastewaters. In this work, a well-known active catalyst prepared in our research group (multi-core shell magnetic nanoparticles,[3]) were applied for the degradation of PCM from real matrices by CWPO. The catalyst was prepared in sequential steps: (i) synthesis of the magnetic core (cobalt ferrite), (ii) resin coating, (iii) carbonization, and (iv) etching.[3] The matrices used to evaluate the catalyst performance for PCM degradation by CWPO were bottled water, river water, and hospital wastewater, and ultrapure water (UPW) was considered for comparison. The reactions were carried out with [PCM] = 100 µg mL^{-1}, 80 °C, [Catalyst] = 2.5 g L^{-1}, pH 3.5 adjusted using H_2SO_4 (0.5 M), and [H_2O_2] = 474 µg mL^{-1}. Non-catalytic (N.C.) runs were performed under the same operating conditions to compare each other. The results obtained for H_2O_2 and PCM concentration profiles upon reaction time are shown in Figure 1. PCM was completely removed from all matrices after 6 h of reaction. The fastest removal was observed using river water matrix, since complete removal was observed after 2 h. Furthermore, catalytic runs overcame the N.C. for PCM removal by at least 50% at the end of the reaction run. The effect of the real matrix can be observed by comparing the catalyst's performance in the run performed using UPW as a matrix, for which PCM removal and H_2O_2 are faster in the first 2 h. The slower removal observed for all matrices is related to chlorides in real matrices (121.42, 17.72, and 8.86 mg L^{-1} for hospital wastewater, bottle, and river water), acting as radical scavengers during H_2O_2 decomposition and hindering the PCM removal. Nonetheless, the results shown here demonstrate the potential application in real scenarios for degrading organic pollutants by CWPO using carbon-coated magnetic nanoparticles as catalysts.

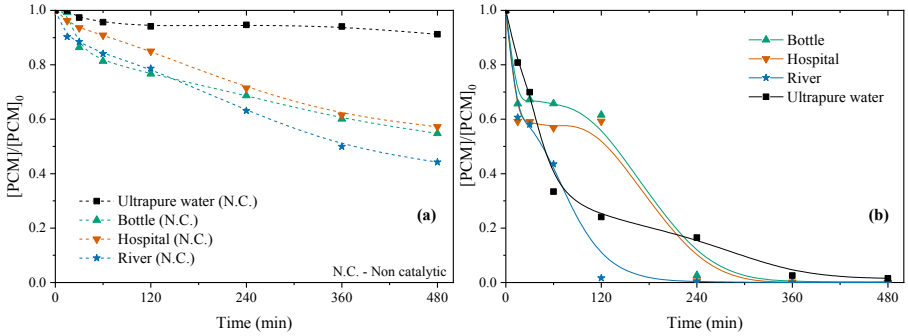


Figure 1: Results for (a) PCM degradation and (b) H_2O_2 decomposition (lines are only used to guide the eyes).

Acknowledgements
This work was financially supported by project RTChip4Theranostics (NORTE-01-0145-FEDER-029394), by CIMO (UIDB/00690/2020) through FEDER under Program PT2020. Adriano S. Silva and Ana Paula F. da Silva were supported by the doctoral Grant SFRH/BD/151346/2021 and PRT/BD/153090/2021 financed by the Portuguese Foundation for Science and Technology (FCT) with funds from NORTE2020, under MIT Portugal Program. Fernanda F. Roman acknowledges the Foundation for Science and Technology (FCT) and the European Social Fund (FSE) for the individual research grant with reference SFRH/BD/143224/2019. Jose L. Diaz De Tuesta acknowledges the financial support through the program of *Atracción al Talento* of *Comunidad de Madrid* (Spain) for the individual research grant 2022-T1/AMB-23946.

References

1. M. Pacheco-Álvarez *et al. Chemosphere*, vol. 303, no. March, 2022, doi: 10.1016/j.chemosphere.2022.134883.
2. A. S. Silva *et al. Catalysts*, vol. 9, p. 705, 2019, doi: 10.3390/catal9090705.
3. N. M. C. Guari *et al. GlobalNest,* 2022, doi: https://doi.org/10.30955/gnj.004309.

XXVIII ENCONTRO NACIONAL DA SPQ
24-26 . JULHO . 2023 AVEIRO

Synthesis, physicochemical characterization, and biological evaluation of novel flavonoid chemotherapeutic metallodrugs

Ariana C. F. Santos[1,2,*], Francisca Carmo[2,3], Nelson Andrade[2,3,4], Ricardo F. Mendes[1], Filipe A. Almeida Paz[1], João Rocha[1], Fátima Martel[2,3], Carmen S. R. Freire[1], Bárbara J. M. L. Ferreira[1]

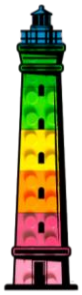
[1]*CICECO-Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[2]*Biochemistry Unit, Biomedicine Department, Faculty of Medicine, University of Porto, 4200-319 Porto, Portugal*
[3]*I3S-Institute of Research and Innovation in Health, University of Porto, 4200-135 Porto, Portugal*
[4]*REQUIMTE/LAQV, Department of Chemical Sciences, Faculty of Pharmacy, University of Porto, 4050-313 Porto, Portugal*
**arianasantos@ua.pt*

Chemotherapeutic metal-based compounds, or metallodrugs, can exhibit potent anticancer properties. However, many of these compounds, such as the well-known cisplatin, may have notable side effects, such as high cytotoxicity or lack of selectivity.[1] Natural products like flavonoids are a valuable source of anticancer agents. Flavonoids can influence the activity of reactive oxygen species (ROS)-scavenging enzymes, play a role in cell cycle arrest, induce apoptosis and autophagy, or suppress cancer cell proliferation and invasiveness.[2] Nevertheless, flavonoids have also some limitations, including poor bioavailability, rapid metabolic breakdown, and low absorption rates.[3] Considering these challenges, the development of new metallodrugs incorporating flavonoids represents a promising alternative for designing novel anticancer agents, not only with improved bioavailability (enhancing their solubility, dissolution rate and permeability[4]), but also with reduced general cytotoxicity, enhanced efficacy, and greater selectivity.[5] Various copper and zinc complexes with different flavonoids, namely chrysin, quercetin, and morin, in combination with N-donor ligands (1,10-phenanthroline and 2,2'-bipyridine), were synthesized using solvothermal synthesis methods, which have been relatively underexplored. The obtained compounds were fully characterized by powder and single crystal X-ray diffraction, Fourier-transform infrared spectroscopy (FTIR)/FT-Raman spectroscopy, elemental analysis, ultraviolet-visible (UV-Vis) spectroscopy, and thermogravimetric analysis. Furthermore, the biological evaluation of these metallodrugs against both malignant and nonmalignant human cell lines, such as CACO-2, MCF-7, AsPC-1, and dermal normal fibroblast (HDFn), has already been initiated. This evaluation aims to assess their cytotoxicity, selectivity, and identify the most promising candidates for future incorporation into biopolymeric nanosystems.

