



# 4<sup>TH</sup> PORTUGUESE YOUNG CHEMISTS MEETING

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APRIL 29<sup>TH</sup> - MAY 1<sup>ST</sup> 2014

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UNIVERSITY OF COIMBRA  
PORTUGAL



**Sociedade Portuguesa de Química**

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**4PYCheM – 4<sup>th</sup> Portuguese Young Chemists Meeting**

Departamento de Química, Faculdade de Ciências e Tecnologias da Universidade de Coimbra

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**Book of Abstracts of the 4<sup>th</sup> Portuguese Young Chemists Meeting**

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Dear Colleagues and Friends,

We are delighted to welcome you to Coimbra and wish a warming staying in this ancient city and century-old University. The scientific programme of the **4<sup>th</sup> Portuguese Young Chemists Meeting** (4<sup>o</sup> PYCheM) reflects some of the most prominent and stimulating areas of Chemistry, which you may assist through the Nobel lectures, invited lectures, oral communications and posters. We are particularly thrilled with the quality of the submitted abstracts of our young colleagues (graduate, PhD and post-docs students) compiled in this book: the future of Portuguese Chemistry looks bright.

The ancient city of Coimbra is famous for its University, which was founded in 1290 (13<sup>th</sup> oldest in the world). The social programme will guide you in a touristic tour across the secrets of this University, which was proclaimed World Heritage in 2013.

The location of the Welcome reception (between the Chemistry and Physics Department) offers you a stunning panoramic view over *Mondego* River. We also hope that you enjoy all the historic sites in Coimbra and surroundings areas (Conímbriga, Penela and Figueira da Foz). We wish you a fruitful conference and an enjoyable stay in Coimbra.

**The 4<sup>th</sup> Portuguese Young Chemists Meeting Organising Committee**

# Scientific Program

29 DE ABRIL		
09h:00m-13h:30m	Registration	
	Main Auditorium	Chemistry Auditorium
13h:40m	Opening Ceremony	
13h:50m	IL1 - Sensing and making sense of temperature and molecules at the nanoscale(30+10) <b>João Rocha</b> CICECO / UA	
	Organic and Inorganic Chemistry	Medicinal Chemistry
14h:30m	IL2 - Boron based dynamic bonding: an emerging tool for bioconjugation (30+10) <b>Pedro Góis</b> FFUL	IL3 - From Molecules to Man: Molecular Imaging as a Translational Tool in Biomedical Research <b>Miguel Castelo-Branco/Antero Abrunhosa</b> IBILI   ICNAS   UC
15h:10m	OC1 - Enzymes – An attractive tool to obtain enantiomeric pure sec-alcohols <b>Monteiro, C. M., Lourenço, N. M. T., Afonso, C. A. M.</b>	OC2 - Spiropyrazoline oxindoles: A new class of compounds with potential anticancer activity <b>Ângelo Monteiro, Lídia M. Gonçalves and Maria M. M. Santos</b>
15h:30m	OC3 - Sustainable Tandem Reactions Involving Hydroformylation <b>Ana R. Almeida, Artur R. Abreu, Pedro M. P. Gois, J. C. Bayón and Mariette M. Pereira</b>	OC4 - Synthesis and biological evaluation of spiroisoxazoline oxindoles as anticancer agents <b>Ribeiro C. J. A., Amaral J. D., Rodrigues C. M. P., Moreira R., and Santos M. M. M.</b>
15h:50m	OC5 - Straightforward synthesis to pyrido[2,3-d]pyrimidine-2,4-diones and their ADME properties <b>Martyna Jatczak, Koen Muylaert, Janneke Keemink, Benjamin Wuyts, Patrick Augustijns, Christian V. Stevens</b>	OC6 - Computational Study of G2 Checkpoint Protein Kinases-Inhibitor Complexes <b>Pedro M. M. Araújo, Luís Pinto da Silva and Joaquim C.G. Esteves da Silva</b>
16h:10m	Coffee break + Poster session (P1-P43)	

17h:30m	OC7 - An efficient synthetic route towards new antimicrobial deoxy sugars with anti-ageing potential - assessing the importance of configuration and deoxygenation pattern <b><u>Catarina Dias</u>, Tobias Lange, Amélia P. Rauter</b>	OC8 - Targeting the erythrocytic and liver stages of malaria parasite with s-triazine-based hybrids <b><u>Rodrigues, C. A. B.</u>, Albuquerque, I. S., Gut, J., Moreira, R.; Mota, M. M., Rosenthal, P. J., Prudêncio, M., Afonso, C.A.M.</b>
17h:50m	OC9 - Rational Design of Novel Anti-inflammatory drugs: is COX-2 selectivity an advantage? <b><u>Luisa C. R. Carvalho</u>, Daniela Ribeiro, Raquel S. G. R. Seixas, Artur M. S. Silva, Eurico J. Cabrita, Eduarda Fernandes and M. Manuel B. Marques</b>	OC10 - Bis-alkylamine indolo[3,2-b]quinolines as hemozoin ligands: antimalarial cytostatic and cytocidal activities <b><u>Marta Figueiras</u>, Marta Machado, Catarina Charneira, João Lavrado, Dinora Lopes, Jiri Gut, Philip J. Rosenthal, Fátima Nogueira, Rui Moreira, Alexandra Paulo</b>
18h:10m	OC11 - Novel Ionic Liquids as Active Pharmaceutical Ingredients (ILs-APIs) based on Ibuprofen and Naproxen <b><u>Alexandra Costa</u>, Andreia Forte, Núria Muñoz, Madalena Dionísio and Luís C. Branco</b>	OC12 - Tackling API solubility and stability problems by developing new multicomponent crystal forms: Azelaic acid, Nalidixic acid and Dapsone <b><u>I. C. B. Martins</u>, M. Martins, V. André and M. T. Duarte</b>
18h:30m	General Assembly	
19h:30m	Welcome Reception	
30 DE ABRIL		
	Main Auditorium	Chemistry Auditorium
	Physical Chemistry	Materials Science and New Technologies
09h:00m	IL4 - Charging redox flow batteries using the sunlight <b>Adélio Mendes</b> FEUP	
09h:40m	IL5 - The Molecules of Colour <b>J. Sérgio Seixas de Melo</b> FCTUC	IL6 - Novel nanostructured conducting materials for application to electrochemical sensing and biosensing <b>Christopher Brett</b> FCTUC
10h:20m	OC13 - Luminescent supramolecular hydrogen-bonded frameworks <b><u>Samuel Guieu</u>, João Rocha and Artur M. S. Silva</b>	OC14 - Bipyridinium salts as reversible electrochromic materials <b><u>Noémi Jordão</u>, Luis Cabrita, Hugo Cruz, Fernando Pina and Luís C. Branco</b>

10h:40m	OC15 - Fenton-like oxidation of small aromatic acids from biomass burning in water and in the absence of light: implications for atmospheric chemistry <b><u>Patrícia S.M. Santos, Armando C. Duarte</u></b>	OC16 - Effect of the microstructure of the polymeric matrix on performance of PDLC devices <b><u>Ana Mouquinho, João Sotomayor</u></b>
11h:00m	Coffee break	
11h:30m	OC17 - Study of the Photostability of UV-filters 4-Methylbenzylidene Camphor and Octocrylene in Chlorinated Water <b><u>Mariana M. de Oliveira e Sá, Margarida S. Miranda and Joaquim C.G. Esteves da Silva</u></b>	OC18 - Insights into the world of pharmaceuticals using mechanochemistry: Polymorphs, co-crystals and bio-inspired metal organic frameworks <b><u>V. André, S.Quaresma, M. Martins and M.T. Duarte</u></b>
11h:50m	OC19 - Role of the Base and Control of Selectivity in the Suzuki–Miyaura Cross–Coupling Reaction <b><u>Carlos F. R. A. C. Lima, Ana S. M. C. Rodrigues, Vera L. M. Silva, Artur M. S. Silva and Luís M. N. B.</u></b>	OC20 - Phosphorescent wood oil <b><u>Diana M. Crista, Maria C. Mendonça and Joaquim Esteves da Silva</u></b>
12h:10m	OC21 - Insights on the Nanostructuration of Ionic Liquids by Infrared Spectroscopy <b><u>Inês C. M. Vaz, Marisa A. A. Rocha, Luís M. N. B. F. Santos</u></b>	OC22 - Silica-bound sulfonic acid catalysts for esterification reactions <b><u>Mohamed M. Aboelhassan, Andreia F. Peixoto and Cristina Freire</u></b>
12h:30m	OC23 - Chemistry in the e-lab: a new wave <b><u>Sérgio Leal, João P. Leal</u></b>	OC24 Two-Photon Activated 3D Data Storage <b><u>Inês F. A. Mariz, Catarina A. B. Rodrigues, Ermelinda M. S. Maçôas, Filipa Siopa, Carlos Afonso and José M. G. Martinho</u></b>
12h:50m	Lunch	
14h:30m	Social Programme	
16h:30m	Coffee Break + Poster Session (P44-P91)	
20h:00m	Conference Dinner	
1 DE MAIO		
	Main Auditorium	Chemistry Auditorium

	Biophysics and Biological Chemistry	Analytical Chemistry
<b>09h:30m</b>	IL7 - The Cellulosome: a multienzymatic and dynamic machine for the degradation of cellulose <b>Maria João Romão</b> FCT /UNL	IL8 – Multifunctional Nanaoscale Oxide Conductors and Semiconductors <b>Elvira Fortunato</b> FCT /UNL
<b>10h:10m</b>	PL1 - Can structures lead to improved therapeutics?" <b>Ada Yonath</b> Weizmann Institute of Science, Jerusalem	
<b>11h:10m</b>	<b>Coffee break</b>	
<b>11h:20m</b>	OC25 - Physiological $\text{Ca}^{2+}$ concentrations induce $\text{PI}(4,5)\text{P}_2$ clustering and have an impact in $\text{PI}(4,5)\text{P}_2$ partition properties <b>M.J. Sarmiento, M.E. Monteiro, A. Coutinho, M. Prieto, F. Fernandes</b>	OC26 - Biosorbents for the removal of mercury, cadmium and lead from salt waters <b>Paula Figueira, Cláudia B.Lopes, Bruno Henriques, Luciana S. Rocha, Ana T. Reis, Miguel A. Pardal, J.A. Borges, Armando C. Duarte and Eduarda Pereira</b>
<b>11h:40m</b>	OC27 - Computational studies on the catalytic mechanism of human Heparan Sulfate 3-O-sulfotransferase in light of the Herpes Simplex Virus type 1 infection. <b>Rui P. Sousa, Pedro A. Fernandes, Maria J. Ramos, Natércia F. Brás</b>	OC28 - How many people contribute to Chemistry in the University of Coimbra? A comparison with other Portuguese and foreign (MIT, Lund) universities <b>Tânia F. Cova, Susana Jarmelo, Sérgio Seixas de Melo and Alberto A.C.C. Pais</b>
<b>12h:00m</b>	PL2 - The revolution of Personalized Medicine: Are we going to cure all diseases and at what price? <b>Aaron Ciechanover</b> Technion - Israel Institute of Technology	
<b>13h:00m</b>	<b>Lunch</b>	
<b>14h:15m</b>	<b>Solchemar – Excellence in Sustainable Chemistry Session sponsored by SOLCHEMAR</b>	
<b>15h:45m</b>	<b>Closing session with PYCA</b>	

## **Invicted lectures**

# IL1 - Sensing and making sense of temperature and molecules at the nanoscale

João Rocha

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In this talk I shall review the work carried out in Aveiro in the last 6 years, or so, on the design, synthesis and characterisation of lanthanide (Ln) -bearing nanostructures for sensing small molecules and temperature. Selected examples of (i) nanoporous metal-organic frameworks, and (ii) gold and Ln oxides nanoparticles systems will be given.

Nanoporous metal-organic frameworks (MOFs) are crystalline materials consisting of metal ions bridged by organic linkers and exhibiting porosity reminiscent of zeolites. Ln<sup>3+</sup>-organic frameworks are very promising materials for tackling the challenges in engineering of luminescent centres, also presenting much potential as multifunctional systems, combining light emission with properties such as microporosity, magnetism, chirality, molecule and ion sensing, catalysis and activity as multimodal imaging contrast agents [1]. Only 10% or so of MOFs are effectively nanoporous, exhibiting zeolite-type behaviour, and photoluminescent. The combination of porosity and light emission allows the design of intriguing new types of chemical species and temperature sensors, which I shall highlight here [2-6].

While the use of plasmonic nanoparticles as sources of heat have attracted much interest in the last decade, research into ratiometric nanothermometers with high-spatial resolution is comparatively new. Suitable nanoplatforms integrating heaters and thermometers, however, have not been realized, despite their great potential in nanophotonics and biomedicine. In this talk I shall report a step forward towards assessing the local temperature of laser-excited gold nanostructures using an all-in-one nanoplatform comprising (Gd,Yb,Er)<sub>2</sub>O<sub>3</sub> nanorods (thermometers, NR) that were surface-decorated with gold nanoparticles (heaters, AuNPs) [7].

**Acknowledgements:** COMPETE, FEDER and Fundação para a Ciência e a Tecnologia, FCT, (PEst-C/CTM/LA0011/2013 and the Portuguese National NMR Network (RNRMN), supported with FCT funds.

- [1] Rocha J., Carlos L. D., Paz F. A. A., Ananias D., *Chem. Soc. Rev.* **2011**, 40, 926-940.
- [2] Shi F. N., Cunha-Silva L., Ferreira R. A. S., Mafra L., Trindade T., Carlos L. D., Paz F. A. A., Rocha, J., *J. Am. Chem. Soc.* **2008**, 130, 150-167.
- [3] Harbuzaru B. V., Corma A., Rey F., Atienzar P., Jordá J. L., García H., Ananias D., Carlos L. D., Rocha J., *Angew. Chem. Int. Ed.* **2008**, 47, 1080-1083.
- [4] Harbuzaru B. V., Corma A., Rey F., Jordá J. L., Ananias D., Carlos L. D., Rocha J., *Angew. Chem. Intl. Ed.*, **2009**, 48, 6476-6479.
- [5] Cadiau A., Brites C. D. S., Costa P. M. F. J., Ferreira R. A. S., Rocha J., Carlos L. D., *ACS Nano* **2013**, 7, 7213-7218.
- [6] Abdelhameed R. M., Carlos L. D., Silva A., Rocha J., *Chem. Commun.* **2013**, 49, (2013), 5019-5021.
- [7] 1) Debasu, M. L., Ananias, D., Pastoriza-Santos, I., Liz-Marzan, L. M., Rocha, J., Carlos L. D., *Adv. Mater.* **2013**, 35, 4868-4874.

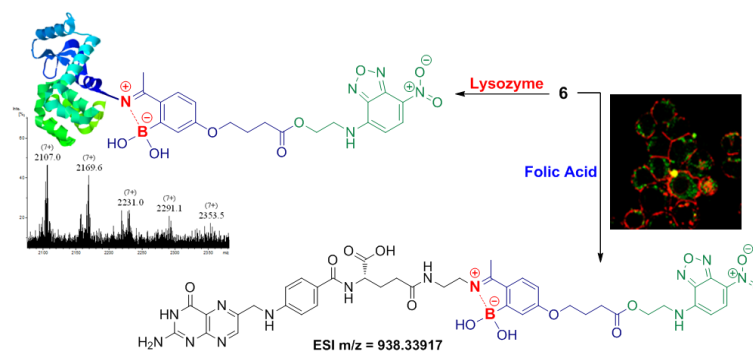
# IL2 – Boron based dynamic bonding: an emerging tool for bioconjugation

Pedro Góis

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Recent appreciation for the unique Boron-Nitrogen bond properties triggered a burgeoning interest for this motif. B-N bonds have been extensively exploited to construct self-assembled molecularly defined nanostructures, polymeric materials and sensors. Recently, the isosterism between B-N and C-C bonds was also recognized as a powerful tool to tune the properties of organic molecules. In this context, we have used the B-N bond to prepare natural product-like structures and heterocycles with activity against HNE.<sup>1,2</sup> In this communication, we will present the use of this bonding motif to efficiently modify proteins and to promote the assemblage of constructs that selectively internalize into tumor cells.<sup>3,4</sup>



This protocol relies on the formation of alkylic iminoboronates in aqueous media. Despite their stability, these modifications were shown reversible in the presence of fructose, dopamine and glutathione, as they presumably induce hydrolysis by disruption of the B-N bond. Fluorescent 2-acetylbenzeneboronic acids derivatives were successfully prepared and conjugated *via* a B-N linkage with lysozyme and *N*-(2-aminoethyl) folic acid, generating conjugates that were selectively recognized and internalized by NCI-H460 cancer cells, which over-express folic acid receptors. The ability of these iminoboronates to undergo a receptor mediated internalization and their efficiency to promote the selective and reversible functionalization of proteins, highlights these constructs to have a promising future in the design of conjugates that selectively target and deliver cargo to cancer cells.

## References

1. F. Montalbano, P. M. P. Gois, et al, *Org. Lett.*, 2012, **14**, 988.
2. F. Montalbano, P. M. P. Gois, et al, *Org. Biomol. Chem.*, 2013, **11**, 4465.
3. P. M. S. D. Cal, P. M. P. Gois, et al, *J. Am. Chem. Soc.*, 2012, **134**, 10299.
4. P. M. S. D. Cal, P. M. P. Gois, et al, *Chem. Comm.* 2013, accepted - 2014 Emerging Investigators Themed collection.

## **IL3 - From Molecules to Man: Molecular Imaging as a Translational Tool in Biomedical Research**

M. Castelo Branco, Antero J. Abrunhosa

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Molecular Imaging (MI) has the unique ability to map molecular processes and interactions in the living body thus providing a crucial bridge between basic biomedical research and clinical application. Over the past few decades many imaging biomarkers have been established using techniques such as PET, SPECT, MRI and Optical imaging among others. In this talk we will show some of the molecules developed and their use in the clinical setting for important applications in Oncology, Cardiology and Neuroscience.

## **IL4 - Charging redox flow batteries using the sunlight**

Adélio Mendes

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With the increasing demand for more energy and the anticipated end of fossil fuels, energy has been a hot topic on discussions in politics, corporations and citizens alike. In the European Unit, the Nearly Zero Energy Building European directive (Directive 2010/31/EU) states that a building should have nearly net energy consumption and nearly zero carbon emissions over the course of one year. To achieve these goals innovative solutions need to be found. In this work we propose an efficient way to harvest and store solar energy in any building using photoelectrochemical cells integrated with redox flow battery: the solar redox flow batteries.