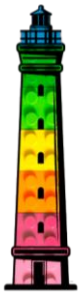
Acknowledgements
This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MEC (PIDDAC). The position held by B.J.M.L.F. was funded by national funds (OE), through FCT—Fundação para a Ciência e a Tecnologia, I.P., in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of Article 23, of the Decree-Law 57/2016, of 29 August, changed by Law 57/2017 of 19 July. FCT is also acknowledged for the PhD grant of A.C.F.S. (2021.08157.BD) and the research contract under Scientific Employment Stimulus of C.S.R.F. (CEECIND/00464/2017). The technical assistance of Dr. Ilda Rodrigues is acknowledged.

References

1. E. Halevas, B. Mavroidi, O. Antonoglou, A. Hatzidimitriou, M. Sagnou, A. A. Pantazaki, G. Litsardakis and M. Pelecanou, *Dalt. Trans.*, 2020, **49**, 2734–2746.
2. D. M. Kopustinskiene, V. Jakstas, A. Savickas and J. Bernatoniene, *Nutrients*, 2020, **12**, 1–25.
3. S. H. Thilakarathna and H. P. Vasantha Rupasinghe, *Nutrients*, 2013, **5**, 3367–3387.
4. J. Zhao, J. Yang and Y. Xie, *Int. J. Pharm.*, 2019, **570**, 118642.
5. V. Uivarosi and A. Munteanu, *Flavonoids - From Biosynth. to Hum. Heal.* 2017, Justino, G.C., Ed.; *IntechOpen:* Rijeka.



Author Index



List of Participants

Nome	Email	Institution
A. Jorge Parola	ajp@fct.unl.pt	Universidade NOVA de Lisboa
Adrian Pastor Espejo	q92paesa@uco.es	Universidad de Córdoba
Adriana Cabrita Sousa Pais	a.c.p.s@ua.pt	University of Aveiro
Adriana Catarina da Costa Gomes	adrianagomes@ua.pt	Universidade de Aveiro
Adriana Katherine Molina Vargas	amolina@ipb.pt	Universidad de Vigo
Alberto Credi	alberto.credi@unibo.it	Alma Mater Studiorum - Università di Bologna
Alberto Trevisan	a.trevisan@fct.unl.pt	Universidade NOVA de Lisboa
Alexander Kirillov	kirillov@tecnico.ulisboa.pt	IST-ULisboa
Alexandra Isabel da Silva Borges	alexandraborgespnf@gmail.com	Universidade do Porto
Alexandra Maria Moita Antunes	alexandra.antunes@tecnico.ulisboa.pt	Instituto Superior Técnico
Alexandra Miguel Morgado Varges	alexandra.varges@ubi.pt	Universidade da Beira Interior
Alexandre Costa Patrocínio Macedo Alves	up201503618@up.pt	Faculdade de Ciências da Universidade do Porto
Alexandre Costa Patrocínio Macedo Alves	up201503618@edu.fc.up.pt	Faculdade de Ciências da Universidade do Porto
Alexandre Miguel Alves Fonseca	alexandrefonseca@ua.pt	Universidade de Aveiro
Alexandre Pires Felgueiras	alexandrefel42@gmail.com	Universidade de Coimbra
Alexis Pereira	pereiraalexis10@gmail.com	Instituto Politécnico de Bragança
Alfredo Bartolomeu	abartolomeu1@gmail.com	Universidade de Coimbra
Ana Barros	abarros@utad.pt	University of Trás-os-Montes e Alto Douro
Ana C. S. Veríssimo	carolinaana@ua.pt	Departamento de Química da Universidade de Aveiro
Ana Carolina da Silva Martins Pinto	anacarolinapinto@ua.pt	Universidade de Aveiro
Ana Carolina Freitas de Jesus	carolinaajesus@gmail.com	Universidade de Coimbra
Ana Catarina Almeida Santos	ac.almeida@ua.pt	University of Aveiro
Ana Catarina Costa Gomes Alves	agomes1@ua.pt	Universidade de Aveiro
Ana Cláudia Ribeiro Negrão	ac.negrao@campus.fct.unl.pt	NOVA SST
Ana Cristina da Silva Fernandes	anacristinafernandes@tecnico.ulisboa.pt	Universidade de LIsboa, Instituto Superior Técnico
Ana Cristina Quintans da Silva	ana.cristina.silva@ua.pt	University of Aveiro
Ana Daniela Coutinho Alves	anadaniela92@hotmail.com	Faculdade de Farmácia Universidade do Porto
Ana Francisca Duarte dos Santos	francisca.santos@ua.pt	Universidade de Aveiro
Ana Gomes	agomes@fc.up.pt	Universidade do Porto
Ana Isabel Bastos Valente	anaivalente@ua.pt	Aveiro Institute of Materials
Ana Margarida Duarte Pereira	anaduarte19@outlook.pt	CIIMAR
Ana Margarida Gomes da Silva	ana.silva@fc.up.pt	Universidade do Porto
Ana Margarida Gomes Moreira Alves	anamargaridaalves00@gmail.com	Instituto Superior Técnico
Ana Margarida Nóbrega Santos	anamargaridasantos207@gmail.com	Universidade do Minho
Ana Maria Simões da Costa	anamariacosta@ua.pt	Universidade de Aveiro
Ana Patrícia Corunha Lei Barreiros Ramalho	up201605715@ff.up.pt	FFUP
Ana Patrícia Lopes Martins	ana.patricia.martins@ua.pt	Universidade de Aveiro
Ana Paula Mora Tavares	aptavares@ua.pt	University of Aveiro
Ana Paula Pereira Lourenço	prof.applourenco@gmail.com	Escola Básica Secundária de Alvide
Ana Paula Pereira Paiva	appaiva@ciencias.ulisboa.pt	Faculdade de Ciências, Universidade de Lisboa

Ana Rafaela Barroso Lopes	lrafaelaa9@gmail.com	University de Aveiro
Ana Rita Sousa Circuncisão	anarcircuncisao@ua.pt	Universidade de Aveiro
Ana Sofia Correia Marques	anascm10@ua.pt	Universidade de Aveiro
Ana Sofia dos Santos Pires	sofia_pires97@hotmail.com	FCUP
Ana Sofia Madureira Bruno	sbruno@ua.pt	Universidade de Aveiro
Ana Teresa Teixeira da Silva	up201303026@edu.fc.up.pt	Faculdade de Ciências da Universidade do Porto
Anabela A. Valente	atav@ua.pt	Universidade de Aveiro, Departamento de Química, CICECO
Anastasiya Voloshchuk	avoloshchuk@edu.lisboa.pt	Faculdade de Farmácia da Universidade de Lisboa
André Carvalho de Oliveira	andreoliveira98@ua.pt	Universidade de Aveiro
André Alexandre Lopes Silva	aal.silva@campus.fct.unl.pt	NOVA FCT
André M. N. Silva	andre.silva@fc.up.pt	Universidade do Porto
André Manuel Gomes Lopes	pg33722@alunos.uminho.pt	Universidade do Minho
André Miguel da Costa Lopes	andremcl@ua.pt	Universidade de Aveiro
André Miguel Lopes Seco	am.seco@campus.fct.unl.pt	FCT-NOVA
Andreia F. Sousa	andreiafs@ua.pt	University of Aveiro
Andreia Gonzalez	andreacsgonzalez@gmail.com	Universidade de Coimbra
Andreia Sofia Filipe Farinha	andreia.farinha@kaust.edu.sa	KAUST
António José Estêvão Grande Candeias	candeias@uevora.pt	Universidade de Évora
Anupong Nuekaew	anupong.nue@gmail.com	Universidade do Porto
Ariana Coelho Ferreira dos Santos	aricfsantos97@gmail.com	University of Aveiro
Armando J. L. Pombeiro	pombeiro@tecnico.ulisboa.pt	Instituto Superior Tecnico
Armando Silvestre	armsil@ua.pt	Universidade de Aveiro
Artem Petrosian	artem.petrosian@tecnico.ulisboa.pt	Centro Qumica Estrutural
Artur Filipe Moreno Farinha	up201506214@fc.up.pt	Faculdade de Ciências da Universidade do Porto
Artur Jorge Carneiro Moro	ajm12769@fct.unl.pt	FCT-NOVA
Artur M. S. Silva	artur.silva@ua.pt	Universidade de Aveiro
Augusto Quaresma Henriques Pedro	apedro@ua.pt	Universidade de Aveiro
Aurora Sofia de Almeida Figueiredo	aurora.figueiredo@ua.pt	Universidade de Aveiro
Baltazar Manuel Romão de Castro	bcastro@fc.up.pt	Universidade do Porto
Bárbara Joana Martins Leite Ferreira	barbaraferreira@ua.pt	Departamento de Química da Universidade de Aveiro
Beatriz Martins Bandeira Pinto de Sousa	beatrizpintosousa@ua.pt	Universidade de Aveiro
Beatriz Roberto Madeira Almeida Raimundo	b.raimundo@campus.fct.unl.pt	FCT NOVA
Bernardo Loureiro Tavares	bernardo.tavares@ua.pt	University of Aveiro
Bruna Eliana Lima Nazaré Duarte	brunaeliduarte@hotmail.com	Universidade de Coimbra
Bruna Patrícia Carvalho Leite	brunacarvalh999@gmail.com	Universidade do Minho
Bruno Daniel André Pinheiro	bruno.pinheiro44@gmail.com	Universidade do Porto (CIQUP)
Bruno Filipe Andrade Gomes	bruno-gomes@edu.ulisboa.pt	Universidade de Lisboa
Carla Cruz	carlacruz@fcsaude.ubi.pt	UBI
Carla Isabel Madeira dos Santos	carla.santos@tecnico.ulisboa.pt	Instituto Superior Técnico
Carla Maria Duarte Nunes	cmnunes@fc.ul.pt	FCUL
Carla Sofia Pinheiro Vitorino	csvitorino@ff.uc.pt	Faculty of Pharmacy, University of Coimbra

Carlos Alberto Cruz Pinto	carlospinto@ua.pt	Departamento de Química, Universidade de Aveiro
Carlos Filipe Pesqueira Miranda	carlospesqueiramiranda@gmail.com	Faculdade de Ciências da Universidade do Porto
Carlos Frederico de Gusmão Campos Geraldes	geraldes@ci.uc.pt	Universidade de Coimbra
Carlos José Rodrigues Crispim Romão	ccr@itqb.unl.pt	ITQB NOVA
Carlos Miguel Calisto Baleizão	carlos.baleizao@tecnico.ulisboa.pt	Centro de Química Estrutural - IST
Carolina Gonçalves	aalmeida@ff.up.pt	Faculdade de Medicina da Universidade do Porto
Carolina Isabel da Silva Gonçalves	carolina.isgoncalves4@gmail.com	Faculdade de Medicina da Universidade do Porto
Catarina Alexandra Aires Henriques	ist1108047@tecnico.ulisboa.pt	Instituto Superior Técnico
Catarina Alexandra Veríssimo Esteves	katvesteves@gmail.com	FCT NOVA
Catarina Esteves da Silva Batista Ferreira	up201804944@fc.up.pt	FCUP
Catarina Guimarães Ribeiro	catarina.gribeiro@ua.pt	University of Aveiro
Catarina Marçal Correia	catarina.m.c@ua.pt	Universidade de Aveiro
Catarina Nogueira Dias	catarinandias3@gmail.com	FCUP
Cátia Isabel Barbosa Sampaio	catia.ibs@hotmail.com	Universidade do Minho
César Augusto Pifre Reis	cesar_reis93@hotmail.com	Instituto Superior Técnico
CHRIS HEBERT DE JESUS FRANCO	chris.franco@tecnico.ulisboa.pt	IST
Christopher M.A. Brett	cbrett@ci.uc.pt	Universidade de Coimbra
Cláudia Filipa Duarte Bento	cdbento@hovione.com	Hovione - Farmaciencia SA
Cláudia Maria Batista Lopes	claudia.b.lopes@ua.pt	Universidade de Aveiro
Cláudia Marisa Barreiros Neves	cmneves@esav.ipv.pt	Instituto Politécnico de Viseu
Cláudia Nunes	claudianunes@ua.pt	Universidade de Aveiro
Cláudia Patrícia Santos Ribeiro	claudia.santos.ribeiro7@gmail.com	Universidade de Aveiro
Cláudia Pereira Passos	cpassos@ua.pt	Universidade de Aveiro
Cláudio M. Gomes	cmgomes@fc.ul.pt	Faculdade de Ciências Universidade de Lisboa
Cláudio Manaia Nunes	cmnunes@qui.uc.pt	Universidade de Coimbra
Clementina M. M. Santos	clems@ipb.pt	IPB
Clementina Maria Cardoso Teixeira da Cunha Pereira	clementina@tecnico.ulisboa.pt	Instituto Superior Técnico
Cristiana Videira Ramos	cristianavramos95@gmail.com	Centro de Química da Universidade de Coimbra
Cristina Maria Grade Couto da Silva Cordas	c.cordas@fct.unl.pt	FCT UNL
Daniel Ascenso Galrito	d.galrito@campus.fct.unl.pt	FCT-NOVA
Daniel Costa Quental de Barrps	barrosdaniel@ua.pt	Univeridade de Aveiro
Daniel José Viegas Antunes dos Santos	daniel.dos.santos@ulusofona.pt	Universidade Lusófona
Daniel Leal Lourenço	daniellourenco98@hotmail.com	Universidade de Lisboa,IST
Daniel Pereira Costa	daniel.pereira.costa@tecnico.ulisboa.pt	IST
Daniela Marisa Pinho Malafaia	danielamalafaia@ua.pt	Universidade de Aveiro
David Elorriaga	elorriagadavid@uniovi.es	Universidad de Oviedo
De Oliveira Vigier	karine.vigier@univ-poitiers.fr	IC2MP University of Poitiers
Débora Sofia Tavares de Sousa	deborasousa99@ua.pt	Universidade de Aveiro
Diana Cláudia Gouveia Alves Pinto	diana@ua.pt	Universidade de Aveiro
Diana Luísa Duarte de Lima	diana.lima@ua.pt	Universidade de Aveiro
Diana Margarida Pereira Gomes	dianamgomes@ua.pt	Universidade de Aveiro