## **IL5 - The Molecules of Colour**

J. Sérgio Seixas de Melo

*CQC, Department of Chemistry, University of Coimbra, 3004-535 Coimbra, Portugal*

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In the past recent year, we have studied molecules that we coined as the *molecules of colour*; some of these are iconic molecules. Along with their historical relevance, aspects such as the mechanisms behind their stability and modern applications of these molecules will be presented.

## **IL6 - Novel nanostructured conducting materials for application to electrochemical sensing and biosensing**

Christopher M.A. Brett

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Recent developments in the preparation and characterisation of electrodes modified by redox and conducting conjugated polymers, carbon nanotubes and graphene will be shown, together with the formation of self-assembled molecularly thin layer-by-layer structures. Applications as sensing and biosensing systems in the areas of environment, food and health will be illustrated.

## **IL7 - The Cellulosome: a multienzymatic and dynamic machine for the degradation of cellulose**

Maria João Romão

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The *Clostridium thermocellum* is an anaerobic bacterium isolated from hot springs and it has the ability to convert hemicellulose and its monomers into ethanol. These microorganisms express large multienzyme complexes dedicated to the degradation of the plant cell wall. These megaDalton complexes, Cellulosomes, comprise a consortium of modular glycoside hydrolases that attack recalcitrant polymers generally contain noncatalytic carbohydrate binding modules (CBMs), which play a critical role in the action of these enzymes by localizing the appended catalytic domains onto the surface of insoluble polysaccharide substrates.

All these modular structures are assembled by a Cellulosome-integrating protein, named scaffoldin. The scaffoldin is composed of several type I cohesin domains, which have the ability to bind the type I dockerin domains of the enzymes responsible for cellulose degradation. A type II dockerin of the scaffoldin binds to a type II cohesin of the protein that anchors the whole complex to the cell surface. The structure of the type I cohesin- dockerin complex at atomic resolution, revealed that the cohesin interacts predominantly with one side of the dockerin. Internal sequence duplication in the dockerin results in near-perfect internal 2-fold symmetry, suggesting that both "halves" of the dockerin may interact with cohesins in a similar manner. A double mutant dockerin has been used to visualize the reverse binding in which the dockerin mutant is indeed rotated relative to the WT dockerin changing the recognition pattern of its protein partner. The dual binding mode is predicted to impart significant plasticity into the orientation of the catalytic subunits within this supramolecular assembly, which reflects the challenges presented by the degradation of a heterogeneous, recalcitrant and insoluble substrate by Cellulosome.

## IL8 - The re(evolution) of conventional materials: metal oxides and cellulose

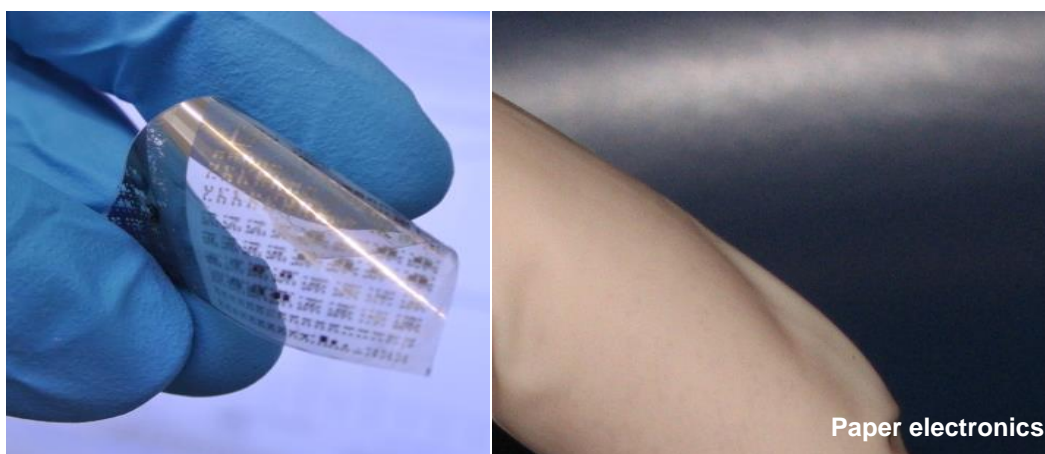
Elvira Fortunato\* and Rodrigo Martins

*Materials Science Department, CENIMAT/I3N, FCT-UNL and  
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Transparent electronics has arrived and is contributing for generating a free real state electronics that is able to add new electronic functionalities onto surfaces, which currently are not used in this manner and where silicon cannot contribute [1,2]. The already high performance developed n- and p-type TFTs have been processed by physical vapour deposition (PVD) techniques like rf magnetron sputtering at room temperature which is already compatible with the use of low cost and flexible substrates (polymers, cellulose paper, among others). Besides that a tremendous development is coming through solution-based technologies very exciting for ink-jet printing, where the theoretical limitations are becoming practical evidences. In this presentation we will review some of the most promising new technologies for n- and p-type thin film transistors based on oxide semiconductors and its currently and future applications.

On the other way round, there is today a strong interest in the use of biopolymers for applications like in the electronic and biomedical or clinic industries, mainly driven by low-cost applications. Cellulose is the earth's major biopolymer and is of tremendous global economic importance. The possibility of developing entirely new kinds of products based on cellulose is of current interest, in order to enhance and to add new functionalities to conventional cellulose fiber based-paper. We briefly present our results aiming the application of paper-based microfluidics in the development of diagnostic tests.



Flexible transparent electronics and paper electronics (paper-e) developed at CENIMAT/I3N.

- [1] E. Fortunato, P. Barquinha, and R. Martins, "Oxide Semiconductor Thin-Film Transistors: A Review of Recent Advances," *Advanced Materials*, vol. 24, pp. 2945-2986, Jun 2012.
- [2] P. Barquinha, R. Martins, L. Pereira and E. Fortunato, *Transparent Oxide Electronics: From Materials to Devices*. West Sussex: Wiley & Sons (March 2012). ISBN 9780470683736.

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## **Oral Communications**

# OC1 – Spiropyrazoline oxindoles: A new class of compounds with potential anticancer activity

Ângelo Monteiro<sup>1,\*</sup>, Lúcia M. Gonçalves<sup>1</sup> and Maria M. M. Santos<sup>1</sup>

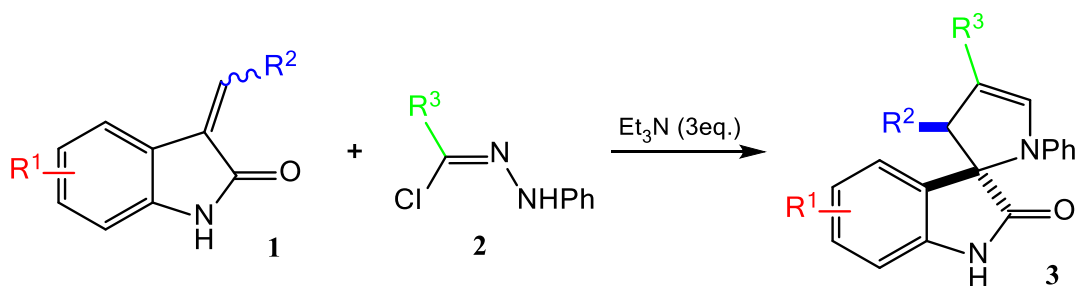
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Cancer is one of the leading causes of mortality worldwide, causing 7.6 million deaths in 2008. Moreover, World Health Organization projects a rise in deaths from cancer to 13.1 million in 2030. More specifically, the female breast cancer, which ranks first among women aged 20 to 59 years, is the only one that incidence rate remained relatively flat since 2003 [1]. As such, cancer continues to pose a major threat to human health and further research regarding new therapeutic strategies that more effectively combat cancer are needed. Furthermore, the increase cases of multidrug resistance (MDR) makes a challenge for the development of new drugs a milestone on the treatment of various types of cancers (e.g. blood, breast, ovarian, lung, and lower gastrointestinal tract cancers).

We previously reported the potential use of spiroisoxazoline oxindoles as anticancer agents [2]. In fact, the spirooxindole framework is present in several natural alkaloids and synthetic agents, which have shown important biological activities (e.g., anti-inflammatory, antimalarial, and anticancer activities) [3].

Here, we report the synthesis of novel 19 spiropyrazoline oxindoles and evaluation of activity in breast cancer cell lines. The library of spiropyrazoline oxindoles **3** was synthesized by 1,3-dipolar cycloaddition reaction between 3-methylene indolin-2-ones **1** and hydrazone chlorides **2** in the presence of triethylamine (Scheme 1). The compounds were evaluated for their cytotoxic activity in breast cancer cell lines (MCF-7 and MDA-MB-231). Six compounds had very good activity against MCF-7 tumor cell line ( $GI_{50} < 12 \mu M$ ). In addition, two of them were highly selective between MCF-7 (ER-positive) and MDA-MB-231 (ER-negative) tumor cell lines and were noncytotoxic against HEK 293T non tumor derived cell line [4].



Scheme 1: Synthesis of spiropyrazoline oxindoles.

**Acknowledgements:** This study was supported by FCT (Fundação para a Ciência e a Tecnologia, Portugal) by research projects PTDC/QUI-QUI/111664/2009, and Pest-OE/SAU/UI4013/2011.

[1] Wong, S. Y., *J. Exp. Clin. Canc. Res.* **2011**, 30, 87-100.

[2] Ribeiro, C. J. A.; Amaral, J. D.; Rodrigues, C. M. P.; Moreira, R.; Santos, M. M. M., *Bioorg. Med. Chem.* **2014**, 22, 577-84.

[3] Galliford, C. V.; Scheidt, K. A., *Angew. Chem Int Ed.* **2007**, 46, 8748-8758.

[4] Monteiro, A.; Gonçalves, L. M.; Santos, M. M. M., *Eur. J. Med. Chem.* **2014**, (revised).

## OC2 - Enzymes – An attractive tool to obtain enantiomeric pure sec-alcohols

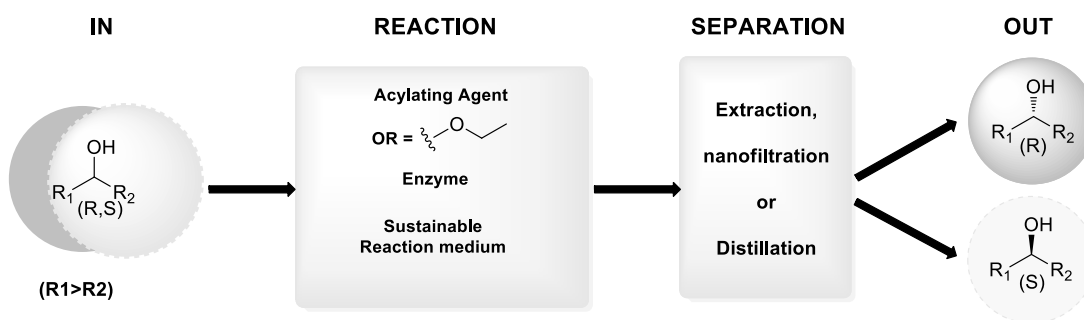
Monteiro, C.M.<sup>1,\*</sup> Lourenço, N. M. T.<sup>2</sup>, Afonso, C. A. M.<sup>1</sup>

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Sec-alcohols are of wide interest as building blocks in organic chemistry, namely due to their biological relevance and versatile functional group transformation. In numerous cases both enantiomers are important, the resolution of racemic alcohols is an attractive approach. Our quest has been the development of appealing, competitive and more sustainable processes for the enzymatic-resolution of secondary alcohols. Therefore, our effort have been made on the development of new strategies for the one-pot resolution-separation of free sec-alcohols by the use of new acylating agents.[1] The resolution-separation is based on the selective reaction of one alcohol enantiomer with acylating agent, where one enantiomer stays in medium, leaving the other enantiomer free to be removed. The anchored enantiomer can be isolated by a second enzymatic reversible reaction. With this approach is possible to obtain both free enantiomers using only the biocatalyst and a sustainable acylating agent. The main advantage of this approach is the possibility to circumvent the limitations of the common existing technology, specifically the use of chromatography separations, the use of organic solvents and post-chemical transformations for the isolation of free enantiomers. This methodology is quite simple, robust and reliable allowing the reuse of the medium and enzyme. Herein, is resumed different strategies developed for the enzymatic one-pot resolution-separation of several sec-alcohols.



Scheme: Methodology for separation-resolution of secondary alcohols.

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[1] Lourenço, N.M.T., Afonso, C. A. M. *Angew. Chem. Int. Ed.*, 2007, 46, 8178;

## OC3 - Synthesis and biological evaluation of spiroisoxazoline oxindoles as anticancer agents

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Tumor suppressor p53 plays a pivotal role in the regulation of cell cycle, apoptosis, DNA repair, senescence and angiogenesis, and consequently carcinogenesis. In wild-type p53 tumors, overexpression of the p53 negative regulator MDM2 is implicated in the inactivation of p53 function. Restoring p53 levels through disruption of p53–MDM2 interaction has been proved to be a valuable approach in fighting cancer. [1]

Due to the fact that mimicking p53 entails three hydrophobic moieties, eighteen spiroisoxazoline oxindole derivatives (Figure 1) were synthesized with different substituents attached to the three phenyl rings to probe their capacity of inhibiting p53–MDM2 interaction. [2,3]

Screening the compounds in human hepatocellular carcinoma cell line (HepG2) revealed that derivatives with chloro or bromo groups at position 6 of the oxindole ring were more active than the positive control nutlin-3. To investigate if cytotoxicity was mediated by p53, all compounds more active than nutlin-3 were tested in three other cell lines with different p53 status: an isogenic pair of wild type p53 and null human colorectal cancer cell lines [HCT116 p53(+/+) and p53(-/-)]; and a p53 mutant human colorectal adenocarcinoma cell line (SW620). Although all compounds showed only a marginal increase in potency in cell lines harboring wild type p53, their inhibitory activity profile was comparable to that of nutlin-3. Furthermore, evaluation of their ability to block the intracellular p53-MDM2 interaction and to activate p53 pathway was accomplished by employing a bimolecular fluorescence complementation assay (BiFC), [4] and by immunoblotting analysis, respectively. Derivatizations of the best compound obtained (**1**) are currently under construction and evaluation, with the most active derivative displaying a cell-based IC<sub>50</sub> of 4  $\mu$ M.

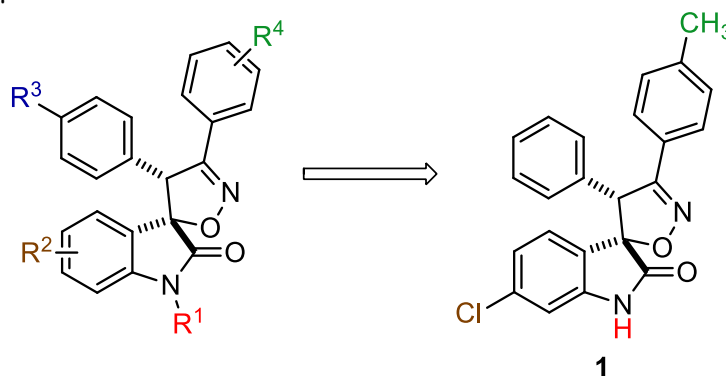


Figure 1: Spiroisoxazoline oxindole scaffold.

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- [1] Cheok, C. F.; Verma, C. S.; Baselga, J.; Lane, D. P., *Nat. Rev. Clin. Oncol.* **2011**, 8, 25-37.
- [2] Ribeiro, C. J. A.; Amaral, J. D.; Rodrigues, C. M. P.; Moreira, R.; Santos, M. M. M., *Bioorg. Med. Chem.* **2014**, 22, 577-584.
- [3] Ribeiro, C. J. A.; Kumar, S. P.; Moreira, R.; Santos, M. M. M., *Tetrahedron Lett.* **2012**, 53, 281-28.
- [4] Amaral, J. D.; Herrera, F.; Rodrigues, P. M.; Dionísio, P. A.; Outeiro, T. F.; Rodrigues, C. M. P., *Biochem. Pharmacol.* **2013**, 85, 745-752.

## OC4 - Sustainable Tandem Reactions Involving Hydroformylation

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Hydroformylation reaction is a crucial process to prepare several synthetically useful aldehydes, which can be sequentially transformed into high value products due to the versatile chemistry of the aldehyde group. [1, 2]

Therefore, following the growing interest of modern organic chemistry in the design of highly efficient sequential chemical reactions, which allows the maximization of structural complexity and diversity with just a minimum number of synthetic isolated steps, hydroformylation is a powerful synthetic tool to be incorporated in multi-step reactions.

In this communication we present the results for sequential rhodium catalysed hydroformylation of olefins, followed by different sequential transformations, namely hydroformylation/aldehyde arylation, [3] -imine arylation, -cyanosilylation, [4] -reductive amination and -Strecker (Figure 1).

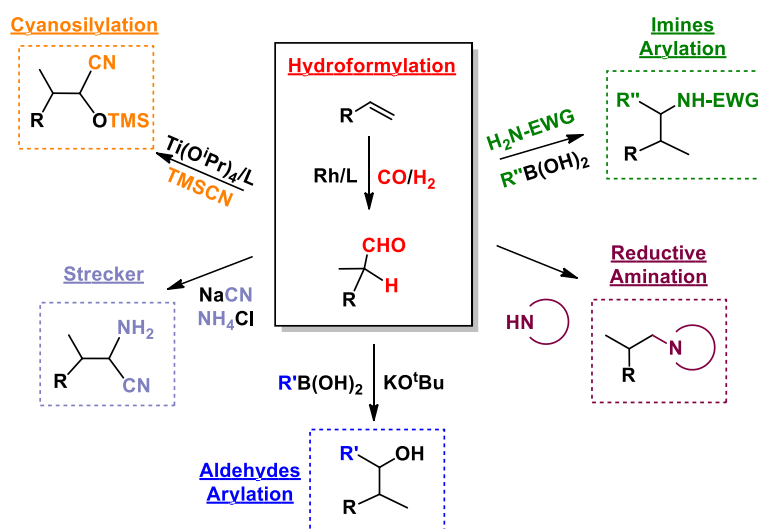


Figure 1: Sequential reactions involving hydroformylation

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[1] Peixoto, A. F.; Melo, D. S.; Fernandes, T. F.; Fonseca, Y.; Gusevskaya, E. V.; Silva, A. M. S.; Contreras, R. R.; Reyes, M.; Usubillaga, A.; Santos, E. N.; Pereira, M. M.; Bayón, J. C., *Appl. Catal., A* **2008**, 340, 212-219.