Diana Mónica de Mesquita Sousa Fernandes	diana.fernandes@fc.up.pt	FCUP
Diogo Filipe Pires Marinheiro	diogomarinheiro@ua.pt	Universidade de Aveiro
Diogo Miguel Geraldes Torres	dm.torres@campus.fct.unl.pt	NOVA School of Science and Technology
Dorinda Marques da Silva	dorinda.silva@ipleiria.pt	IPLeiria
Duarte Nuno Caçador Borralho	fc51349@alunos.fc.ul.pt	Faculdade de Ciências da Universidade de Lisboa
Eduarda Manuela Pinho Andrade	eduardaandrade@ua.pt	Universidade de Aveiro
Eduardo Filipe Dionísio Ramos	up201805070@fc.up.pt	FCUP
Eduardo Jorge Morilla Filipe	efilipe@tecnico.ulisboa.pt	Instituto Superior Técnico
Élia Simões Fogeiro	eliafogeiro@ua.pt	Universidade de Aveiro
Enrique Ortí	enrique.orti@uv.es	Instituto de Ciencia Molecular - Universidad de Valencia
Eva Monteiro	eva.monteiro@bruker.com	Bruker Portugal
Fábio André Moura Martins	up201704556@fc.up.pt	Universidade do Porto
Fábio M. F. Santos	fabiosantos1@campus.ul.pt	FFUL
Federico Basso	federico.basso@uniud.it	University of Udine
Fernanda do Carmo Machado Silva	fernandamachado@ua.pt	Universidade de Aveiro
Fernanda Fontana Roman	roman@ipb.pt	Polytechnic Institute of Bragança
Fernando Manuel Gomes Remião	remiao@ff.up.pt	Faculdade de Farmácia da Univ. do Porto
Fernando Pina	fp@fct.unl.pt	DQ-FCT-UNL
Filipa Daniela Freitas Barbosa	barbosa.filipadaniela@gmail.com	Faculty of Pharmacy, Universidade de Lisboa, Portugal
Filipa Viegas Pereira	filipaviegaspereira@ua.pt	Universidade de Aveiro
Filipe Almeida Paz	filipe.paz@ua.pt	Universidade de Aveiro
Filipe Carlos Teixeira Gil	fteixeira@quimica.uminho.pt	University of Minho
Filipe Guilherme de Almeida Estrada	filipe.estrada@campus.ul.pt	Faculdade de Farmácia da Universidade de Lisboa
Filipe Lopes Estanislau	festanislau@hovione.com	Hovione
Filipe Manuel Coreta Gomes	filipecoreta@ua.pt	Departamento de Química, Universidade de Aveiro
Filipe Manuel Lázaro dos Santos Monteiro	filipelsmonteiro@ua.pt	Universidade de Aveiro
Filipe Miguel Pinto Morais	filipemorais@ua.pt	University of Aveiro
Flavia Carina Freitas Magalhães	flaviamagalhaes@ua.pt	Universidade de Aveiro
Flávia Lidónio Leitão	fl.leitao@campus.fct.unl.pt	NOVA School of Science and Technology
Francisco Luís de Aragão Faísca	f.faisca@campus.fct.unl.pt	FCT-UNL
Francisco M. Fernandes	francisco.fernandes@sorbonne-universite.fr	Sorbonne Université
Francisco Miguel Reis Moreira	francisco.moreira@ua.pt	Departamento de Química, Universidade de Aveiro
Gabriel de Nóbrega Valério	g.valerio@campus.fct.unl.pt	FCT-UNL / NMBU
Gabriela Antunes Corrêa	up201900612@edu.fc.up.pt	Departamento de Química e Bioquímica, Faculdade de Ciências, Universidade do Porto
Gabriela Marisa Ferreira de Matos	gabrielamatos@ua.pt	Universidade de Aveiro
Gabriela Pinto de Queirós	up201304097@edu.fc.up.pt	REQUIMTE / FCUP
German Perez Sanchez	gperez@ua.pt	University of Aveiro
Giovanna Gardenal dos Santos Grous	gisantos143@gmail.com	Departamento de Química e Bioquímica da Faculdade de Ciências da Universidade do Porto
Gonçalo Filipe Cabete Oliveira	goncalofoliveira@ua.pt	University of Aveiro
Gonçalo Pinto Valente	goncalovalente@ua.pt	University of Aveiro
Guilherme Duarte Serrão	gui.serrao@hotmail.com	Universidade de Coimbra

Guilherme Ferreira Pinto	guilhermepinto@ua.pt	Universidade de Aveiro
Hajer Bouznif	bouznifhajer13@gmail.com	Universidade de Coimbra (FCTUC)
Hanieh Mahmoodi	h.mahmoodi@campus.fct.unl.pt	Nova school of science and technology
Hélder José Couto Oliveira	helder.oliveira@fc.up.pt	Universidade do Porto
Helena Isabel da Silva Laronha	h.laronha@ua.pt	Universidade de Aveiro
Helena Isabel Seguro Nogueira	helenanogueira@ua.pt	Universidade de Aveiro
Hélio Miguel Teixeira Albuquerque	helio.albuquerque@ua.pt	University of Aveiro
Hugo Filipe Margaça Rocha	hugofmr@ua.pt	Universidade de Aveiro
Hugo Miguel Dias dos Santos	hsantos27@ua.pt	Universidade de Aveiro
Humberto Rodríguez Solla	hrsolla@uniovi.es	Universidad de Oviedo
Iago Cavalcante Vogel	iagocvogel@ua.pt	University of Aveiro
Ilídio Joaquim Sobreira Correia	icorreia@ubi.pt	Universidade da Beira Interior
Inês Cristina Carreira Costa	a52917@ualg.pt	Universidade do Algarve
Inês De Almeida Marques	up201804927@fc.up.pt	Universidade do Porto
Inês Filipa Morais da Costa	inesfmcosta@tecnico.ulisboa.pt	Instituto Superior Técnico
Inês Martins Bastos	inesmbastos99@ua.pt	Universidade de Aveiro
Inês Pereira Gomes	ip.gomes@campus.fct.unl.pt	NOVA School of Science and Technology
Inês Sequeira Ribeirinha Marques	ines_marques_25@hotmail.com	Universidade do Porto
Irene Gómez Cruz	igcruz@ujaen.es	Universidade de Aveiro
Isabel Cristina Maia da Silva Santos Vieira	ivieira@ua.pt	Universidade de Aveiro
Isabel Cristina Ribau Fernandes Coutinho	i.coutinho@fct.unl.pt	FCT Universidade Nova de Lisboa
Isabel Margarida Bento Calhau	isabel.calhau@ua.pt	University of Aveiro
Isabel Maria Pinto Leite Viegas Oliveira Ferreira	isabel.ferreira@ff.up.pt	Faculdade de Farmácia-Universidade do Porto
Isabel Moura	lbmaia@fc.ul.pt	NOVA School of Science and Technology
Isabella Marques Gonçalves de Souza	isabellamgsouza@ua.pt	University of Aveiro
Ismael Rufino de Carvalho	ismaelrc198@gmail.com	Universidade de Lisboa
Ivo Silva Cruz	ivo.silv@ua.pt	Aveiro University
Iwona Kuzniarska-Biernacka	iwonakb@fc.up.pt	Universidade do Porto
Joana Alexandra da Silva Oliveira Pinto da Silva	jsoliveira@fc.up.pt	Universidade do Porto
Joana Carvalho Lopes	joanacl@fe.up.pt	FEUP
Joana Filipa Carvalho da Silva	joana.silva@qui.uc.pt	Universidade de Coimbra
Joana Filipa dos Santos Teixeira	joanafsteixeira@hotmail.com	Faculty of Sciences - University of Porto
Joana Filipa Monteiro de Sousa	uc2011141774@student.uc.pt	Universidade de Coimbra
Joana Filipa Paiva Martinho	joana.martinho@ctn.tecnico.ulisboa.pt	Instituto Superior Técnico
Joana Lia Cardoso de Sousa	joanasousa@ua.pt	University of Aveiro
Joana Mafalda Nunes Paulo Silva Martins	jmn.martins@campus.fct.unl.pt	FCT-NOVA
Joana Patrícia Rodrigues Figueiredo	figueiredo_joana@hotmail.com	Universidade da Beira Interior
Joana Raquel Mendes Ferreira	joanarmf@ua.pt	University of Aveiro
Joana Rita Cerveira Santos	joanarcs95@gmail.com	Universidade de Coimbra
Joana Rita do Vale Pais Costa	joanavcosta@tecnico.ulisboa.pt	Instituto Superior Técnico
Joana S. Amaral	jamaral@ipb.pt	Instituto Politécnico de Bragança

João Basso	joaobasso@ff.uc.pt	UC
João Carlos Salgueiro Simões	joao95simoes@gmail.com	Universidade de Coimbra
João Cláudio Fonseca Nunes	jcfn@ua.pt	University of Aveiro
João Costa Pessoa	joao.pessoa@ist.utl.pt	Instituto Superior Técnico
João Filipe Ramos da Silva Carvalho Borges	joaoborges@ua.pt	Universidade de Aveiro
João Humberto Gonçalves Francisco Nogueira	jh.nogueira@ua.pt	University of Aveiro
João Manuel Marques Rodrigues	jrodrigues@ua.pt	Universidade de Aveiro
João Miguel Ferreira Vaz	joaomvaz@campus.ul.pt	Faculdade de Farmácia da Universidade de Lisboa
João Paulo Lourenço Serrano	serrano.joao@hotmail.com	UBI
João Pedro Dias Pinto	joao.pedro.pinto@ua.pt	Universidade de Aveiro
João Pedro Fernandes Carvalho	joao.pedro.carvalho@ua.pt	DQ - Universidade de Aveiro
João Pedro Lourenço de Castro	jcastro@ua.pt	Universidade de Aveiro
João Pedro Sousa e Silva	joaop.s.silva@hotmail.com	University of Minho
João Rocha	rocha@ua.pt	Universidade de Aveiro
João Samuel de Almeida Pereira Patinha	jsamuelpatinha@ua.pt	Universidade de Aveiro
João Tomás Silva Martins	jtmartins@ua.pt	Universidade de Aveiro
Joaquim Luís Faria	jlfaria@fe.up.pt	University of Porto
Jorge Manuel Alexandre Saraiva	jorgesaraiva@ua.pt	Universidade de Aveiro
Jorge Ventura Manuel	manueljorge6501@gmail.com	Faculdade de Ciências da Universidade do Porto
José Abrunheiro da Silva Cavaleiro	jcavaleiro@ua.pt	Universidade de Aveiro
José Câmara	jsc@uma.pt	Universidade da Madeira
José Carlos Ferreira da Cunha	jcf.cunha@campus.fct.unl.pt	Nova School of Science and Technology
José Dinis Freitas da Silva	UP201404392@EDU.FC.UP.PT	Universidade do Porto
José Gonçalo Deira Duarte de Campos Justino	goncalo.justino@tecnico.ulisboa.pt	Instituto Superior Técnico
Jose Luis Mascarenãs	joseluis.mascarenas@usc.es	Universidade de Santiago de Compostela
José Miguel Cardoso da Silva	jose.miguel.silva@ua.pt	University of Aveiro
Jose Moura	jose.moura@fct.unl.pt	DQ, FCT, NOVA
Jose Paulo Farinha	farinha@tecnico.ulisboa.pt	Instituto Superior Tecnico
José Paulo Lopes Roque	jroque@qui.uc.pt	Universidade de Coimbra
José Ricardo Alves Coelho	jr99@live.com.pt	Universidade do Minho
Judite Sofia Santos Resende	judite.resende@ua.pt	Universidade de Aveiro
Juliana Marisa Nunes Machado	juliana.machado.20001@gmail.com	Universidade do Porto
Kais Iben Nassar	kais.nassar@ua.pt	University of Aveiro
Lara Carolina Henriques de Almeida	laracarolina18@ua.pt	Universidade de Aveiro
Laura Gonçalves Pereira	lauraa13.gp@gmail.com	Instituto Superior Técnico, Universidade de Lisboa
Leandro Miguel de Oliveira Lourenço	leandrolourenco@ua.pt	Universidade de Aveiro
Leonardo Mendes	leonardo.mendes@spq.pt	SPQ
Leonor S. Castro	l.castro@ua.pt	University of Aveiro
Liliana Jorge Gomes	lj.gomes@campus.fct.unl.pt	FCT-Nova
Lillian Barros	lillian@ipb.pt	IPB
Lúcia Inês Cruz Melo	luciainesmelo@gmail.com	Universidade de Aveiro