[2] Eilbracht, P.; Schmidt, A. M., *Top. Organomet. Chem.* **2006**, 18, 65–95.

[3] Almeida, A. R.; Dias, R. D.; Monteiro, C. J. P.; Abreu, A. R.; Gois, P. M. P.; Bayon, J. C.; Pereira, M. M., *Adv. Synth. Catal.* **2014** in press.

[4] Pereira, M. M.; Neves, A. C. B.; Calvete, M. J. F.; Dias, L. D.; Fernandes, A., *Catalysis Today* **2013**, 218– 219, 99– 106.

## OC5 - Computational Study of G2 Checkpoint Protein Kinases-Inhibitor Complexes

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In the field of drug discovery the focus on protein kinases is increasing. This class of enzymes was already one of the major targets for drug discovery programs in cancer treatment, with hundreds of molecules undergoing clinical trials and with more than 20 already approved drugs. Since this class of molecules is present in virtually all process of the eukaryotic cell, especially in signal transduction and cell cycle control, the usage of protein kinase inhibitors has a vast spectrum of applications [1].

We focused our attention in the protein kinases involved in the cell cycle, particularly those involved in checkpoints. Cell cycle checkpoints are control mechanisms that have the ability to arrest the cycle if the conditions aren't the ideal to its progression. Protein p53 is of major importance in the start checkpoint (G1) however the gene coding this protein is commonly mutated in cancer cells. With the loss of p53 G1 checkpoint is lost. Through the inhibition or abrogation of G2 checkpoint p53-deficient tumour cells lose another checkpoint. Thus resulting in a catastrophic mitotic process that leads to apoptosis. By targeting protein kinases it is possible to inhibit G2 checkpoint [2].

In our study we use a computational approach to study the binding site of Ser/Thr protein kinases, the largest and most relevant class in this family [3]. We aim the comprehension of the binding properties of already known kinase inhibitors and, using the obtained knowledge, improve the binding potential. To achieve this objective we performed semi-empirical calculations obtaining the binding energy of the complexes kinase-compound. With the obtained data it is also possible to identify the favourable and the unfavourable residues to the formation of the complexes, and determine the contribution of each.

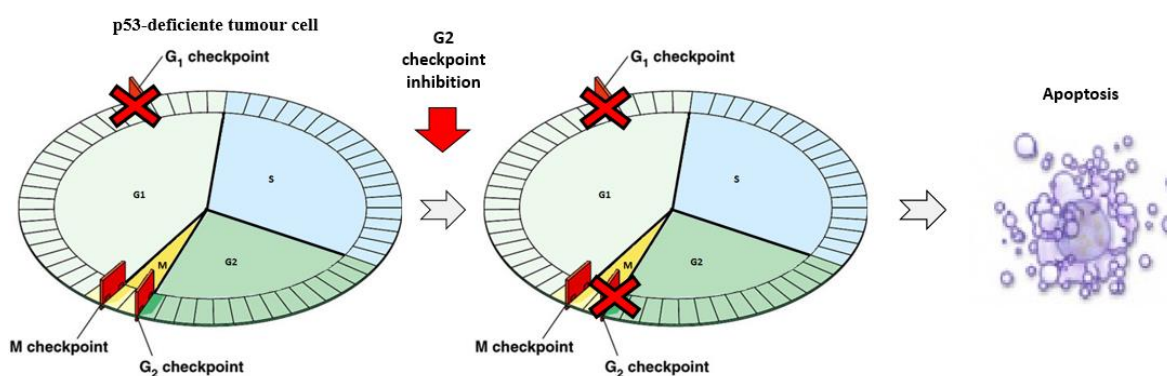


Figure 1: Schematic representation of the outcome when G1 and G2 checkpoints are absent simultaneously.

[1] P. Cohen, ACS Chem. Biol. 2013, 8, 96–104.

[2] C.X. Ma, S. Cai, S. Li, C.E. Ryan, Z. Guo, W.T. Schaiff, et al., J. Clin. Invest. 2012, 122, 1541–1552.

[3] P.M.M. Araújo, L. Pinto da Silva, J.C.G. Esteves da Silva, Chem. Phys. Lett. 2014, 591, 273–276

## OC6 - Straightforward synthesis to pyrido[2,3-*d*]pyrimidine-2,4-diones and their ADME properties

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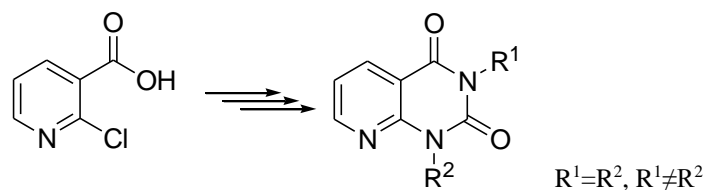
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Pyridines and pyrimidines have proven to be very valuable building blocks because of diverse pharmacological activities.<sup>[1]</sup> Pyrido[2,3-*d*]pyrimides exhibit a variety of promising pharmacological activities.<sup>[2]</sup> Various methods are known for the synthesis of pyrido[2,3-*d*]pyrimidine-2,4(1*H*,3*H*)-diones.<sup>[3]</sup>

We wish to present a simple and efficient protocol for the synthesis of pyrido[2,3-*d*]pyrimidine-2,4(1*H*,3*H*)-diones. The method starts from 2-chloropyridine-3-carboxylic acid by esterification, nucleophilic aromatic substitution and amide formation in one step, and ring closure. This synthesis allows for synthesis with two identical or two different groups attached to nitrogen. The structural diversity of these pyrido[2,3-*d*]pyrimidine-2,4(1*H*,3*H*)-diones resulted in significant variation in the biopharmaceutical properties.



The selective nucleophilic aromatic substitution with sterically hindered amines at C1 (cyclopropylamine, *t*-butylamine, 1-adamantylamine) is more difficult than with other amines (e. g. allylamine, butylamine, *i*-pentylamine). Amines with a sterically hindered C2, allows a synthesis of *N*-alkyl 2-(alkylamino)-3-pyridinecarboxamides in good yields. The ring closure proceed in good yields of pyrido[2,3-*d*]pyrimidine-2,4(1*H*,3*H*)-diones.

The results indicate remarkable structural dependency of intestinal solubility, permeability and hepatic metabolism, which will influence compound decisions during drug development. The structural differences of the selected pyrido[2,3-*d*]pyrimidine-2,4(1*H*,3*H*)-diones highly influenced the compounds' drug-like properties.

[1] Ravi Kanth, S.; Venkat Reddy, G.; Hara Kishore, K.; Shanthan Rao, P.; Narsaiah, B.; Surya Narayana Murthy, U., *Eur. J. Med. Chem.* **2006**, *41*, 1011-1016.

[2] Samai, S.; Chandra Nandi, G.; Chowdhury, S.; Shankar Singh, M., *Tetrahedron* **2011**, *67*, 5935-5941.

[3] a) Iaroshenko, V. O.; Vilches-Herrera, M.; Gevorgyan, A.; Mkrtchyan, S.; Arakelyan, K.; Ostrovskiy, D.; Abbasi, M. S.A.; Supe, L.; Hakobyan, A.; Villinger, A.; Volochnyuk, D. M.; Tolmachev, A., *Tetrahedron* **2013**, *69*, 1217-1228; b) Pike, K. G.; Malagu, K.; Hummersone, M. G.; Menear, K. A.; Duggan, H. M. E.; Gomez, S.; Martin, N. M. B.; Ruston, L.; Pass, S. L.; Pass, M., *Bioorg. Med. Chem. Lett.* **2013**, *23*, 1212-1216.

## OC7 - Targeting the erythrocytic and liver stages of malaria parasite with s-triazine-based hybrids

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Malaria is a deadly disease that, despite being preventable and curable, is threatening the world wide health. It is caused by Plasmodium parasites that are transmitted to people through the bites of infected female Anopheles mosquitoes[1].

A considerable range of structurally diverse antimalarial drugs is under research but an efficient molecule in both liver and blood stages was not yet established. The major problem in finding an effective molecule against malaria is that Plasmodium parasite gains a fast resistance to the new drugs[2]. Combination of structures known to have antimalarial activity – hybrids - is a very used strategy to circumvent this inefficiency drawback. Hybrids have shown to be beneficial once it is possible to reach several biological targets by attaching different structures that act by different mechanisms in one single molecule[3]. Among them, s-triazine is a versatile core widely applied in the synthesis of hybrids with antimalarial activity, namely 4-aminoquinoline-s-triazine[4].

Primaquine is an 8-aminoquinoline compound which presents the highest activity in liver stage. It is also the only registered drug for radical cure of blood and liver stages malaria caused by *P. vivax* and *P. ovale* infection[5].

Herein we study the combination of the liver stage active primaquine with s-triazine core, aiming to find a hybrid molecule active in both liver and blood stage of malaria disease. In vitro tests in blood stage against *P. falciparum* W2 strain have shown encouraging results, for s-triazine hybrids carrying one or two primaquine moieties were obtained IC<sub>50</sub> ranging from 0.2 to 8.3 microM. One primaquine-s-triazine hybrid also showed promising results in in vitro human hepatoma Huh-7 cells infected with a firefly luciferase-expressing *P. berghei* line at a 1 microM dose.

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[1] <http://www.who.int/mediacentre/factsheets/fs094/en/>, visited in 17-03-2014.

[2] (a) O. Dechy-Cabaret, F. Benoit-Vical, *Journal of Medicinal Chemistry* **2012**, 55, 10328-10344; (b) P. F. Salas, C. Herrmann, C. Orvig, *Chemical Reviews* **2013**, 113 (5), 3450–3492

[3] B. Meunier, *Accounts Chem. Res.* **2008**, 41, 69-77.

[4] (a) S. Manohar, S. I. Khan, D. S. Rawat, *Bioorganic & Medicinal Chemistry Letters* 2010, 20, 322-325; (b) A. Kumar, K. Srivastava, S. R. Kumar, M. I. Siddiqi, S. K. Puri, J. K. Sexana, P. M. S. Chauhan, *European Journal of Medicinal Chemistry* **2011**, 46, 676-690; (c) M. Sharma, K. Chauhan, S. S. Chauhan, A. Kumar, S. V. Singh, J. K. Saxena, P. Agarwal, K. Srivastava, S. R. Kumar, S. K. Puri, P. Shah, M. I. Siddiqi, P. M. S. Chauhan, *MedChemComm* **2012**, 3, 71-79.

[5] N. Vale, R. Moreira, P. Gomes, *European Journal of Medicinal Chemistry* **2009**, 44, 937-953.

## OC8 - An efficient synthetic route towards new antimicrobial deoxy sugars with anti-ageing potential - assessing the importance of configuration and deoxygenation pattern

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The increasing average life expectancy in developed countries led to an escalating concern regarding geriatric infectious diseases. Infections in elderly populations are known to be not only more frequent but also more severe, being this susceptibility often related to neurodegenerative diseases such as dementia and Alzheimer's [1].

Sugar-based surfactants are a very appealing class of compounds due to their low toxicity and their synthesis from renewable resources. They are biocompatible and have various applications in personal care and food industry as detergents, pharmaceuticals and agrochemicals [2,3]. Alkyl 2-deoxy/2,6-dideoxy-*arabino*-hexopyranosides with a potent antimicrobial activity in several *Bacillus* species have been previously described by our research group [3]. Moreover, promising results arising from interaction studies of some of these 2,6-dideoxyglycosides with cystatin B amyloid fibrils, assessed by NMR spectroscopy, show their potential for neurodegenerative diseases as well. We are now motivated to investigate the effect of small structural and configurational changes, in the bioactivity of these interesting molecules.

To assess the significance of the *cis* orientation of the hydroxyl groups at C-3 and C-4, dodecyl 2,6-dideoxy-*L-arabino*-hexopyranoside and 2,6-dideoxy-*L-xylo*-hexopyranoside were synthesised by reaction of dodecanol with 3,4-di-*O*-acetyl-6-deoxy-*L*-glucal and 3,4-di-*O*-acetyl-6-deoxy-*L*-Fucal, respectively, using triphenylphosphane hydrobromide (TPHB), followed by deprotection.

On the other hand, aiming at a better insight of the importance of the deoxygenation pattern for the bioactivities presented by these glycosides, synthetic methodologies towards new alkyl 3-deoxy, 4-deoxy and 6-deoxy glycosides were investigated. 3-Deoxygenation of the glycosidic moiety was accomplished starting from diacetone-*D*-glucose, via reduction of glucosyl triflate using *n*-Bu<sub>4</sub>BH<sub>4</sub>, while the synthesis of 4-deoxy glycosidic precursor involves the dehydroxylation of a  $\alpha$ -hydroxylactone using the system Ph<sub>3</sub>P/I<sub>2</sub>/imidazole, as reported by our research group [4], after a selective oxidation of C-3 using PFC. Finally, the synthesis of 6-deoxy precursor was attained via iodide and subsequent reduction with LiAlH<sub>4</sub> at C-6.

Their antimicrobial activity will also be studied and presented. The compounds which synthesis is herein presented will be a key to determine a possible structure-activity relationship and to possibly find an optimised bioactive structure.

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- [1] Gavazzia G.; Krause K.-H. *Lancet Infec. Dis.* **2002**, 2 (11): 659-666.
- [2] Rauter A. P.; Lucas S.; Almeida T.; Sacoto D.; Ribeiro V.; Justino J.; Neves A.; Silva F. V. M.; Oliveira M. C.; Ferreira M. J.; Santos M. S.; Barbosa E.; *Carbohydr. Res.* **2005**, 340: 191-201.
- [3] Silva F.; Goulart M.; Justino J.; Neves A.; Santos F.; Caio J.; Lucas S.; Newton A.; Sacoto D.; Barbosa E.; Santos M. S.; Rauter A.P.; *Bioorg. Med. Chem.* **2008**, 16: 4083-4092.
- [4] Rauter, A. P., Fernandes, A. C., Czernecki, S., Valery, J.-M. *Journal of Organic Chemistry*, **1996**, 61: 3594-3598.

## OC9 - Bis-alkylamine indolo[3,2-*b*]quinolines as hemozoin ligands: antimalarial cytostatic and cytotoxic activities.

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Malaria, in particular infection with *Plasmodium falciparum*, the mostly lethal of the human malaria parasite species, is a global health problem. A major contributor to the problem is the emergence and spread of multidrug-resistant strains of *P. falciparum*.<sup>1</sup> Thus, there is an urgent need for novel drugs targeting parasite intra-erythrocytic stages to treat infected individuals. Malaria parasites have a complex life cycle. One of the most extensively studied stages is that of the red blood cell (RBC). In the RBC stage the parasite digests haemoglobin (Hb) into heme, a toxic by-product that is detoxified by a biomineralization process into a crystal structure called hemozoin (Hz) or malarial pigment.<sup>2</sup> Hb degradation and Hz formation are essential for parasite survival, making these processes important targets for antimalarial drug development. To get insight into the relevance of targeting Hz crystal, two isomeric series, *N*<sup>5</sup>,*N*<sup>10</sup>-bis-alkylamine (**1a-k**) and *N*<sup>10</sup>,*O*<sup>11</sup>-bis-alkylamine (**2a-k**) indolo[3,2-*b*]quinolines, were evaluated for their *in vitro* activity against chloroquine (CQ)-resistant and sensitive strains of *Plasmodium falciparum*. In general, compounds of series **2** were more active than isomers **1**, with IC<sub>50</sub>/LD<sub>50</sub> ranging from 25/233 nM (**2i**) to 1.3 (**2a**)/10.7 (**2b**) μM. SAR analyses showed that lipophilicity and chlorine substitution at C3 increased both cytostatic and cytotoxic activities. Also, cytostatic and cytotoxic activities of series **2**, but not those of isomers **1**, correlated with calculated vacuole accumulation ratios (VAR), suggesting different capacities of **1** and **2** to bind to Hz crystal face {001} exposed on vacuole aqueous medium.

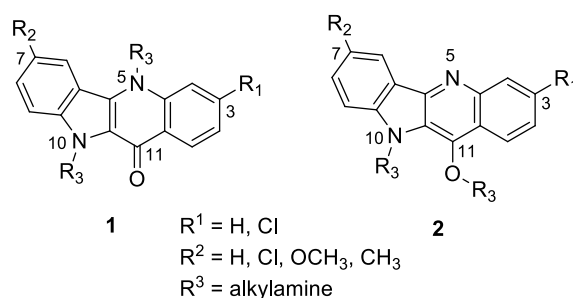


Figure 1 - Bis-alkylamine indolo[3,2-*b*]quinolines **1** and **2**.

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[1] Alonso, P. L.; Djimde, A.; Kremsner, P.; Magill, A.; Milman, J.; Najera, J.; Plowe, C. V.; Rabinovich, R.; Wells, T.; Yeung, S.; Drugs, m. C. G., *Plos Med.* **2011**, 8, e1000402.

[2] Bray, P. G.; Ward, S. A.; O'Neill, P. M., *Curr. Top. Microbiol.* **2005**, 295, 3-38.

## OC10 - Rational Design of Novel Anti-inflammatory drugs: is COX-2 selectivity an advantage?

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Nonsteroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen, naproxen or diclofenac are the most prescribed and commercialized therapeutic drugs in the last decades. The mechanism of action of these drugs comprises the inhibition of cyclooxygenase (COX), an enzyme involved in the inflammatory process. However, COX exists as two distinct isoforms, COX-1 and COX-2: while COX-1 is constitutively expressed in most cells, maintaining physiological functions, such as gastrointestinal protection, COX-2 is usually viewed (in a simplistic way) as the inducible isoform, implicated in the inflammatory process. [1]

The inhibition of both COX isoforms by NSAIDs frequently leads to gastric complications, encouraging the scientific community to develop potent and selective COX-2 inhibitors, commonly known as coxibs. However, some groups support that selective COX-2 inhibition is associated to an increased incidence of thrombotic events, which in fact were verified for rofecoxib – which caused acute cardiovascular side effects – and consequently was withdrawn from the market. [2] The solution can reside in new anti-inflammatory entities comprising a balanced inhibition of both isoenzymes. [3]

Our work consists on a rational drug design strategy to assemble and evaluate 1,2-disubstituted benzimidazole as potential anti-inflammatory drugs. This strategy comprised preliminary docking studies, a new synthetic route to prepare these compounds, STD-NMR experiments and evaluation of its *in vitro* biological activity in an iterative approach.