Luis Alexandre Almeida Fernandes Cobra Branco	l.branco@fct.unl.pt	FCT-NOVA
Luis Carlos Moutinho da Silva	luis.moutinho@iucs.cespu.pt	CESPU
Luís Filipe Baptista Fontes	lfontes@ua.pt	Universidade de Aveiro
Luis M. Liz-Marzán	llizmarzan@cicbiomagune.es	CIC biomaGUNE
Luís Manuel Pires Veríssimo	luis.verissimo@ua.pt	Universidade de Aveiro
Luis Miguel Neves Ferreira Serra Cruz	luis.cruz@fc.up.pt	Faculdade de Ciências da Universidade do Porto
Luís Pedro da Franca e Silva Caleiras Viegas	lpviegas@ci.uc.pt	CQC-IMS
Luis Pereira	imprim@sapo.pt	NOVA School of Science and Technology
Luís Pinto da Silva	luis.silva@fc.up.pt	Faculdade de Ciências da Universidade do Porto
Luisa Maia	luisa.maia@fct.unl.pt	FCT NOVA
Luísa Margarida Dias Ribeiro de Sousa Martins	luisammartins@tecnico.ulisboa.pt	Instituto Superior Técnico
Mª Isabel Ismael	iismael@ubi.pt	CQE
Mª Fátima C. Guedes da Silva	fatima.guedes@tecnico.ulisboa.pt	Instituto Superior Técnico, Universidade de Lisboa
Manuel António Coimbra	mac@ua.pt	Universidade de Aveiro
Manuel Jesús Luna Aguilera	manuelluna@fe.up.pt	University of Porto
Manuel João dos Santos Monte	mjmonte@fc.up.pt	Universidade do Porto
Manuel Lima Faria Ferreira	mlferreira@ivdp.pt	Instituto dos Vinhos do Douro e do Porto, I.P.
Manuel Melle Franco	manuelmelle@ua.pt	Dept of Chemistry, University of Aveiro
Manuel Souto Salom	manuel.souto@ua.pt	Universidade de Aveiro
Mara Guadalupe Freire	maragfreire@ua.pt	University of Aveiro
Marcela Segundo	msegundo@ff.up.pt	FFUP
Marcelo Dias Catarino	mcatarino@ua.pt	University of Aveiro
Márcia Carvalho Neves	mcneves@ua.pt	Departamento de Química, Universidade de Aveiro
Marcos António Martins Bento	mambento@fc.ul.pt	Faculdade de Ciências da Universidade de Lisboa
Margarida Maria da Silva Teixeira	margaridateixeira2000@hotmail.com	Universidade do Porto
Maria Amália Velez Antão Roque	mroque2861@gmail.com	Agrupamento de Escolas de Alapraia
Maria Amélia Gabriel de Barros	up201608044@fe.up.pt	FEUP
Maria da Conceição rangel	mrangel@icbas.up.pt	ICBAS
Maria da Graça de Pinho Morgado Silva Neves	gneves@ua.pt	Universidade de Aveiro
Maria da Graça Moura Teixeira	mgmteixeira@gmail.com	
Maria de Lurdes dos Santos Cristiano	mcristi@ualg.pt	University of Algarve
Maria do Amparo Ferreira Faustino	faustino@ua.pt	Universidade de Aveiro
Maria do Céu Esteves Amaral Teixeira	maria.teixeira@ua.pt	University of Aveiro
Maria Eduarda da Cunha Pereira	eduper@ua.pt	Universidade de Aveiro
Maria Fernanda de Jesus Rego Paiva Proença	fproenca@quimica.uminho.pt	Universidade do Minho
Maria Gabriela Leichtweis	mariagabriela@ipb.pt	IPB
Maria Gabriela Marques Teixeira Maia	gabymaria1976@gmail.com	Agrupamento de Escolas de Pinhel
Maria Inês Dias Lopes	mariaineslopes180@gmail.com	Escola Superior de Saúde do Politécnico do Porto
Maria Inês Lopes Roque	maria.inesroque@outlook.com	Faculdade de Farmácia da Universidade de Lisboa
Maria João Marques Nunes	mjm.nunes@fct.unl.pt	FCT NOVA, LAQV-REQUIMTE

Maria José Diogo da Silva Calhorda	mjc@fc.ul.pt	FCUL
Maria Manuel Duque Vieira Marques dos Santos	mariasantos@ff.ulisboa.pt	Faculdade de Farmácia, Universidade de Lisboa
Maria Manuel Martinho Sequeira Barata Marques	msbm@fct.unl.pt	FCT-NOVA
Maria Margarida Feitor Pintão Moreno Antunes	margarida.antunes@ua.pt	Universidade de Aveiro
Maria Margarida Pires Borges	up202007142@g.uporto.pt	Faculdade de Ciências da Universidade do Porto
Maria Teresa De Abreu Abreu	ing.mariadeabreu@gmail.com	Universidade da Madeira
Mariana Isabel Cordeiro Raposo	micr@ua.pt	Universidade de Aveiro
Mariana Isabel Cunha Nogueira Almeida Monteiro	marianaicnamonteiro@ua.pt	Aveiro University
Mariana Nunes Correia José	mn.jose@campus.fct.unl.pt	NOVA School of Science and Technology | FCT NOVA
Mariana Salomé Nunes da Cunha	mariana.salome.cunha@gmail.com	Faculdade de Ciências da Universidade do Porto
Marina Ilkaeva	marinailkaeva@ua.pt	University of Aveiro
Marina Setubal Justi	marinasetubalj@ua.pt	Universidade de Aveiro
Mário Berberan e Santos	mbs@tecnico.ulisboa.pt	Instituto Superior Técnico - Universidade de Lisboa
Mário Manuel Quialheiro Simões	msimoes@ua.pt	Universidade de Aveiro
Mário Túlio dos Santos Rosado	mario.rosado@qui.uc.pt	Universidade de Coimbra
Marisa Louro Monteiro	mmonteiro@reit.up.pt	Natural History and Science Museum
Marta Pineiro	mpineiro@qui.uc.pt	Universidade de Coimbra
Marta Sofia Vilela Barreira Teixeira	id9191@alunos.uminho.pt	University of Minho
Marta Susete da Silva Nunes	marta.nunes@fc.up.pt	Faculdade de Ciências, Universidade do Porto
Martinique da Silva Nunes	nunes.m@ua.pt	University of Aveiro
Matheus Matos do Nascimento	matheus.nascimento@ufac.br	Universidade Federal do Acre
Matilde Santos Faustino Silva	matilde.faustino@hotmail.com	NOVA School of Science and Technology
Melani Joana Almeida Reis	melani@ua.pt	Universidade de Aveiro
Mélanie Fernandes Fonte	up201305020@edu.fc.up.pt	Faculdade de Ciências da Universidade do Porto
Miguel Feijão Galrinho	miguel.fgalrinho@ua.pt	Universidade de Aveiro
Mikel Añibarro-Ortega	mikel@ipb.pt	Universidade de Vigo - CIMO Bragança
Mónica Gabriela dos Santos Honrado	monica-honrado@hotmail.com	Centro de Investigação de Montanha
Monica Susana Gonçalves de Almeida Válega	mvalega@ua.pt	Universidade de Aveiro
Nádia Alexandra Esteves Santos	nadiaasantos@ua.pt	Universidade de Aveiro
Nalin de Seixas Borges	nalexs@gmail.com	Aveiro University
Natacha Camboa Pinto Rodrigues	ncprodrigues@ua.pt	Universidade de Aveiro
Navendu Paul	lbmaia@sapo.pt	FCT NOVA
Newton Valério Verbisck	newton.verbisck@embrapa.br	EMBRAPA, Brasil
Nicole Silva Lameirinhas	nicoleslameirinhas@ua.pt	University of Aveiro
Nuno A. G. Bandeira	nuno.bandeira@ciencias.ulisboa.pt	BioISI-Biosystems and Integrative Sciences Institute
Nuno Alexandre Sousa Dias	alexsousadiaswork1@gmail.com	Faculdade de Ciências, Universidade do Porto
Nuno André dos Santos Viduedo	n.viduedo@campus.fct.unl.pt	Nova School of Science and Technology
Nuno Candeias	ncandeias@ua.pt	Universidade de Aveiro
Nuno Mateus	nbmateus@fc.up.pt	Universidade do Porto
Nuno Miguel Jesuíno Basílio	nuno.basilio@fct.unl.pt	FCT-NOVA