Herein we will present the latest results of our strategy to construct 1,2-disubstituted benzimidazoles as promising COX inhibitors and discuss how a balanced inhibition of COX isoforms can be a favorable characteristic for these new therapeutic targets.

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- [1] Laneuville, O.; Breuer, D.; Dewitt, T.; Funk, C.; Smith, W. *J. Pharmacol. Exp. Ther.* **1994**, 271, 927; b) Seibert, K.; Zhang, Y.; Leahy, K.; Hauser, S.; Masferrer, J.; Perkins, W.; Lee, L.; Isakson, P. C. *Proc. Natl. Acad. Sci.* **1994**, 91, 12013.
- [2] Roubille, C.; Martel-Pelletier, J.; Davy, J. M.; Haraoui, B.; Pelletier, J. P. *Antiinflamm. Antiallergy Agents Med. Chem.* **2013**, 12, 55.
- [3] Funk, C. D.; FitzGerald, G. A. *J. Cardiovasc. Pharmacol.* **2007**, 50, 470.

# OC11 - Tackling API solubility and stability problems by developing new multicomponent crystal forms: Azelaic acid, Nalidixic acid and Dapsone

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Over the last years, multicomponent crystal forms (co-crystals, molecular salts and solvates) of active pharmaceutical ingredients (APIs) have been extensively studied by Pharmaceutical materials Science and Crystal Engineering. [1] These new multicomponent forms constitute a unique approach to solve API common problems, such as poor solubility, stability and/or bioavailability, by improving the physicochemical properties without affecting their pharmacological behavior. [1] Having this in mind we decided to tackle solubility issues in 3 different APIs, having poor to very poor solubility in water. Azelaic acid, an antibacterial product used in the treatment of acne, has low solubility in water and its performance would benefit from solubility enhancement. [2] Recently, we developed new co-crystals with *N*-heterocyclic molecules. Results show an improvement of physicochemical properties, in particular solubility and thermal stability. Nalidixic acid and dapsone are antibiotics used for the treatment of urinary tract infections and pneumonia, tuberculosis and Alzheimer, respectively. [3, 4] These APIs are almost insoluble in water and the improvement of this property is a point of huge interest in our research project. Work developed with nalidixic acid led to the discovery of a molecular salt with morpholine, soluble in water. For dapsone, we produced two co-crystals with  $\epsilon$ -caprolactam and 4,4'-bipyridine that show different physicochemical properties from dapsone. [3] Structural, chemical and thermal characterization were carried out for all the systems and some of the results are presented here.

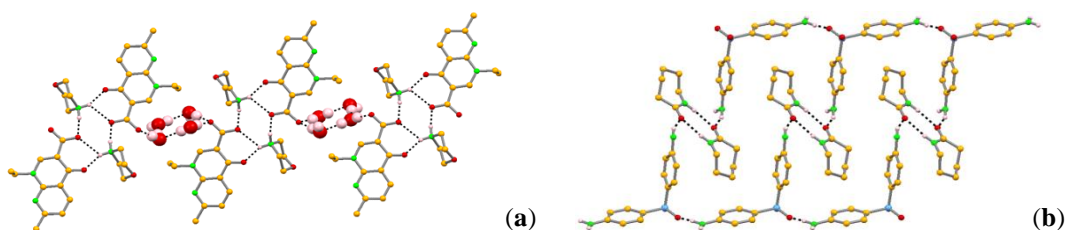


Figure 1. Packing diagrams of (a) molecular salt hydrate of nalidixic acid with morpholine; (b) co-crystal of dapsone with  $\epsilon$ -caprolactam

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- [1] André, V.; Piedade, M. F. M.; Duarte, M. T., *CrystEngComm* **2012**, 14, 5005-5014.
- [2] Braga, D.; Maini, L.; Sanctis, G.; Rubini, K.; Grepioni, F.; Chierotti, M. R.; Gobetto, R., *Chem.Eur.J.* **2003**, 9, 5538.
- [3] Martins, I.; Martins, M.; Fernandes, A.; André, V.; Duarte, M. T., *CrystEngComm* **2013**, 15, 8173.
- [4] Gangavaram, S.; Raghavender, S.; Sanphui, P.; Pahl, S.; Manjunatha, G., *Cryst. Growth Des.* **2012**, 12, 4963-4971.

## OC12 - Novel Ionic Liquids as Active Pharmaceutical Ingredients (ILs-APIs) based on Ibuprofen and Naproxen

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The most usual way of drug administration is using solid formulations, being its therapeutic efficacy related to their crystalline structure. The polymorphism appears as a problem in the pharmaceutical industry, and its control is extremely important in the development of new drugs since the modification of the drug crystalline structure can modify its properties [1]. Ionic Liquids (ILs) such as organic salts whose melting point is below 100 C (many of them are liquids at room temperature) have been largely applied in different research areas due to its peculiar properties. Recently, Ionic Liquids as Active Pharmaceutical Ingredients (ILs-APIs) have been reported as alternative pharmaceutical salts that can solve the polymorphism problem, improve the bioavailability and their therapeutic effect [2]. Ibuprofen (1) and naproxen (2) are non-steroidal, anti-inflammatory and non-water soluble drugs. These compounds are a BCS (Biopharmaceutics Classification System) class II drugs i.e., high permeability and low solubility [3], [4]. In this work we have been developed new ILs-APIs based on ibuprofen and naproxen through their combination with the appropriate biocompatible counter ions (1-Ethyl-3-methyl-imidazolium, 1-Methoxyethyl-3-methyl-imidazolium, cetylpyridinium, N,N,N-ethyl(2-hidroxypropyl)dimethylammonium, tetraethylammonium, and N,N,N-2-(hidroxyethyl)trimethylammonium). All ILs-APIs prepared were completely characterized by spectroscopic techniques (e.g. <sup>1</sup>H NMR, <sup>13</sup>C NMR, FTIR) and detailed thermal studies were also performed (DSC). In some cases it was possible to eliminate or reduce the well-known characteristic polymorphism associated to ibuprofen and naproxen.

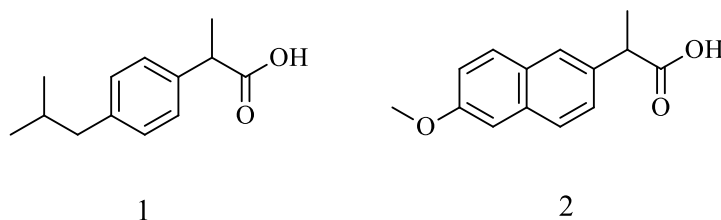


Figure 1: Structure of ibuprofen (1) and naproxen (2).

**Acknowledgements:** This work has been supported by FCT/MCTES (PTDC/CTM-NAN/120658/2010).

- [1] a) Hough, W. L. *et al*, *New J. Chem.* **2007**, 31, 1429; Ferraz, R. *et al*, *ChemMedChem*, **2011**, 6, 975 c) Ferraz, R. *et al*, *Med. Chem. Commun.*, **2012**, 3, 494  
[2] a) Variankval, N.; Cote, A. S.; Doherty, M. F., *AIChE Journal*, **2007**, 54(7), 1682-1687 b) Florindo, C. *et al*, *RSC Adv.*, **2014**(4), 4301-4307 c) Florindo, C *et al*, *International Journal of Pharmaceutics*, **2013**, 456, 553–559  
[3] Dudognon, E. *et al*, *Pharm Res*, **2013**, 30:81–89  
[4] Song, J.S. and Sohn, Y. T., *Arch Pharm Res*, **2011**, 34(1), 87-90

## OC13 - Luminescent supramolecular hydrogen-bonded frameworks

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Crystallization-induced emission enhancement is a recently described phenomenon [1], in which molecules that are non-emissive in solution become brightly luminescent upon crystallization. This was rationalized by a stiffening of the dye core, preventing non-emissive relaxation, and particular crystal packing avoiding the formation of  $\pi$  stacking [2]. In the work presented here, a family of diphenylmethane derivatives has been synthesized and their luminescence properties characterized. While in solution the bis-phenols are only weakly emissive, their crystals exhibit intense emission (Figure 1). In all the crystal structures, the carbonyl oxygen accepts two hydrogen bonds, one intra-molecular and one inter-molecular. This particular molecular packing stiffens the structure of the compounds via hydrogen bonds, as it prevents consecutive  $\pi$ - $\pi$  interactions. As a consequence, the bis-phenols derivatives become highly emissive in the crystalline state. On the contrary, the presence of water in the solid disrupts these hydrogen-bonded frameworks, and only amorphous materials can be obtained in humid environment. In this case, the solids are non-emissive [3].

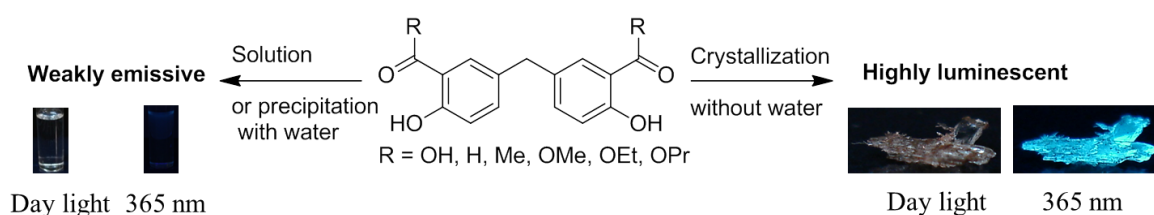


Figure 1 - Illustration of the bisphenols Crystallization-Induced Emission Enhancement.

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[1] *Aggregation-Induced Emission: Fundamentals*; Tang, B. Z., Qin, A., Eds.; John Wiley & Sons, 2014.

[2] Yan, D.; Evans, D. G., *Mater. Horiz.* **2014**, 1, 46-57.

[3] Guieu, S.; Rocha, J.; Silva, A. M. S., *Tetrahedron* **2013**, 69, 9329-9334.

## OC14 - Bipyridinium salts as reversible electrochromic materials

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Bipyridinium salts are prepared by mono or diquaternization of 4,4'-bipyridine scaffold using appropriate halide alkylating agents. These ionic species are electroactive and present electrochromic behavior as expected [1, 2]. The dication species are more attractive due to their higher electrochemical stability and the potential application as electrochromic material.

Novel electrochromic materials with reversible redox behaviour associated with a significant colour change have been prepared combining di- and tetrasubstituted bipyridinium cations with bis(trifluoromethanesulfonyl)imide (NTf<sub>2</sub>) and docusate (AOT) anions to give intrinsic electrochromic ionic liquids (Figure 1A)[3-5].

In this context, we developed more sustainable synthetic methods for preparation of these di- and tetracation salts with different alkyl or ether side substituents [4]. All bipyridinium salts were characterized by <sup>1</sup>H, <sup>13</sup>C and <sup>19</sup>F (in the case of NTf<sub>2</sub> as anion) NMR, FTIR, thermal and electrochemical (cyclic voltammetry, square wave voltammetry) studies. Rheological studies of Novel electrochromic room temperature ionic liquids have been performed.

The most promising electrochromic ionic liquids have been tested in the development of reversible and efficient liquid electrochromic cell as well as electrochromic devices (Figure 1B).

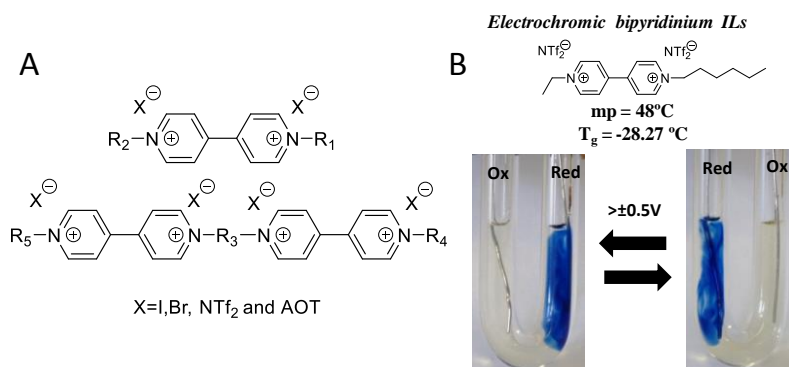


Figure 1: A) Di- and tetrasubstituted bipyridinium salts prepared in this work; B) Example of a reversible liquid electrochromic cell with disubstituted bipyridinium salts prepared in this work.

**Acknowledgements:** This work has been supported by FCT (PTDC/CTM-NAN/120658/2010).

- [1] Monk, P.M.S.; Mortimer, R. J., Rosseinsky, D. R. *Electrochromism and Electrochromic Devices*, Cambridge University Press, Cambridge, 2007.
- [2] Monk, P. M. S. *The Viologens: Physicochemical Properties, Synthesis and Applications of the Salts of 4,4'-bipyridine*, Wiley and Sons, Chichester, 1998.
- [3] Branco, A.; Branco, L.C.; Pinheiro, C.; Pina, F.; *Portuguese Patent Application 20101000067779*, 2010.
- [4] Branco, A.; Branco L.C.; Pina, F., *Chem. Commun.* 2011, 47, 2300-2302.
- [5] Jordão, N.; Cabrita, L.; Pina, F.; Branco, L.C., *Chem. Eur. J.* 2014, DOI: 10.1002/chem.201304451.

## OC15 – Fenton-like oxidation of small aromatic acids from biomass burning in water and in the absence of light: implications for atmospheric chemistry

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The oxidation of organic compounds from biomass burning in the troposphere is worthy of concern due to the uncertainty of chemical transformations that occur during the reactions and to the possibility of such compounds producing others more aggressive to the environment in general. In this work was studied the oxidation of relevant atmospheric organic compounds resulting from biomass burning, three small aromatic acids with similar molecular structures (benzoic, 4-hydroxybenzoic and 3,5-dihydroxybenzoic acids), in aqueous phase and in the absence of light. The oxidation process used was the Fenton-like reaction  $[H_2O_2/Fe(III)]$  and it was evaluated by ultraviolet-visible (UV-vis) and molecular fluorescence spectroscopies. The extent of oxidation of the small aromatic acids depended on the pH of the solution, and the rate of reaction increased as the pH decreased from neutral (5) to acid (4) in atmospheric waters. Even in the absence of light, Fenton-like oxidation of the three acids originated new chromophoric compounds, which tended to be more complex than the reactants, possibly with a high degree of unsaturation, aromaticity and substitution of the hydrogens in the benzene ring by hydroxyl groups. The rate of formation of colored compounds increased with the degree of substitution of the ring of the benzoic acid by hydroxyl groups. However, after the formation of new compounds they were total oxidized for 3,5-dihydroxybenzoic acid and only partial degraded for benzoic and 4-hydroxybenzoic acids, at least up to 48 h of reaction at pH 4.5. Furthermore, for the 3,5-dihydroxybenzoic acid the night period may be sufficient for a full degradation of acid and of their oxidation products in atmospheric waters. Thus, the results obtained in this study highlight that organic compounds from biomass burning with similar molecular structures may have different behavior regarding to their reactivity and persistence in atmospheric waters, even in the absence of light.

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## OC16 - Effect of the microstructure of the polymeric matrix on performance of PDLC devices

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Polymer dispersed liquid crystal (PDLC) films are a mixed phase of liquid crystals (LC) commonly dispersed as inclusions in a solid polymer. PDLC can be switched electrically from an opaque scattering state to a highly transparent state by application of an electric field. When the applied electric field is removed the PDLC can appear opaque again or a high transparency state is kept for a long period of time at room temperature. In this last case, such PDLC films have a permanent memory effect (PME) [1]. This effect can be related with the anchoring effect, i.e., the interaction between the liquid crystal and polymer matrix. The anchoring effect can be controlled by the size and the shape of liquid crystal domains, in other words by the microstructure of the polymer matrix [2,3,4,5]. PDLCs have two main morphologies: swiss cheese or polymer ball types each one with different characteristics. The PME seems to be exclusive of a polymer ball morphology, when formed microsized polymer balls are merged together to form a network that is in contact with a continuous liquid crystal phase [6]. This type of morphology implies a collective alignment of the LC molecules that tend to remained the alignment even after the removal of electric field. In the case of swiss cheese (isolated LC droplets), after the reorientation of LC molecules in each droplet upon application of an electric field, with the removal of the field, the LC molecules tend to return to the initial configuration to minimize the elastic free energy [7]. Therefore, we have been trying to have a deeper understanding of the microstructure of polymer matrix which would be a great help to establish the mechanisms responsible for the PME. The observation of the microstructure of the polymer matrix has been traditionally carried out by scanning electron microscopy (SEM). However, we also use the confocal optical microscopy for the nondestructive study of PDLC morphology (Fig.1). We pretend analyse the structure in three dimensions through the digital image analysis on a stack of such optical sections.

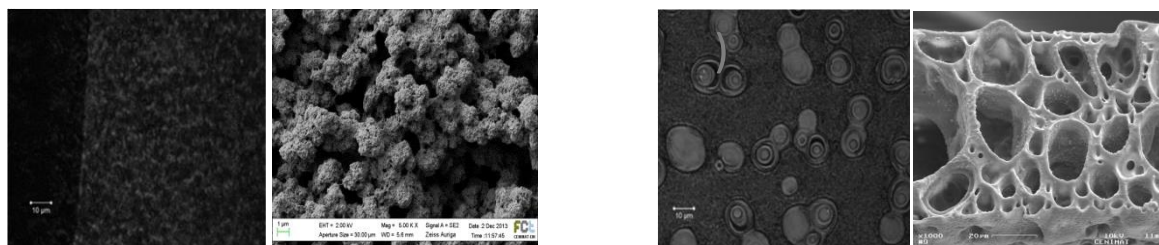


Figure 1 – Confocal microscope images of PDLC films (a, c) and SEM micrographs (b, d) with polymer ball (left) and swiss cheese (right) morphologies.

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- [1] Drazaic, PS. *Liquid Crystal Dispersions*, 1rd ed. World Scientific Publishing: Singapore, 1995.
- [2] Bedjaoui L, Gogibus N, Ewen B, Pakula T, Coqueret X, Benmouna M, Maschke U. *Polymer* **2004**; 45: 6555-6560.
- [3] Amundson K, Blaaderen AV, Wiltzius P. *Am. Phys. Soc.* **1997**;55:1646-1654.
- [4] Andy F Y G, Tsung CK, Mo HL. *J. Appl.Phys.* **1992**;31:3366-3369.
- [5] Rumiko Y, Susumu S. *J. Appl. Phys.* **1992**;31:254-256.
- [6] Mouquinho A, Petrova K, Barros MT, Sotomayor “New Polymer Networks for PDLC Films Application” (chapter 5), Ailton de Sousa Gomes (ed), Polymerization/Book 2. Intech, 2012. [7] Han J., *Korean J. Phys.Soc.* **2006**;49:1482-1487.