Nuno Miguel Malavado Moura	nunomour@gmail.com	Universidade de Aveiro
Olinda Coelho Monteiro	ocmonteiro@fc.ul.pt	FCUL - Universidade de Lisboa
Orlando Augusto Pinto de Oliveira	o.oliveira@ua.pt	Universidade de Aveiro / INL (Braga)
Paloma Levy Lopes	palomalopes@ua.pt	Universidade de Aveiro
Patrícia dos Santos Neves	pneves@ua.pt	Universidade de Aveiro
Patrícia Inês Carvalho Godinho	patricia.godinho@ua.pt	Universidade de Aveiro
Patrícia Raquel da Silva Moreira	patriciamoreira99@hotmail.com	Centro de Investigação em Química da Universidade do Porto
Patricia Rijo	patricia.rijo@ulusofona.pt	Universidade Lusófona
Paula Brandão	pbrandao@ua.pt	Universidade de Aveiro
Paula Celeste da Silva Ferreira	pcferreira@ua.pt	Universidade de Aveiro
Paula Cristina de Sério Branco	paula.branco@fct.unl.pt	NOVA FCT
Paula Cristina Ramos Soares e Santos	paula.santos@ua.pt	Dep Química, Universidade de Aveiro
Paulo Fernandes de Barros	pbarros@ivdp.pt	Instituto dos Vinhos do Douro e do Porto, I.P.
Paulo Jorge da Silva Almeida	pjsa@ubi.pt	Universidade da Beira Interior
Paulo N. Martinho	pnmartinho@ciencias.ulisboa.pt	Faculdade de Ciências, Universidade de Lisboa
Pedro Alexandre de Sousa Rosa	pedroasrosa@tecnico.ulisboa.pt	Instituto Superior Técnico
Pedro Ângelo Miranda	up202008689@up.pt	FCUP
Pedro da Conceição Rosado	pedrocrosado@tecnico.ulisboa.pt	Instituto Superior Técnico, Universidade de Lisboa
Pedro Filipe Gonçalves Rodrigues	fc48088@alunos.ciencias.ulisboa.pt	Faculdade de Ciências - Universidade de Lisboa
Pedro Franco Pinheiro	pedro.pinheiro@tecnico.ulisboa.pt	Centro de Química Estrutural - Instituto Superior Técnico
Pedro Jorge Marques de Carvalho	quijorge@ua.pt	Universidade de Aveiro
Pedro Miguel César Barbosa Ferreira	pmcferreira@ua.pt	Universidade de Aveiro
Pedro Miguel Oliveira Gomes	pm.gomes@ua.pt	Universidade Aveiro
Pedro Miguel Pinto Fernandes	pedrompf92@gmail.com	Universidade de Coimbra
Pedro Simão Freitas Mendes	pedro.f.mendes@tecnico.ulisboa.pt	Instituto Superior Técnico
Rafael Filipe Teixeira Arbuez Gomes	rafael.gomes@campus.ul.pt	ULisboa
Rafaela Farelo Silva Tenera Marques	rafaela.m.1996@gmail.com	Faculty of Science of University of Lisbon
Rafaela Gonçalves Cabral	rafaela.cabral@tecnico.ulisboa.pt	Instituto Superior Técnico
Raquel da Costa Rainha Gonçalves	raquelrainha10@hotmail.com	Universidade do Minho
Raquel Dias Dantas	raqueldantas@ua.pt	Universidade de Aveiro
Raquel María González Soengas	rsoengas@uniovi.es	Universidad de Oviedo
Raquel Sofia de Oliveira Nunes da Silva	rsilva@ctcor.com	CTCOR
Renata Alexandra Tavares Amaral	renata.amaral@ua.pt	Universidade de Aveiro
Renata Teixeira Correia de Matos	renata_matos@live.com.pt	Faculdade de Ciências da Universidade do Porto
Ricardo Alexandre Luís Silva Santos	ricardossantos@ua.pt	Chemistry Department, University of Aveiro
Ricardo João Borges Pinto	r.pinto@ua.pt	Universidade de Aveiro
Ricardo João Freitas Ferreira	ricardojferreira@edu.ulisboa.pt	Faculdade de Farmácia da Universidade de Lisboa
Ricardo José Pinto Miranda	adnarim.ricardo@aefp.pt	Agrupamento de Escolas Fernão do Pó - Bombarral
Ricardo Lima Navarro Silva de Oliveira	rl.oliveira@campus.fct.unl.pt	Universidade Nova de Lisboa

Rita Alexandra do Nascimento Cardoso Guedes	rguedes@ff.ulisboa.pt	Faculdade de Farmácia da Universidade de Lisboa
Rita Alexandra Padinha Lopes	rita.padinha.lopes@tecnico.ulisboa.pt	Instituto Superior Técnico
Rita Briz Müller Assis dos Santos	rita.assis.santos@tecnico.ulisboa.pt	Instituto Superior Técnico
Rita Engrácia Antunes Moutinho de Barros	up201604653@edu.fe.up.pt	Faculdade de Engenharia da Universidade do Porto
Rita Maria Pinho Ferreira	ritaferreira@ua.pt	Universidade de Aveiro
Rita Moreira Carvalho	up201706341@up.pt	Faculdade de Ciências, Universidade do Porto
Robert A. Pascal	rpascal@tulane.edu	Tulane University, New Orleans
Rodrigo Miguel Amaro e Silva	rodrigo.m.a.silva98@gmail.com	Faculdade de Ciências da Universidade do Porto
Rodrigo Pinto Monteiro	rod.monteiro@ua.pt	CICECO - Instituto de Materiais de Aveiro
Rui André Dias da Costa	ruiacosta@utad.pt	UTAD
Rui Fausto	rfausto@ci.uc.pt	Department of Chemistry - University of Coimbra
Rui Filipe Jesus Pereira	r97pereira@gmail.com	Faculdade de Farmácia da universidade do Porto
Rui Francisco Gonçalves Pinto Fernandes Pereira	rpereira@quimica.uminho.pt	Universidade do Minho
Rui Gonçalo Pereira Faria	rui_faria_619@hotmail.com	Universidade do Porto
Rui Rocha	rui.rocha@bruker.com	Bruker Portugal
Rui Sérgio da Silva Ribeiro	rsribeiro@fe.up.pt	University of Porto - Faculty of Engineering
Samuel Guieu	sguieu@ua.pt	universidade de Aveiro
Samuel Martins SIlvestre	silvestres84@gmail.com	Faculdade de Ciências, Universidade da Beira Interior
Sandra Cristina da Cruz Nunes	snunes@qui.uc.pt	Universidade de Coimbra
Sandra Maria Pinto Cerqueira	xana@quimica.uminho.pt	Universidade do Minho - Centro de Química
Sara Hummeid	s.hummeid@ff.ulisboa.pt	Universidade de Lisboa
Sara Jacinta Godinho Salgado	saraagodinho@outlook.com	Faculdade de Farmácia da Universidade do Porto.
Sara Martinho Almeida Pinto	smpinto@qui.uc.pt	Universidade de Coimbra
Sara Quintela Realista	smrealista@fc.ul.pt	Faculdade de Ciências, Universidade de Lisboa
Sara Virginia Almeida Vitoriano Teixeira	luis.sara@gmail.com	Agrupamento de escolas de Estarreja
Silvestre João José Isidoro	sisidoro@edu.ulisboa.pt	Universidade de Lisboa, Faculdade de Farmácia
Sílvia Lancha Petronilho	silviapetronilho@ua.pt	Universidade de Aveiro
Simone Coelho Fernandes	up201603496@fc.up.pt	FCUP
SIXTO MALATO	sixto.malato@psa.es	Plataforma Solar de Almeria, CIEMAT
Sofia Nunes Sarabando	sofia.sarabando@ua.pt	Universidade de Aveiro
Sofia Pauleta	srp@fct.unl.pt	FCT NOVA
Soraia Maria Sousa Santos	soraiamsantos98@gmail.com	Universidade Trás-os-Montes e Alto Douro
Stéphanie Branco Leal	sb.leal@campus.fct.unl.pt	NOVA School of Science and Technology
Susana Maria de Almeida Cardoso	susanacardoso@ua.pt	Universidade de Aveiro
Tânia Sofia Almeida Fonte	taniafonte28@ua.pt	Universidade de Aveiro
Tatiane Cristina Gonçalves de Oliveira	tatiane.oliveira@ipb.pt	IPB
Telmo Neves Francisco	telmofrancisco@ua.pt	Universidade de Aveiro
Teresa Sousa Pereira	teresa97pereiraa@gmail.com	Universidade do Minho
Thais Sayuri Berberich	up202111842@edu.fe.up.pt	FEUP
Tiago Adriano Fernandes	tiago.a.fernandes@tecnico.ulisboa.pt	Centro de Química Estrutural
Tiago Pereira Gomes	tpereiragomes@hotmail.com	Faculdade de Ciências da Universidade de Lisboa
Tiago Rodrigues	tiago.rodrigues@ff.ulisboa.pt	FFULisboa

up201304097@edu.fc.up.pt	gabrielapintoq@hotmail.com	Universidade do Porto
Valentina Guimarães da Silva	valentinagsilva@ua.pt	Departamento de Química, Universidade Aveiro
Vânia Margarida da Silva Costa	vaniasilvacosta@gmail.com	Universidade do Porto
Vânia Maria Amaro Calisto	vania.calisto@ua.pt	Universidade de Aveiro
Vasco Bonifácio	vasco.bonifacio@tecnico.ulisboa.pt	Instituto Superior Técnico
Vasco José Costa de Lima	vasco.lima@ua.pt	Universidade de Aveiro
Vasco Miguel Sabino Castanheira	vasco.castanheira@ua.pt	Universidade de Aveiro
Vera Lúcia Marques da Silva	verasilva@ua.pt	Universidade de Aveiro
Verónica Cortés de Zea Bermudez	vbermude@utad.pt	Universidade de Trás-os-Montes e Alto Douro
Vicente Ferreira da Silva	vmbmfs@gmail.com	CICP - UMinho
Victor Armando Pereira de Freitas	vfreiast@fc.up.pt	Faculdade de Ciências - Universidade do Porto
Victor Manuel de Matos Lobo	vlobo@ci.uc.pt	Universidade de Coimbra
Victória Inês Patrício Paz	victoriapatriciopaz@gmail.com	NOVA School of Science and Technology
Vincenzo Vigna	vincenzo.vigna@unical.it	University of Calabria / University of Coimbra
Vitaliy Masliy	vmasliy@mail.ru	University of Coimbra
Vitor Hugo Mordido	v.mordido@campus.fct.unl.pt	Universidade Nova de Lisboa
Vítor Jorge Pais Vilar	vilar@fe.up.pt	Faculty of Engineering, University of Porto
Vítor José Inácio Martins	vitorjmartins@ua.pt	Universidade de Aveiro
Wei-Jian XU	weijxu@ua.pt	University of Aveiro
Yaroslav Hryhoryev	yaroslav.hryhoryev@gmail.com	University of Coimbra
Yuliya Dulyanska	ydulyanska@esav.ipv.pt	CERNAS, IPV
Zoé Ladieu Arcas Arnaut Moreira	zoearnaut@gmail.com	Universidade de Coimbra