## OC17 - Study of the Photostability of UV-filters 4-Methylbenzylidene Camphor and Octocrylene in Chlorinated Water

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The increasing concern about the effects of solar ultraviolet (UV) radiation resulted, in the last decades, in an increased production and use of UV filters. UV filters are vital ingredients of sunscreens and other personal care products as they absorb, reflect and/or scatter UV radiation (320-400 nm for UVA and 290-320 nm for UVB), therefore protecting us from its harmful effects on human skin and health. On the basis of their increasing production and use UV-filters are expected to be found in aquatic environments. UV-filters have been detected in surface water, waste water and in chlorinated waters, but it's rather scarce the data related with their fate in swimming pools [1]. A number of UV-filters are known to undergo degradation under sun exposure and it is thus expected that they will photo-degrade in outdoor swimming pools [2]. Chlorinated water can also promote their degradation leading to the formation of chlorinated by products which are considered to be more toxic than the parent UV-filters [3]. Here we report the results of a study on the photostability of two commonly used UVB-filters: 4-methylbenzylidene camphor and octocrylene in deionized water and in chlorinated water under natural and artificial sunlight. The analysis of the UV-filters and transformation/degradation products was performed by UV-Vis spectrometry and HPLC-MS.

- [1] Santos, A. J. M.; Miranda, M. S.; Esteves da Silva, J. C. G., *Water Research* **2012**, 46, 3167-3176.
- [2] Rodil, R.; Moeder, M.; Altenburger, R.; Schmitt-Jansen, M., *Analytical and Bioanalytical Chemistry* **2009**, 395, 1513-1524
- [3] Santos, A. J. M.; Crista, D. M. A.; Miranda, M. S.; Almeida, I. F.; Sousa e Silva, J. P.; Costa, P. C.; Amaral, M. H.; Lobão, P. A. L.; Sousa Lobo, J. M.; Esteves da Silva, J. C. G., *Environmental Chemistry* **2013**, 10, 127-134.

## OC 18 - Insights into the world of pharmaceuticals using mechanochemistry: Polymorphs, co-crystals and bio-inspired metal organic frameworks

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Mechanochemistry is an amazing environment-friendly technique with a very wide scope of applications, that has proved to promote, promptly and quantitatively, reactions between solids, with either no added solvent or only using catalytic amounts of solvent (liquid-assisted grinding, LAG) or even also catalytic amounts of an ionic salt (ion- and liquid-assisted grinding, ILAG) [1].

In supramolecular synthesis, mechanochemistry is nowadays extensively used to obtain multicomponent molecular crystals. This issue assumes a special interest in the pharmaceutical field as new solid forms can improve relevant properties such as dissolution rate, solubility, thermal and hydration stability, or compressibility [2]. We have obtained not only different polymorphs, but also several co-crystals and other multicomponent crystal forms of different active pharmaceutical ingredients using this technique, which has shown to be particularly excellent when dealing with two compounds with very different solubility, such as gabapentin and terephthalic acid, the later being insoluble in most common acceptable solvents [3].

Also in the field of coordination complexes with pharmacologically active molecules - which metallodrugs and metallopharmaceuticals - mechanochemistry is an alternative synthetic pathway with several advantages. Our most relevant work in this area was the rapid, efficient, and selective synthesis by ILAG of bismuth subsalicylate, as well as of two other bismuth salicylates, directly from Bi<sub>2</sub>O<sub>3</sub>, revealing the first crystal structure of a bismuth salicylate without auxiliary ligands [4].

More recently, we are exploring bio-inspired metal organic frameworks for controlled drug release. Even though this type of compounds is traditionally synthesized by solvothermal methods, we are obtaining interesting results with mechanochemistry. As an example, we have synthesized a dapsone:Ni compound whose crystal structure solution from ESRF data is being attempted.

Mechanochemistry is undoubtedly a versatile synthetic technique that is nowadays successfully applied to a very wide range of reactions.



Mechanochemistry towards the discovery of new API crystal forms

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[1] Duer, M. J. *Angew. Chem. Int. Ed.* **2010**, 49, 712.

[2] Rodriguez-Hornedo, N. *Cryst. Growth Des.* **2009**, 9, 2252.

[3] Andre, V.; Fernandes, A.; Santos, P.P.; Duarte, M.T. *Cryst. Growth Des.* **2011**, 11, 2325–2334.

[4] Andre, V.; Hardeman, A.; Halasz, I.; Stein, R. S.; Jackson, G. J.; Reid, D. G.; Duer, M. J.; Curfs, C.; Duarte, M. T.; Friscic, T. *Angew. Chem. Int. Ed.* **2011**, 50, 7858.

## OC19 - Role of the Base and Control of Selectivity in the Suzuki–Miyaura Cross–Coupling Reaction.

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The outcome of the Suzuki–Miyaura cross-coupling [1, 2] for the direct competition reaction between two boronic acids was evaluated under routine synthesis conditions. The reaction selectivity was found to depend on the amount of the base used, with fewer bases favoring the reactivity of the boronic acid with lower  $pK_a$  (stronger acid). The dependence of the reaction selectivity on base stoichiometry was found to increase with the increase in the difference in the  $pK_a$  values of the competing boronic acids. These results confirm a relationship between acid–base chemistry and the Suzuki–Miyaura reaction catalytic cycle. Moreover, the results indicate that under these specific conditions, the most reactive organoboron species toward transmetalation is the borate anion  $R-B(OH)_3^-$  instead of the neutral boronic acid  $R-B(OH)_2$ . Hence, the main role of the base in the reaction mechanism is to increase the reactivity of the boronic acid toward the Pd–halide complex by converting it into the respective organoborate. In addition, boric acid, an important reaction byproduct, affects the selectivity in the Suzuki reaction because its gradual formation in the reaction medium disturbs the acid–base equilibrium.

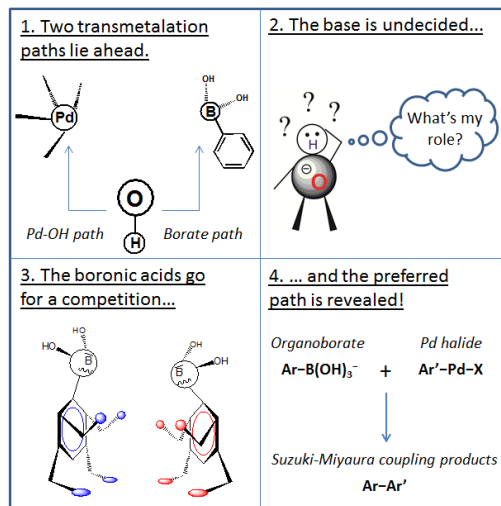


Figure 1: Organoborates compete in Suzuki–Miyaura cross-couplings.

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[1] Miyaura, N.; Suzuki, A., *Chem. Rev.* **1995**, 95, 2457.

[2] Suzuki, A., *Angew. Chem. Int. Ed.* **2011**, 50, 6722.

## OC20 - Phosphorescent wood oil

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Portugal has an important traditional wood industry with strong export capability. However, R&D and innovation in this industrial sector is not common. In order to increase international competitiveness of the Portuguese wood products scientific and/or technological innovations are welcome to this sector. In a University/Industry R&D project a new treatment for wood was developed that confers wood with the property of glowing in the dark after being exposed to natural and/or artificial light (phosphorescent wood). This technology was licensed to Strong Export Lda for all over the world and it has already been presented to international fairs. Phosphorescent wood oil describes a new product for wood that incorporates wood oils and long persistent phosphors among other components. This product constitute a technology for wood treatment that allows, after its application, the development of phosphorescent wood planks, i.e, wood planks that emit green, turquoise and violet blue light in the dark by a phosphorescent mechanism after being exposed to natural or artificial light. The phosphorescence of the wood planks persists visible in the dark after exposition to heavy rain (water) and shows good resistance to physical wear. This product can be applied to wood (indoor or outdoor) with the following proposes: decoration; safety; energy economy; etc. This new wood oil solves the problem of conferring the surface of wood a long persistent glow in the dark property by a straightforward technology. In this communication the technology will be demonstrated and samples will be shown. Also, the strategic advances of the technology for a wood industry will be discussed.



Figure 1 - Wood planks with phosphorescent wood oil.

# OC21 - Insights on the Nanostructuration of Ionic Liquids by Infrared Spectroscopy

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Ionic Liquids (ILs) are salts with a melting point lower than 100°C. They are usually constituted by an organic cation and an organic or inorganic anion. Due to their unusual properties (low vapour pressures, high thermal stabilities) and wide range of applications they have been gaining popularity [1]. Aiming to understand the interplay between their structure and their properties, they have been extensively studied. It had been already evidenced both experimentally [2, 3] and by molecular simulations [4] that ILs are nanostructured. In this work the nanostructuration of ILs was explored by FTIR spectroscopy in the  $[C_{N-1}C_1im][NTf_2]$  and  $[C_{N-1}C_1im][PF_6]$  ILs series (fig.1) giving some additional insights concerning the effect of the alkyl side chain length and the anion effect (fig.2) in their nanostructuration and the CALS (critical alkyl length size).

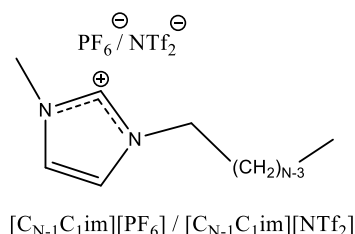


Figure 1 - Chemical structure of the studied compounds.

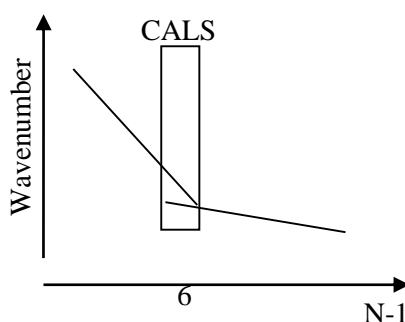


Figure 2 - Schematic representation of the variation of wavenumber of C-H stretching vibrations with the variation of the alkyl side chain length.

- [1] Plechkova, N.V.; K.R. Seddon, *Chemical Society Reviews* **2008**, 37 (1), 123-150.
- [2] Rocha, M.A.A., Bastos, M.; Coutinho, J. A. P.; Santos, L. M. N. B. F., *The Journal of Chemical Thermodynamics* **2012**, 53 (0), 140-143.
- [3] Rocha, M.A.A., et al. *The Journal of Physical Chemistry B* **2011**, 115 (37), 10919-10926.
- [4] Lopes, C.; Pádua, J.N.A.; A.A. *The Journal of Physical Chemistry B* **2006**, 110 (7), 3330-3335.

## OC22 - Silica-bound sulfonic acid catalysts for esterification reactions

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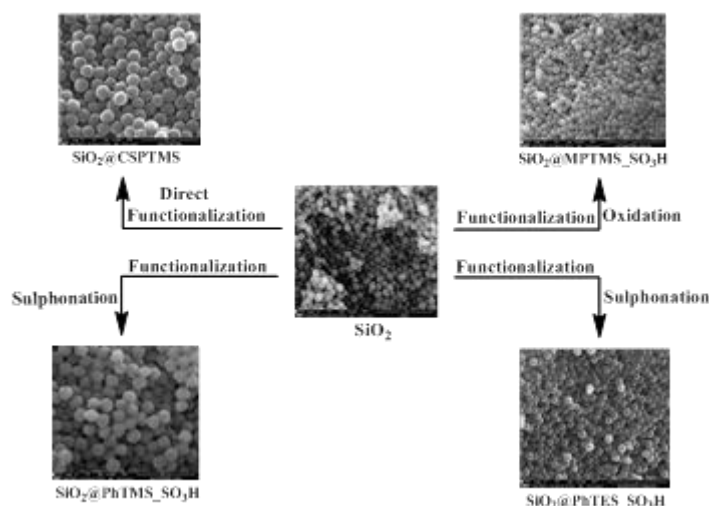
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The development of selective and reusable solid acid catalysts to be applied in a wide variety of organic reactions has been a very attractive area of research. Large pore size to minimize diffusion problems, high concentration of acid sites, high stability and reusability are the main properties which needs to be considering for a good solid acid catalyst [1,2].

Esterification reaction is one of the most important chemical reaction for the preparation of alkyl esters which are useful as solvents, artificial flavors, plasticizers and essences for perfumery industry. Esters are commonly prepared using  $H_2SO_4$  as liquid catalyst, but this often causes problems such as corrosion, toxicity and production of a large amount of byproducts. So, a global effort has been made to replace conventional acid liquid catalysts by efficient solid acids catalysts, easily recovered, less toxic and reusable [3].

Here in we present a set of acid solid catalysts prepared from silica by functionalization with different organosilanes, (3-mercaptopropyl)-trimethoxysilane (MPTMS), phenyltrimethoxysilane (PhTMS), phenyltriethoxysilane (PhTES) and 2-(4-chlorosulfonylphenyl)ethyltrimethoxysilane (CSPTMS), scheme 1. The MPTMS- and the PhTES- functionalized silica were then transformed in sulfonic acid groups. The final silica sulfonic-acid materials were characterized by Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), Fourier Transform Infrared Spectroscopy (FTIR) and  $pH_{pzc}$ . The catalytic activity was investigated towards esterification of linoleic acid with methanol. Silica-CSPTMS exhibited significantly higher catalytic activity and stability than any of the previously reported catalysts. It could be easily recovered and reused for six times at least with good conversion (~ 98%).



Scheme 1

**Acknowledgements:** FCT and FEDER through grant no. PEst-C/EQB/LA0006/2011 and through Operation NORTE-07-0124-FEDER-000067 – NANOCHEMISTRY funded by FEDER and CCDRN. AFPeixoto thanks FCT post-doc grant (SFRH/BPD/72126/2010).

- [1] Corma, A.; Garcia, H. *Adv. Synth. Catal.* **2006**, 348, 1391-1412.  
[2] Clippel, F.; Dusselier, M.; Van de Vyver, S.; Peng, L.; Jacobs, P. A.; Sels, B. F. *Green Chem.* **2013**, 15, 1398-1430.  
[3] Alvaro, M.; Corma, A.; Das, D.; Fornés, V.; García, H. *J. Catal.* **2005**, 231, 48–55.

## OC23 - Chemistry in the e-lab: a new wave

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The e-lab ([www.elab.ist.utl.pt](http://www.elab.ist.utl.pt)) is a remotely controlled laboratory that allows students of primary and secondary school to consolidate their knowledge in science and hence develop their scientific skills, matters that have been confirmed in the classroom since 2009-2010, after the conduction of a pilot study [1,2].

In operation in Instituto Superior Técnico (IST) since 1999-2000, the e-lab has recently undergone a usability study, and currently offers a simpler and user friendly interface, allowing easy access to the chosen experience. It has been used in the basic disciplines of Physics of the first cycle of higher education, but it was recently created an extension of the contents to primary and secondary levels of education, with some experiences and respective online content revised for this purpose.

Although most e-lab experiments are in Physics, at this time there are several experiments in Chemistry under investigation [3]. This investigation has started in 2012, and since then we have been studying the integration of several chemistry experiments in the platform. However, remote chemistry experiments are more difficult to execute in this kind of environment [4,5]. This is currently our main challenge. Nevertheless, in the near future several chemistry e-lab experiments working in real time will be available. Figure 1 shows the sketch of one of the chemistry e-lab experiments that we are working and intends to study a chemical equilibrium reaction.

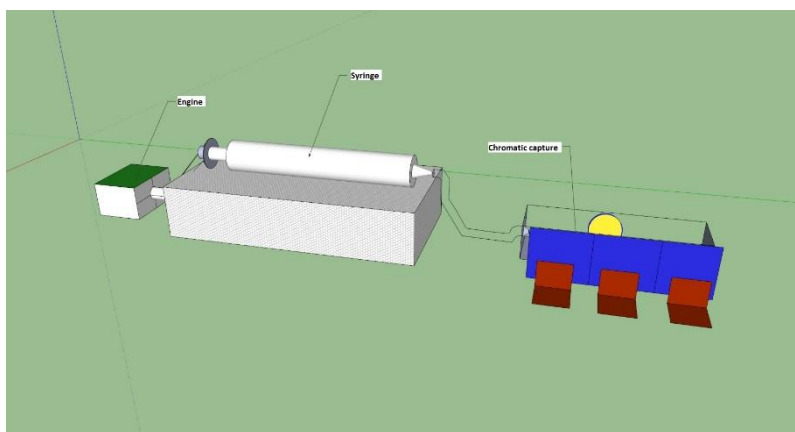


Figure 1 - Sketch of a chemistry e-lab experiment: chemical equilibrium reaction.

**Acknowledgements:** S. C. Leal wants to thank the Portuguese Foundation for Science and Technology a PhD grant (SFRH/BD/44889/2008) and Instituto Superior Técnico, the Portuguese University Institute that lodges the e-lab platform.

[1] Fernandes, H.; Leal, S. C.; Leal, J. P., *E-lab: o laboratório online*, *Gazeta da Física* **2010**, 33(3), 37-40.

[2] Leal, S. C.; Leal, J. P.; Fernandes, H., *E-lab: a valuable tool for teaching*, *Contemporary Issues in Education* **2010**, 1(2), 167-174.

[3] Leal, S. C.; Leal, J. P., *One example of a Chemistry e-lab experiment: Chemical equilibrium reaction*, *International Journal of Online Engineering (iJOE)*, vol. 9, pp. 41-43, 2013.

[4] Maiti, A.; Tripathy, B., *Remote Laboratories: Design of Experiments and Their Web Implementation*, *Educational Technology & Society*, vol. 16 (3), pp. 220-233, 2013.

[5] Senese, F. A.; Bender, C.; Kile, J., *The internet chemistry set: web-based remote laboratories for distance education in chemistry*, *IMEJ J. Comput.-Enhanced Learning*, vol. 2(2), 2000.

## OC24 - Two-Photon Activated 3D Data Storage

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Computer technology needs high performance storage devices that must store, retrieve and process huge volumes of data at high speeds. Two-photon 3D data storage is one of the most promising techniques to meet these demands. The longer wavelengths used in two-photon activated writing process allows for a longer penetration depth into the optical materials and the nonlinearity of the process confines the writing to a nanometer volume. Using two-photon activated processes it is possible to store hundreds of layers within the volume of a 1 mm thick DVD-type [1].

For optical recording based on photochromic transformations, the storage medium typically consists of a photochromic molecule with two distinct forms (open and closed ring, cis and trans, etc), which provide the two states necessary for storing information in a binary code: zero, 0, and one, 1. The photochromic compound must have a high two-photon absorption cross-section and efficient photochemical conversion between the two forms, for fast writing, its written form should emit fluorescence with a high quantum yield, for high contrast, both forms must be optically and thermally stable, to be able to perform 10<sup>6</sup> write-read-erase cycles [2].

Typically, optimized photochromic compounds meet the stability and high photoconversion efficiency requirements but fail to have a high two-photon absorption and high emission quantum yield. To overcome these limitation we present a FRET assisted two-photon data storage system based on a linear polymer with 2,4,6-tris(thiophen-2-yl)-1,3,5-triazine electron acceptor core that by FRET will trigger the switching between the two forms of the photochromic molecule 1,2-bis(2-methylbenzo[b]thiophen-3-yl)hexafluorocyclopentene (PC).

Data was recorded with an irradiation time as short as 1 ms at 740 nm with a good S/N ratio, a performance that represents an improvement of the writing speed by 3 orders of magnitude when compared with photochromic polymer composites studied earlier [3].

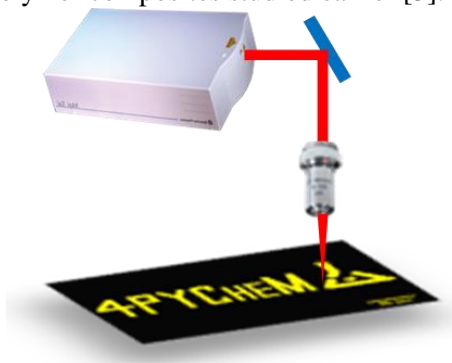


Figure 1 - 4th Portuguese Young Chemists Meeting Logo written in 200x250  $\mu\text{m}$  area using a confocal laser scanning microscope. The recording and readout were done under excitation at 740 nm in a film with PC, TPA and ethyl cellulose.

**Acknowledgements:** FCT is acknowledged for financial support (SFRH/BPD/75782/2011, PTDC/CTM-POL/114367/2009 and PEst-OE/CTM/LA0024/2013)

[1] Dvornikov, A. S.; Walker, E. P.; Rentzepis, P. M. J. Phys. Chem. A 2009, 113, 13633

[2] Walker, E.; Rentzepis, P.M.; Nat. Photonics 2008 406-408.

[3] Corredor, C. C., Huang, L-Z, Belfield, K. D.; Morales, A. R.; Bondar, M. V. Chem. Of Materials 2007, 19, 5165-5173.

## OC25 - Physiological $\text{Ca}^{2+}$ concentrations induce $\text{PI}(4,5)\text{P}_2$ clustering and have an impact in $\text{PI}(4,5)\text{P}_2$ partition properties.

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Phosphatidylinositol 4,5-bisphosphate ( $\text{PI}(4,5)\text{P}_2$ ) is a minor component of the inner leaflet of the plasma membrane of eukaryotic cells that has been shown to be a key player in the regulation of calcium-induced exocytosis, actin cytoskeleton remodelling, membrane trafficking and endocytosis. The dramatic influence of  $\text{PI}(4,5)\text{P}_2$  on exocytosis after calcium influx, is likely to be associated with the recent observation of changes in  $\text{PI}(4,5)\text{P}_2$  lateral distribution in the presence of this divalent ion. Using several different approaches targeting spectroscopic and diffusion properties of a fluorescent derivative of  $\text{PI}(4,5)\text{P}_2$ , we show that  $\text{Ca}^{2+}$  promotes clustering in lipid bilayers at physiological concentrations of both  $\text{Ca}^{2+}$  and  $\text{PI}(4,5)\text{P}_2$ . Our steady-state fluorescence anisotropy data are consistent with an approximate cluster size of 15  $\text{PI}(4,5)\text{P}_2$  molecules, and formation of large clusters results in lower diffusion coefficients measured by FCS. Moreover, calcium-mediated clustering increases the affinity of  $\text{PI}(4,5)\text{P}_2$  for liquid ordered membranes, where clustering is more efficient. Calcium-induced changes in  $\text{PI}(4,5)\text{P}_2$  distribution among physiologically relevant membrane phases, is also compared with results obtained for other related phosphatidylinositol molecules.

**Acknowledgments:** This work was supported by FCT-Foundation of Science and Technology (PTDC/QUI-BIQ/112067/2009 and RECI/CTM-POL/0342/2012). M.J.S. and F.F. acknowledge research grants (SFRH/BD/80575/2011 and SFRH/BPD/64320/2009) from FCT.

## OC26 - Biosorbents for the removal of mercury, cadmium and lead from salt waters

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The progressive rise in world population and the increasing need for goods and products, led to production of large amounts of effluents, with high levels of pollutants. Among pollutants, metals are a serious threat, in particular mercury, lead and cadmium, due to their toxicity and persistent character in the environment and biota as well as bioaccumulation and bioamplification along the food chain [1,2]. As a result of proliferation of water contaminants, the remediation of contaminated water is a field of technology that always has attracted much interest, and new approaches are continually being examined to supplement traditional water remediation methods. However, most of the remediation studies are intended to fresh water but salt waters are often the last receptor of pollutants. Biosorption has emerged as an area of great potential for the removal of metal ions from wastewaters, since the materials used are cheap, environmental friendly and very available in nature, but so far it has not been applied to saltwater. In this work we studied the sorption capacity of different biowastes (rice husk, cork stoppers and two types of algae) toward mercury, lead and cadmium in natural seawater. All biosorbents tested have a particle size < 0.2 mm and the amount used was 500 mg/L. The efficiency of the materials was tested for two contamination scenarios: one in which all metals are in concentrations equal to 50 µg/L, and the other in which Hg, Cd and Pb are in concentrations that equal their maximum legal limit allowed for wastewater discharges (Hg – 50 µg/L; Cd – 200 µg/L and Pb – 1000 µg/L) [3]. Under the experimental conditions studied we concluded that the affinity of biosorbents to the selected metals is in the order Hg>Pb>>Cd. In the case of Hg, the biosorbents removed between 92 and ~100%, while for Pb, the maximum removal (>80%) was obtained with the brown alga and cork stoppers. In the case of Cd, after 24h the percentage of removal did not exceed 10%.



Figure1 - Biosorbents: cork stoppers, rice husk, green and brown algae.

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[1] Boudou, A.; Delarche, A.; Ribeyre, F.; Marty, R., *Bulletin of Environmental Contamination and Toxicology* **1979**, 22, 813-818.

[2] Lopes, C.B.; Coimbra, J.; Otero, M.; Pereira, E.; Duarte, A.C.; Lin, Z.; Rocha, J., *Química Nova* **2008**, 31, 321-325.

[3] Decreto-Lei nº 236/98, *Diário da República — I série-A N.º 176 — 1-8-1998*.

# OC27 - Computational studies on the catalytic mechanism of human Heparan Sulfate 3-O-sulfotransferase in light of the Herpes Simplex Virus type 1 infection

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Heparan sulfates (HS) are linear polysaccharides that consist of repeating disaccharide units of uronic acid-(1-4)-D-glucosamine, with different patterns of sulfation and acetylation. HS are involved in several biological interactions, such as assisting viral infection or regulating blood coagulation. As the HS chain is being formed, it suffers several modification processes which affect its biological function [1].

3-O-sulfotransferase (3-OST) is one of the enzymes involved in the HS biosynthesis. It is responsible for the transfer of a sulfo group to glucosamine units linked to uronic acid residues. Different 3-OST isoforms have distinct substrate specificities and produce HS with different biological functions. HS modified by isoform 1 has anticoagulant activity; HS modified by isoforms 2, 3, 4 and 6 serves as an entry receptor for the Herpes Simplex Virus type 1 (HSV-1) and HS modified by isoform 5 has both anticoagulant activity and serves as an entry receptor for HSV-1 [2].

The main goal of this work is to clarify the catalytic mechanism [3] of the reaction catalyzed by 3-OST isoform 3 with atomic detail, using computational methods. In order to achieve this, we applied the ONIOM method, with the B3LYP:AMBER methodology, to a large enzyme model divided into two regions, studied at different theoretical levels. The high layer was treated at the Quantum Mechanics (QM) level and includes the substrate, part of the co-substrate and the side chains of six key residues. The low layer was treated at the Molecular Mechanics (MM) level. We also investigated the protonation state of key residues using Molecular Dynamics (MD) simulations, in order to assess the behavior of the system over time, in different protonation states. Furthermore, we performed single-point energy calculations on the optimized geometries, treating the high-layer with different functionals and a higher basis set.

Our results show that the molecular mechanism of 3-OST occurs by a single mechanistic step. We were able to determine, to a high degree of certainty, the protonation state of the key amino acids in the active site. We were also able to obtain optimized reactants, transition state (TS) and products geometries and confirm the proposed catalytic mechanism. We have obtained the activation energy for this reaction. The data obtained in this study will enable further studies on the inhibition of this enzyme, which is a useful target for drug design.

**Acknowledgements:** The authors would like to acknowledge FCT for financial support (Project PTDC/QUI-QUI/122916/2010).

[1] Moon, A., Edavettal, S., Krahn, J. et al., *J. Biol. Chem.* **2004**, 279 (43), 45185-45193.

[2] Xu, D., Moon, A., Song, D., Pedersen, L., Liu, J. *Nat. Chem. Biol.* **2008**, 4 (3), 200-202.

[3] Bras, N.F., Fernandes, P.A., Ramos, M.J., *J. Chem. Theory Comp.* **2010**, 6, 421-433.

## OC28 - How many people contribute to Chemistry in the University of Coimbra? A comparison with other Portuguese and foreign (MIT, Lund) universities

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In recent decades, the expansion of science and technology has been coupled to an increasing necessity of evaluating scientific production in the various disciplines of knowledge. In the evaluation of scientific production, normalization is paramount. It often relies just on lists of faculty members, i.e. dividing the number of papers by the number of faculty members, either active or not. The parameterization approach presented in this communication enables to identify the active faculty members, being thus essential in terms of policy making and funding [1,2]. In this context, the task-force involved in scientific production, globally or per area or sub-area, is established. This task-force will be split in core (permanent members), and collaborators (more mobile or belonging to other areas), and would allow normalization of productivity, so that groups/institutions/countries of different sizes may be directly compared. New indicators are used assessing the patterns found: average number of collaborators per core member, number of publications per core member, etc. It should be remarked that the overall characterization of collaboration that is proposed, relies on a variety of indicators that also include (i) connection (ii) interaction, and (iii) diffusion. Another important tool of research evaluation is related to the institutions rankings. ESI ranking, from Thomson Reuters [3], provides a useful criterion to quantitatively assess institutions on their best performances. In this communication, 26 Portuguese research institutions are compared taking into account the scientific ESI disciplines (Figure 1). A detailed analysis is also made on the role and performance of Chemistry as an ESI discipline.

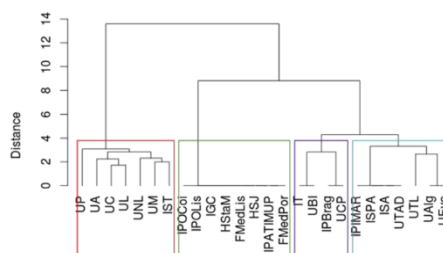


Figure 1 - HCA results: the dendrogram shows the clustering of 26 Portuguese research institutions, resulting from the similarity in the number and specific nature of the scientific disciplines given by the ESI database – May 2013.

**Acknowledgements:** The Coimbra Chemistry Centre is supported by the Fundação para a Ciência e a Tecnologia (FCT), Portuguese Agency for Scientific Research, through the project PEst-OE/UI/UI0313/2014.

- [1] Almeida, J.; Pais, A.; Formosinho, S., *Journal of Informetrics* **2009**, 3(2), 134–142.  
 [2] Cova, T.; Pais, A.; Formosinho, S., *Scientometrics* **2013**, 94(3), 1239–1251.  
 [3] Essential Science Indicators. The Thomson Corporation. <http://scientific.thomson.com/products/esi>.

## Posters

## **Medicinal Chemistry**

## P1 - Synthesis of a potential orally-active antithrombotic small molecule.

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In CEQUIMED-UP a new class of antithrombotic agents, polysulfated glycosidic small-molecules, with dual anticoagulant/antiplatelet activity, was identified (Figure 1). However, by oral administration in mice, they were not active [1, 2].

The aim of this work was to obtain a new series of compounds with potentially improved oral bioavailability. Thus, a new compound was successfully obtained in 85 % yield. The structure elucidation of the synthesized compound was established by IR, <sup>1</sup>H and <sup>13</sup>C NMR, and HRMS.

The anticoagulant activity was measured by the classical clotting times - activated partial thromboplastin time (APTT), prothrombin time (PT), and thrombin time (TT) - in five different concentrations. The derivative was found to prolong the APTT and PT in a dose-dependent manner, and no effect was observed on the thrombin time (TT).

Future work will consist in the investigation of the permeability of this compound across mouse small intestine by the Ussing chamber technique and of the oral efficacy by *in vivo* studies.

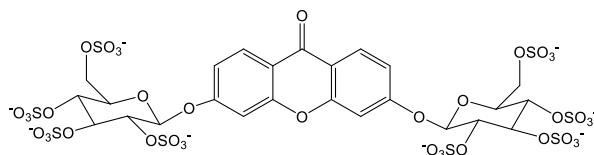


Figure 1: Example of a polysulfated glycosidic small molecule with dual anticoagulant/antiplatelet activity.

**Acknowledgements:** FCT, PEst-OE/SAU/UI4040/2014, FEDER, POCI, POPH/FSE/QREN for financial support and for the post-doctoral grant to M. Correia-da-Silva (SFRH/BPD/81878/2011).

[1] Correia-da-Silva, M.; Sousa, E.; Duarte, B.; Marques, F.; Carvalho, F.; Cunha-Ribeiro, L.M.; Pinto, M.M.M., *J. Med. Chem.* **2011**, 54, 5373-5384.

[2] Correia-da-Silva, M.; Sousa, E.; Duarte, B.; Marques, F.; Carvalho, F.; Cunha-Ribeiro, L.M.; Pinto, M.M.M., *J. Med. Chem.* **2011**, 54, 95-106.

## P2 - Rational design and synthesis of 8-β-D-glucosylgenistein analogues with activity against Diabetes and Alzheimer's disease

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Diabetes mellitus (DM) and Alzheimer's disease (AD) are related amyloid disorders that attained epidemic proportions in the last decades. 8-β-D-glucosylgenistein, the major component of *Genista tenera* ethyl acetate extract, is a potent antidiabetic that was able to decrease glucose excursion to normal values upon an oral glucose tolerance test with concomitant increase of glucose-induced insulin secretion [1]. In our ongoing work, we intend to accomplish the synthesis of several 8-β-D-glucosylgenistein analogues. For this purpose, we are using the conventional synthetic route for 8-β-D-glucosylgenistein, developed by our group, involving a C-glycosylation reaction by means of a Friestype rearrangement, an aldol condensation and an oxidative rearrangement that delivers the desired isoflavone product. Essentially, we aim not only to improve the biological activity and pharmacological properties of the lead compound, but also to study the underlying mechanism of action and understand the structural requirements for its antidiabetic activity. Moreover, we wish to study the chemical interactions that may be responsible for the disruption of amyloid aggregation in both diseases by NMR techniques, while keeping blood-brain barrier permeability assured.

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[1] A. P. Rauter, A. Jesus, A. Martins, C. Dias, Rogério Ribeiro, M. P. Macedo, J. Justino, H. Mota-Filipe, R. Pinto, B. Sepodes, M. Medeiros, J. Barbero, C. Airolidi, F. Nicotra, PT106202, submitted 2012.

### P3 - Chemical analysis of *Salvia sclareoides* volatile oil obtained by supercritical fluid extraction

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Supercritical fluid extraction (SFE) of the volatile oil from the dried flowering parts of the medicinal plant *Salvia sclareoides* was performed under different conditions of pressure, temperature, mean particle size, and CO<sub>2</sub> flow rate <sup>[1]</sup>. The volatiles chemical composition was analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) and 30 components were detected. The major constituents identified were phytol acetate, linoleic acid ethyl ester, hexadecanoic acid methyl ester, palmitic acid, *trans*- $\beta$  caryophyllene oxide and *trans*- $\beta$  caryophyllene, guaia- 6,9-diene, elemol, bicyclogermacrene, and globulol. As minor compounds ( $\leq 0.5\%$ ), *n*-nonanal,  $\alpha$ -humulene, *trans*- $\beta$  farnesene,  $\beta$ -ionone and *trans*-nerolidol were also identified, while c.a. fifteen constituents were detected in trace amounts ( $< 0.05\%$ ). This is the first study on *S. sclareoides* SFE extract, aiming at to identify bioactive molecules responsible for its medicinal activity <sup>[2]</sup>.

**Acknowledgements:** The authors thank Prof. Dr. Ana Cristina Figueiredo (DBV-FCUL) for her collaboration in GC and GC-MS analysis and Fundação para a Ciência e a Tecnologia for financial support (CQB Strategic Project Pest-OE/QUI/UI0612/2013).

[1] Grosso, C.; Figueiredo, A. C.; Burillo, J.; Mainar, A. M.; Urieta, J. S.; Barroso, J. G.; Coelho, J. A.; Palavra, A. M. F., *Journal of Separation Science* **2010**, 33, 2211-2218.

[2] Rauter, A. P.; Branco, I.; Lopes, R. G.; Justino, J.; Silva, F. V.; Noronha, J. P.; Cabrita, E. J.; Brouard, I.; Bermejo, J. *Fitoterapia* **2007**, 78, 474-481.

## P4 - Comparative Study of the Photodynamic Effectiveness of 5,10,15,20-tetrakis-(quinolin-2-yl)-porphyrin and 5,10,15,20-tetrakis-(4-carboxyphenyl)-porphyrin against Colon Cancer Cells *in vitro*.

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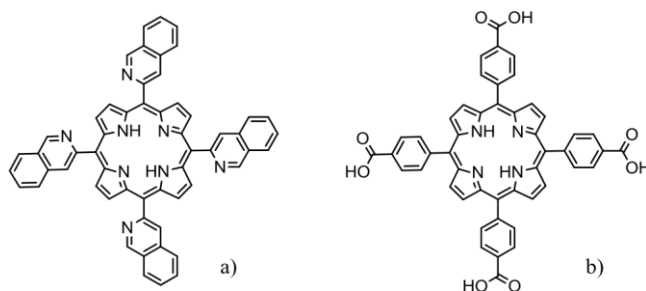
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Photodynamic therapy (PDT) is a selective therapeutic approach, approved for oncological and non-oncological disorders, that requires the combination of a light-sensitive compound, visible light and molecular oxygen. The interaction of these three components results in the production of radicals and other reactive species, namely reactive oxygen species (ROS) responsible for a series of cellular and molecular events that lead to selective destruction of harmful cells [1-5]. PDT can provide local control of the disease noninvasively and with minimal side effects, thereby improving patient's quality of life and lengthen survival. Moreover, the procedure can be repeated safely without harming normal tissues and with a good cost-effect ratio [5]. The development of an ideal photosensitizing agent must fulfil several guidelines. Porphyrins and related macrocycles possess a number of key photochemical, photophysical and biological properties that make them potential candidates as photosensitizers for PDT [6]. This study describes the synthesis and characterization of 5,10,15,20-tetrakis-(quinolin-2-yl)-porphyrin (2-TQP) and 5,10,15,20-tetrakis-(4-carboxyphenyl)-porphyrin (TCPP), whose molecular structures are represented in Figure 1, and the subsequent comparison of their photodynamic effectiveness against HT29 colorectal adenocarcinoma cancer cells *in vitro*, as a function of different light doses and porphyrin concentration. Our results indicate that both porphyrins exhibit characteristics of great interest for PDT, namely high singlet oxygen quantum yield and strong absorption in the phototherapeutic window, negligible dark cytotoxicity and high phototoxic activity upon light activation. The results will also contribute to the establishment of correlations between the chemical structure of the porphyrins and their efficiency. Nevertheless, further studies will be performed in order to clarify their intracellular localization and the exact mechanism by which colon cancer cells died.



**Figure 1:** Molecular structures of (a) 2-TQP and (b) TCPP.

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- [1] Plaetzer, K. *et al*, Lasers Med. Sci., **2009**, 24, 259–268
- [2] Silva, P. *et al*, Photochem. and Photoobiol., **2010**, 86, 1147–1153
- [3] Agostinis, P. *et al*, Ca Cancer J. Clin., **2011**, 61, 250–281
- [4] Kiesslich, T. *et al*, J. Porphyrins Phthalocyanines, **2013**, 17, 197–209
- [5] Jiang, Z. *et al*, J. Pharm. Biomed. Anal., **2014**, 87, 98–104
- Vicente, M. G. H., Curr. Med. Chem. - Anti-Cancer Agents, **2001**, 1,175–194.

## P5 - Improved precursors to new bio-inspired materials: novel coordination networks by mechanochemical and solvothermal synthesis

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Polymeric systems in addition to mesoporous silicas and zeolites have been commonly used for the controlled release of drugs. However, some of these systems might present strong drawbacks: low drug-storage capacity, too rapid delivery and high toxicity. The use of Metal Organic Networks (MOFs) as new drug carriers has been proposed as a way to tackle these problems, requiring a biological-friendly composition with acceptable toxicity levels.[1-4] We are exploring a new pathway for the development of improved precursors to new bio-inspired materials (BioMOFs), using safe metals and having active pharmaceutical ingredients (API) as linkers. This type of compounds is traditionally synthesized by solvothermal methods, but in this project we are also deeply engaged in using “green” techniques such as mechanochemistry and microwave.

New coordination networks of Gabapentin (GBP), a neuroleptic drug, with several lanthanide chlorides (LnCl<sub>3</sub>), Ln= La<sup>3+</sup>, Ce<sup>3+</sup>, Nd<sup>3+</sup>, Er<sup>3+</sup> and Y<sup>3+</sup>, were synthesized by mechanochemistry.[5] These networks have potential interest for imaging applications. More recently, we are exploring coordination networks with adenine and folic acid and several safe metals such as Zn, Cu and others. Novel compounds have been synthesized and their structural and physico-chemical characterizations are in progress, already showing promising results. Also worth mentioning are the results from solvothermal synthesis involving ZnNO<sub>3</sub>, azelaic acid and 4,4-bypiridine with the aim of obtaining Zn BioMOFs with both ligands. A side reaction occurred and novel Zn coordination networks were formed with formate, one of the decomposition products of dimethylformamide, the solvent used. This project is indeed very challenging and promising as coordination complexes of an API may open up a new route for the delivery of drugs.[1-3]

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- [1] Horcajada, P.; Serre, C.; Vallet-Regi, M.; Sebban, M.; Taulelle, F.; Ferey, G., *Angewandte Chemie-International Edition* **2006**, 45(36), 5974-5978.
- [2] Keskin, S.; Kizilel, S., *Industrial & Engineering Chemistry Research* **2011**, 50(4), 1799-1812.
- [3] McKinlay, AC.; Morris, RE.; Horcajada, P.; Ferey, G.; Gref, R.; Couvreur, P.; Serre, C.; *Angewandte Chemie-International Edition* **2010**, 49(36), 6260-6266.
- [4] Horcajada, P.; Gref, R.; Baati, T.; Allan, PK.; Maurin, G.; Couvreur, P.; Ferey, G.; Morris, RE.; Serre, C.; *Chemical Reviews* **2012**, 112(2), 1232-1268.
- [5] Quaresma, S.; André, V.; Antunes, A. M. M.; Cunha-Silva, L.; Duarte, M.T.; *Crystal Growth & Design* **2013**, 13, 5007-5017.

## P6 - Galectin-1 as a promising target on the development of photosensitizers

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Photodynamic Therapy (PDT) is a treatment modality for various cancers, which involves the application of a photosensitizing compound (photosensitizer, PS) and irradiation of the tumor with light. The molecular mechanisms underlying PDT are not clearly understood. However, it has been described that the generation of reactive oxygen species (ROS) will trigger signalling pathways that ultimately destroy the targeted tissue.

Knowing that the structure of the PSs has a key role in the effectiveness of cancer PDT, we have developed new PSs by conjugating them with biochemical motifs.<sup>1,2</sup> Among several biomolecules, the biocompatibility of galactose molecules and their ability to bind galectins overexpressed in cancer cells led us to conjugate a phthalocyanine with dendrimers of galactose (PcGal<sub>16</sub>).<sup>1</sup> PcGal<sub>16</sub> has strong absorbance in the red spectral region (600–800 nm), fluorescence emission bands at 734 and 805 nm, solubility in water media and interaction with human serum albumin. Additionally, PcGal<sub>16</sub> demonstrates photostability and ability to generate ROS after photoactivation.

Recently, we have studied the efficiency of PcGal<sub>16</sub> as photosensitizer for PDT against bladder cancer cells.<sup>3</sup> The galacto-dendritic units around the macrocycle of the Pc demonstrated to be important during the uptake process, since it was higher for PcGal<sub>16</sub> than for the non-conjugated phthalocyanine used as control. Additionally, the uptake and phototoxicity of PcGal<sub>16</sub> was higher in bladder cancer cells overexpressing galectin-1 than in a non-tumoral epithelial cell line. Knockdown of galectin-1 in bladder cancer cells decreased the intracellular uptake and phototoxicity of PcGal<sub>16</sub>, suggesting that this protein plays an important role for the efficacy of photodynamic therapy mediated by PcGal<sub>16</sub>. The photoactivation of PcGal<sub>16</sub> generated oxidative stress which induced an antioxidant response. Although PDT with PcGal<sub>16</sub> has induced an increase on the activity of antioxidant enzymes, bladder cancer cells were unable to recover from the PDT-induced damage effects for at least 72 h after treatment.

Our results show PcGal<sub>16</sub> as a promising therapeutic agent for the treatment of bladder cancer, which is the fifth most common type of cancer with the highest rate of recurrence of any cancer.

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[1] Silva S.; Pereira P.M.R.; Silva P.; Paz F.A.; Faustino M.A.; Cavaleiro J.A.S.; Tome J.P.C., *ChemCommun (Camb)* **2012**, 48:3608–3610.

[2] Pereira P.M.R.; Carvalho J.J.; Silva S.; Cavaleiro J.A.S.; Schneider R.J.; Fernandes R.; Tome J.P.C., *OrgBiomolChem* **2014**, 12:1804–1811.

[3] Pereira, P.M.R.; Silva, S.; Cavaleiro, J.A.S.; Ribeiro, C.A.F.; Tome, J.P.C.; Fernandes, R., *PLoS ONE* **2014**, accepted.

## **Organic and Inorganic Chemistry**

## P7- SYNTHESIS OF LUMINESCENT LEAD IODIDE NANOPARTICLES EMBEDDED IN ZEOLITE MATRIX AND APPLICATION AS WATER SENSOR

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We report, to the best of our knowledge, the first synthesis of a water sensor based on luminescent lead iodide nanoparticles embedded in a zeolite matrix. These nanoparticles were synthesized by ship-in-a-bottle method using the molecular sieve (zeolite) 4Å as matrix, controlling the size and preventing agglomeration. First,  $\text{Pb}^{2+}$  ions were introduced in the zeolite pore by ionic exchange with  $\text{Na}^+$ . Then,  $\text{I}^-$  ions were added to the solution drop-wise, forming the nanoparticles that become trapped in the zeolite pores. The as synthesized nanoparticles form luminescent clusters when embedded in the zeolite. These clusters show a high sensitivity to water, losing their luminescence at very low water contents. Our studies reveal a relation between the water content of a given solvent and the clusters luminescence, making them suitable to be used as a water sensor. After losing the luminescence the sensors can be recycled by drying under vacuum. Further studies will determine how the temperature influences the luminescence and how to improve the sensors accuracy.

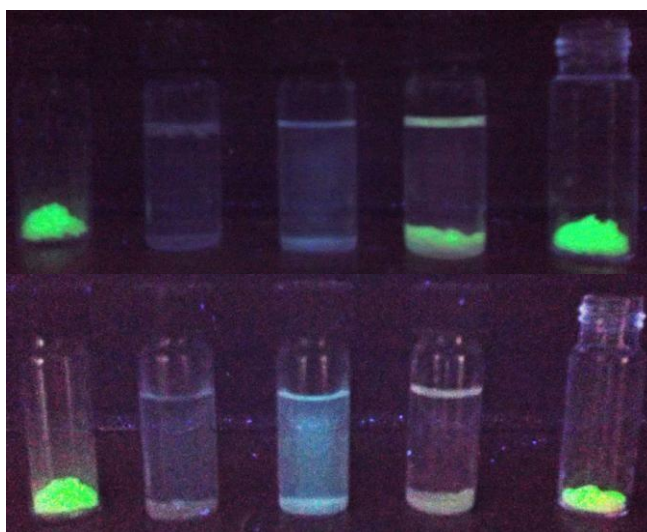


Figure 1: Samples of lead iodide clusters after 5min (top) and after 24h (bottom). Legend (from left to right): without solvent, in water, in acetonitrile/methanol 1:1, in toluene, without solvent (open to air).

## P8 - Supramolecular networks self-assembled from copper(II) aminoalcohol blocks and 2,6-naphthalenedicarboxylate linkers

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The design of new copper(II) coordination polymers (CPs) with attractive functional properties is an increasingly growing field of research in inorganic, coordination and supramolecular chemistry [1]. In particular, some Cu(II) CPs built from different aminoalcohol building blocks have found notable uses in oxidation catalysis [2] and molecular magnetism [3]. Herein we report a series of copper(II) aminoalcohol derivatives  $[\text{Cu}_2(\mu\text{-dmea})_2(\mu\text{-nda})(\text{H}_2\text{O})_2]_n \cdot 2n\text{H}_2\text{O}$  (**1**),  $[\text{Cu}_2(\mu\text{-Hmdea})_2(\mu\text{-nda})]_n \cdot 2n\text{H}_2\text{O}$  (**2**),  $[\text{Cu}_2(\mu\text{-Hbdea})_2(\mu\text{-nda})]_n \cdot 2n\text{H}_2\text{O}$  (**3**) and  $[\text{Cu}_2(\text{H}_4\text{etda})_2(\mu\text{-nda})] \cdot \text{nda} \cdot 4\text{H}_2\text{O}$  (**4**), generated by self-assembly method in water at ~25 °C from copper(II) nitrate, various aminoalcohols [N,N'-dimethylethanolamine (Hdmea), N-methyldiethanolamine (H<sub>2</sub>mdea), N-butyldiethanolamine (H<sub>2</sub>bdea) or N,N,N',N'-tetrakis(2-hydroxyethyl)ethylenediamine (H<sub>4</sub>etda) for **1–4**, respectively] and 2,6-naphthalenedicarboxylic acid (H<sub>2</sub>nda). They were isolated as crystalline solids and fully characterized by IR and EPR spectroscopy, ESI-MS(±), elemental, and single-crystal X-ray diffraction analyses. The crystal structures reveal that **1–3** are 1D coordination polymers constructed from the dicopper(II) aminoalcohol blocks and  $\mu\text{-nda}$  linkers, whereas **4** is a discrete 0D dimer composed of two  $[\text{Cu}(\text{H}_4\text{etda})]^{2+}$  fragments interlinked by the  $\mu\text{-nda}$  moiety. The main distinctive features of **1–4** arise from the different H-bonding patterns driven by the crystallization H<sub>2</sub>O molecules, thus giving rise to a further extension of the structures [1D→3D (**1**, **2**), 1D→2D (**3**), or 0D→3D (**4**)] into various supramolecular networks. Their topological analysis disclosed distinct and complex multinodal underlying nets with unique (**1**, **2**, **4**) or rare topologies (**3**). Besides, the magnetic susceptibility studies revealed a very strong (**1**, **3**) or moderately strong (**2**) antiferromagnetic coupling between the copper(II) atoms through the  $\mu\text{-alkoxo}$  bridges, which was described by the Bleaney-Bowers dinuclear model. The obtained magnetic coupling constants are in good agreement with the general trend for alkoxo-bridged dicopper(II) derivatives.

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[1] (a) Mukherjee, S.; Mukherjee, P. S. *Acc. Chem. Res.* **2013**, *46*, 2556-2566. (b) Clegg, J. K.; Li, F.; Lindoy, L. F. *Coord. Chem. Rev.* **2013**, *257*, 2536-2550. (c) Kumar, G.; Gupta, R. *Chem. Soc. Rev.* **2013**, *42*, 9403-9453.

[2] Kirillov, A. M.; Kirillova, M. V.; Pombeiro, A. J. L. *Coord. Chem. Rev.* **2012**, *256*, 2741-2759.

[3] (a) Seppala, P.; Colacio, E.; Mota, A. J.; Sillanpaa, R. *Inorg. Chem.* **2013**, *52*, 11096-11109. (b) Xu, G.-H.; He, X.-Y.; Lv, J.; Zhou, Z.-G.; Du, Z.; Xie, Y.-R. *Cryst. Growth Des.* **2012**, *12*, 3619-3630. (c) Gao, Q.; Li, F.-G.; Wang, Y.-C.; Xu, L.; Bai, J.; Wang, Y. *Dalton Trans.* **2014**, *43*, 941-944.

## P9 - Synthesis and immobilization of Bian bearing Mo(II) complexes for use as heterogeneous precursor catalysts in olefin epoxidation catalysis

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Molybdenum(II) complexes are well known for their worthwhile catalytic properties, e.g. oxidation and polymerization, while being capable of accommodating a wide range of ligands.

Based on promising results from previous research performed at our group [1, 2], we set out to synthesize a new  $\alpha$ -diimine type ligand, 1,2-bis[(4-phenylcarboxylate)imine]acenaftene (**Bian**, fig 1), to generate the hepta-coordinated Mo(II) complexes,  $[\text{MoX}_2(\text{CO})_3\text{Bian}]$  (X=Br, I). Preliminary studies revealed potentially interesting catalytic properties for these complexes. Taking into account the rising environmental consciousness the attained complexes were then immobilized in Zn/Al and Mg/Al LDH (Layered Double Hydroxides) clay matrices. This was achieved making use of the high ion exchange capacity and dynamic structure that these materials present [2] through a process of anion exchange after deprotonation of the carboxylate groups of the ligand. All synthesized complexes and materials were characterized by adequate spectroscopic techniques (FTIR and NMR) or other techniques (XRD). For the determination of the catalytic capabilities of the prepared material immobilized complexes we focused on the epoxidation of cis-cyclooctene, styrene, trans-hexen-1-ol, 1-octene, and *R*-limonene, using tert-butylhydroperoxide as oxidant, with very good performance results. The catalytic studies show that the catalysts yield selectively the desired epoxides. In addition, the catalysts are found to work under a wide temperature range and over several catalytic cycles without notorious performance loss, further determining the catalysts recovery and leaching rates. The reaction conditions were found to influence catalytic performance.

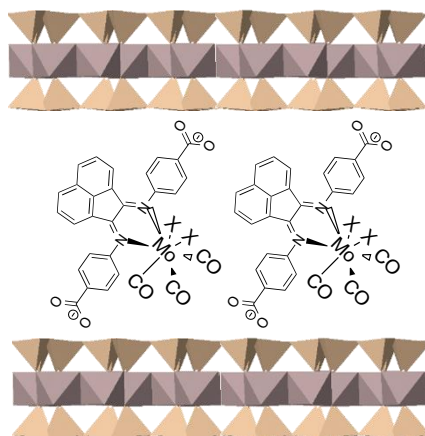


Figure 1: Structure of the synthesized materials

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[1] Gimenez, J., Nunes, C. D., Vaz, P. D., Valente, A. a., Ferreira, P., & Calhorda, M. J. *Journal of Molecular Catalysis A: Chemical* **2006**, 256, 90–98.

[2] Vasconcellos-Dias, M., Nunes, C. D., Vaz, P. D., Ferreira, P., & Calhorda, M. J., *European Journal of Inorganic Chemistry* **2007**, 18, 2917–2925.

## P10 - Solid acid catalysts for epoxide ring opening with amines

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Epoxides are useful intermediates for organic synthesis, due to their high reactivity as a consequence of their ring strain. Their chemical properties play an important role in chemical reactions such as the synthesis of valuable pharmaceutical compounds [1].

Epoxides can react with a great number of nucleophiles like alcohols and amines to yield different products like alkoxy-alcohols or amino alcohols with high regioselectivity.[1] Usually the epoxide ring opening reaction involves a well-known variety of Lewis or Brønsted acid catalysts, already reported in literature [2,3]. The majority of these catalysts are homogeneous and are always associated to high reaction temperature, prolonged reaction times, non-catalytic nature of the reagents, low conversion and poor selectivity, difficulty of separation and the impossibility to recover from the reaction media.[1,3] Thus, considering the importance of the epoxides as intermediates for the preparation of promising molecules it is a challenge to develop new, less toxic and high selective heterogeneous catalysts.

One of the possible approaches is the functionalization of easily available solid materials like silica and natural clays in order to create or improve their acidity (acid sites) and also to enhance some properties like surface area or porosity and so, increase their catalytic activity in the epoxide opening reaction. One of the most versatile method for the functionalization of these solid materials is the organosilylation where an organosilane is covalently anchored to the silica or clay surface [4]. These organosilanes, can act directly as catalysts or can have the appropriate functional groups to be transformed in sulfonic acid groups in order to improve the acid sites in the materials.

In this work we performed the catalytic epoxide ring opening of styrene oxide with amines using as catalysts clays and silica functionalized with different organosilanes-SO<sub>3</sub>H groups. The amines used were aniline and *n*-butylamine and the reactions were performed in absence of solvent. The catalytic reactions were monitored by thin layer chromatography (TLC) and by nuclear magnetic resonance (NMR); substrate conversions higher than 95 %, were obtained.

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- [1] Trikittiwong, P.; Sukpirom, N.; Chavasiri, W. *J. Mol. Cat. A: Chem.* **2013**, 378, 76-81.
- [2] Guidotti, M.; Psaro, R.; Ravasio, N.; Sgobba, M.; Carniato, F.; Bisio, C.; Gatti G.; Marchese, L. *Green Chem.*, **2009**, 11, 1173-1178.
- [3] Tajbakhsh, M.; Hosseinzadeh, R.; Rezaee, P.; Alinezhad, H. *J. Mex. Chem. Soc.* **2012**, 56, 402-407.
- [4] Corma, A.; Garcia, H. *Adv. Synth. Catal.* **2006**, 348, 1391-1412.

## P11 - Mo nano-sized nanoparticles as efficient catalysts

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Nanoparticles have been attracting a great deal of attention related to their special properties as compared to bulk material counterparts, with multidisciplinary applications in areas including drug discovery, energy storage, electronic devices and heterogeneous catalysis [1]. Among the metal oxide nanoparticles developed over the last few years, molybdenum trioxide ( $\text{MoO}_3$ ) has been widely used in sensors, lubricants, fuel cell materials, since it is a wide band gap n-type semiconductor. The high surface-to-volume ratio associated with nanostructures makes its electrical response extremely sensitive to the species adsorbed on the surface [2]. However, little attention was paid to catalytic performance. To develop a highly active and selective catalyst it is necessary to couple the synthesis of a nanostructured material with the understanding of its surface structures, such as local geometry and electronic properties of active sites. Regarding geometry and synthesis, various  $\text{MoO}_3$  nanostructures including nanorods, nanowires, nanofibers, nanoribbons and nanobelts were fabricated using hydrothermal, solvothermal, electrodeposition and physical vapor deposition methods. Hydrothermal (or solvothermal) method is a simple, cost-effective, and low temperature process which yields various nanostructures with controlled size, stoichiometry and shape [2]. In this study,  $\text{MoO}_3$  nanoparticles were prepared by combining solvothermal synthesis of  $\text{MoO}_2$  nano-crystallites and subsequent thermal oxidation. The synthesized nanoparticles were characterized by FTIR, powder XRD and SEM/TEM imaging. Subsequently, nanoparticles were tested as catalysts in the epoxidation of olefins and allylic alcohols using t-butylhydroperoxide as oxidant, because epoxides are valuable intermediates for the synthesis of fine chemicals. The catalyst performance was evaluated under different reactions conditions. The studies show that  $\text{MoO}_3$  nanoparticles are efficient recyclable catalysts in epoxidation reactions leading selectively to the corresponding epoxides.

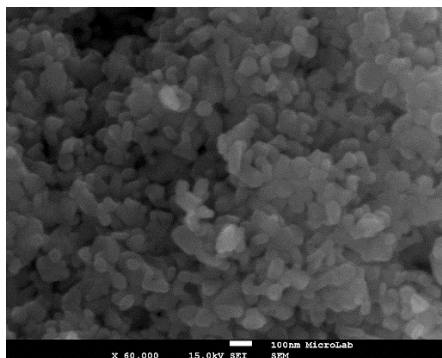


Figure 1 - SEM image of  $\text{MoO}_3$  nanoparticles.

**Acknowledgements:** The authors are grateful to FCT for financial support (project PEst-OE/QUI/UI0612/2013). Cristina I. Fernandes also thanks FCT for a grant (SFRH/BD/81029/2011).

[1] Gawande, M. B.; Branco, P. S.; Nogueira, I. D.; Ghumman, C. A. A.; Bundaleski, N.; Santos, A.; Teodoro, O. M. N. D.; Luque, R., *Green Chem.* **2013**, 15, 682-689.

[2] Kim, W.S.; Kim, H.-C.; Hong S.-H., *J. Nanopart. Res.* **2010**, 12, 1889-1895.

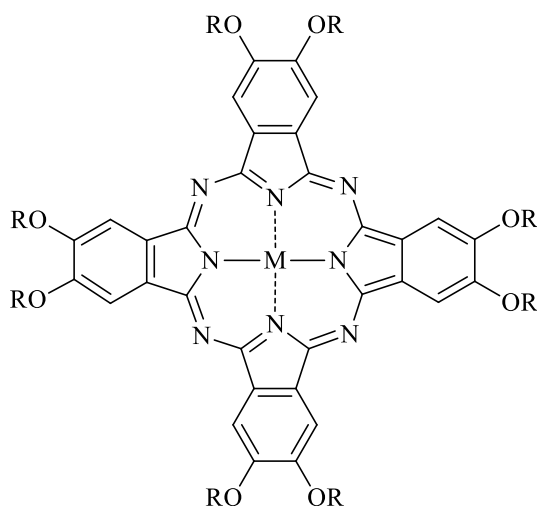
## P12 - Synthesis of Metal-Free and Copper Phthalocyanines Containing Chiral Carbons in the Side Chain

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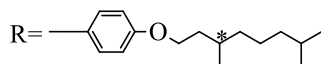
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Phthalocyanines (Pcs) are highly delocalized  $\pi$ -conjugated organic systems and exhibit wide variety of roles in a various high technological areas such as semiconductor devices, liquid crystals, sensors, catalysts, non-linear optics, photovoltaic solar cells and photodynamic therapy. Although a wide range of studies on the synthesis, properties and applications of many phthalocyanines has received more research interest than porphyrins, chiral phthalocyanines have received less attention than chiral porphyrins. However, optically active Pcs are more available than porphyrins in some respects. For instance, Pcs tend to co-facial aggregation and may form helical superstructures. In addition, to analyze their circular dichroism (CD), Pcs are superior to porphyrins, since the Q-band is much more intense. In this study, we have synthesized peripherally octa substituted metal-free and copper phthalocyanines bearing long alkyl chains.



M= 2H, Cu(II)



- [1] Yüksel, F.; Durmuş, M.; Ahsen, V.; *Dyes and Pigments* **2011**, 90, 191-200.
- [2] Kobayashi, N.; *Coordination Chemistry Reviews* **2001**, 219-221, 99-123.
- [3] Karaca, H.; Sezer, S.; Tanyeli, C.; *Dyes and Pigments* **2011**, 90, 100-105.

## P13 - High Pressure Microwave in Homogeneous Catalysis

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Homogeneous catalysts based on transition metal complexes, namely for carbonylation and hydrogenation reactions, are a crucial tool for the development of industrial processes. Nowadays there is a great demand for the development of more sustainable chemical processes, using less toxic solvents and lower energy consumption. To achieve this goal there are in the recent literature few examples of the application of microwave irradiation in hydrogenation and hydroformylation reactions. However, there are no precedents for the rationalization of the effect of solvents, temperature and pressure on the activity and selectivity of model olefins. The experiments were carried out on a 10 mL vial of a Discover microwave pressure oven connected with a gas addition system to a cylinder of CO and/or H<sub>2</sub>, using Rh/phosphorous as catalyst. The effect of time of irradiation, temperature and solvent will be discussed, (Figure 1).



Figure 1: Styrene hydroformylation under microwave conditions.

**Acknowledgements:** The authors are thankful to CEM corporation and FCT for financial support (FCT/QREN/FEDER/COMPETE, PTDC/QUI-QUI/112913/2009). A. R. Almeida and C. J. P. Monteiro also thank to FCT for PhD grant SFRH/BD/73190/2010 and post-doc grant SFRH/BPD/86525/2012, respectively. The Coimbra Chemistry Centre is supported by the Fundação para a Ciência e a Tecnologia (FCT), Portuguese Agency for Scientific Research, through the project PEst-OE/QUI/UI0313/2014.

[1] a) Almeida, A. R.; Peixoto, A. F.; Calvete, M. J. F.; Gois, P. M. P.; Pereira M. M. *Curr. Org. Synth.* **2011**, 8, 764-77. b) Neves, A. C. B.; Calvete, M. J. F.; Pinho e Melo, T. M. V. D.; Pereira, M. M. *Eur. J. Org. Chem.* **2011**, 6309-6320.

[2] Elena, P.; Mann, A.; Schoenfelder, A.; Rota, A.; Taddei, M. *Org. Lett.*, **2006**, 8, 3725-3727.

## P14 - Copper complexes of selected Biginelli 3,4-dihydropyrimidine-2(1H)-thiones: synthetic studies and structural characterization

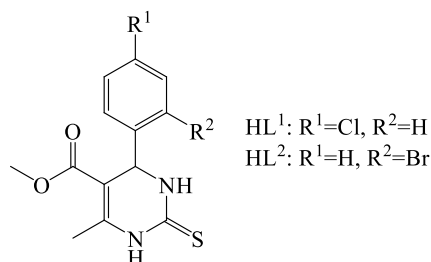
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Copper is an essential metal that can be found in trace amounts in all living organisms. Copper deficiency or toxicity is implicated in a large variety of pathological conditions, like Menkes syndrome and Wilson's disease. In recent years, inorganic complexes of copper have been investigated for their therapeutic and diagnostic potential. Some examples of their biological activity are antibacterial, antifungal, antitumor and anti-inflammatory. The use of copper complexes for the treatment of several diseases, such as diabetes, Alzheimer's, Parkinson's and Huntington's has also been studied.[1] Ethyl 4-(3-hydroxyphenyl)-6-methyl-3,4-dihydropyrimidine-2(1H)-thione-5-carboxylate, widely known as Monastrol, is a cell-permeable Biginelli molecule that arrests cells in mitosis by specifically inhibiting Eg5, a member of the kinesin-5 motor protein family.[2] Comparing to traditional chemotherapeutic agents, this type of inhibitors does not lead to neuropathic side effects and, thus, kinesin spindle protein has become an attractive anticancer target.[3] Given that we have a fair amount of experience regarding Biginelli molecules,[4] we decided to develop novel Biginelli-like transition metal complexes and determine whether or not a synergistic effect concerning their biological properties, particularly the anticancer activity, could be obtained with the introduction of a metal center. A group of 3,4-dihydropyrimidine-2(1H)-thiones was easily prepared through a multicomponent, acid-catalyzed and microwave-assisted methodology, generally good isolated yields being obtained. Some of these Biginelli compounds were selected, utilized as ligands and reacted with copper(II) salts (Figure 1). The resulting copper complexes were characterized by <sup>1</sup>H and <sup>13</sup>C NMR spectroscopy, IR spectrophotometry, elemental analysis and mass spectrometry, as well as via conductivity and susceptibility measurements, and allowed us to propose the following structural formulas: [Cu(HL<sup>1</sup>)(L<sup>1</sup>)], [Cu(L<sup>2</sup>)<sub>n</sub>] and [Cu(HL<sup>2</sup>)<sub>2</sub>Cl].



**Figure 1.** Some Biginelli compounds used as ligands in the synthesis of novel copper complexes.

**Acknowledgments:** Financial support provided by *Centro de Química de Coimbra, Chymiotecnion* and *Fundação para a Ciência e Tecnologia* (SFRH/BD/41472/2007 PhD grant received by B.F.O.N.) is gratefully appreciated.

- [1] Duncan, C.; White, A.R.; *Metallomics* **2012**, 4, 127-138.
- [2] Mayer, T. U.; Kapoor, T. M.; Haggarty, S. J.; King, R. W.; Schreiber, S. L.; Mitchison, T. J.; *Science* **1999**, 286, 971-974.
- [3] Zhang, Y.; Xu, W.; *Anticancer Agents Med. Chem.* **2008**, 8, 698-704.
- [4] Pineiro, M.; Nascimento, B. F. O.; Rocha Gonsalves, A. M. d'A.; *Dihydropyrimidinone Derivatives: Redox Reactivity, Pharmacological Relevance and Medicinal Applications*. In *Quinones: Occurrence, Medicinal Uses and Physiological Importance*; Price, E. R., Johnson, S. C., Eds.; Nova Science Publishers: Hauppauge, NY, USA, 2013; pp 1-56.

# P15 - Novel high efficiently photosensitizer axially carborane-cage substituted silicon phthalocyanine; Synthesis, Characterization and Photophysicochemical Properties

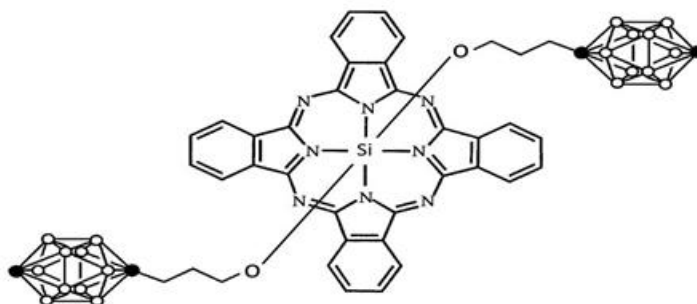
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Metallophthalocyanines (MPcs) are important dyes used in the medicinal field as photosensitizers for photodynamic therapy (PDT) of cancer treatment [1]. This technology is based on the light excitation of a photosensitizer which induces a localized oxidative damage within the cells by formation of highly reactive oxygen species, the most important of which is singlet oxygen [2].

The photophysical properties of MPc dyes are strongly influenced by nature of the central metal ion. Closed shell and diamagnetic ions, for example  $Zn^{2+}$ ,  $Ga^{3+}$  and  $Si^{4+}$ , give phthalocyanine complexes excellent properties such as high triplet yields and long triplet lifetimes [3-4].



Synthetic route of the new silicon phthalocyanine

In this study; the new axially substituted silicon (IV) phthalocyanine was synthesized by treating silicon phthalocyanine dichloride  $SiPc(Cl)_2$  with o-Carborane monool. The compound and o-Carborane monool were characterized by elemental analysis, mass spectrometry, UV-Vis, FT-IR,  $^1H$  NMR,  $^{13}C$  NMR and  $^{11}B$  NMR spectroscopy. Photophysical (fluorescence quantum yield and lifetime) and photochemical (singlet oxygen and photodegradation quantum yield) properties of complex were reported in different solutions (DMSO, DMF, Toluene). The results of spectral measurements were showed, that both  $SiPc$  and carborane cage are potential to use as sensitizers in boron neutron capture therapy (BNCT) and photodynamic therapy (PDT).

**Keywords:** Phthalocyanine; Silicon; Carborane; Photochemistry; Photophysical.

## References:

- [1] Allen CM, Sharman WM, van Lier JE, *J. Porphyrins Phthalocyanines* **2001**, 5, 161-169.
- [2] G, Yaşa.; A, Erdoğan.; A, L. Uğur.; M, K. Şener.; U, Avcıata.; T, Nyokong., *Journal of Porphyrins and Phthalocyanines* **2012**, 16, 845-854.
- [3] A, Oğunsipe.; D, Maree.; T, Nyokong., *Journal of Molecular Structure* **2003**, 650, 131-140
- [4] E, Kırbaç.; G, Y. Atmaca.; A, Erdoğan., *Journal of Organometallic Chemistry* **2014**, 752, 115-122

## P16 - Synthesis of Azido Sugars as Synthons for Nitrogen-Containing Sugar Derivatives with Potential Biological Interest

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Azido sugars are recognized as useful and versatile precursors for a variety of biologically active compounds, including amino sugars, imino sugars, triazole-containing sugars or nucleosides [1]. The azido group can undergo a variety of transformations, enabling the introduction of a number of functionalities in a carbohydrate backbone and the synthesis of new derivatives. With this in mind, we were motivated to synthesize and exploit the ability of a panel of azido sugars as synthons for sugar sulfonamides and imino sugars. Both sulfonamide-containing molecules and imino sugars are frequently associated with a wide spectrum of bioactivities [2, 3], and hence the development of synthetic methodologies towards their synthesis is highly encouraging.

Protected 5- and 6-azido sugars (compounds type **I**, Figure 1) were synthesized in few steps from readily available furanoses or pyranoses, by reaction of intermediate 5- or 6-*p*-toluenesulfonyl derivatives with sodium azide. Further conversion of **I** into sulfonamides (**II**) or imino sugars of type **III** was exploited, through Staudinger reduction followed by sulfonylation or by using the intramolecular Boyer reaction, respectively. In this communication our results will be presented and discussed.

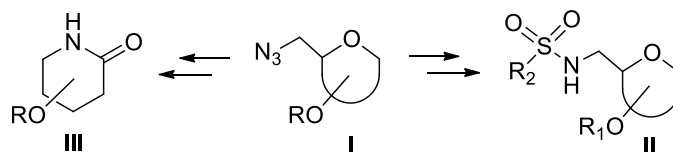


Figure 1. Access to sugar sulfonamides (**II**) or imino sugars of type **III** from azido sugars (**I**)

**Acknowledgements:** The authors thank Fundação para a Ciência e Tecnologia (FCT) for financial support through the project PEst-OE/QUI/UI0612/2013.

- [1] Beckmann, H. S. G.; Wittmann, V. Azides in Carbohydrate Chemistry. In *Organic Azides: Syntheses and Applications*; Bräse, S., Banert, K., Eds.; John Wiley & Sons, Ltd, Chichester, UK, 2010; pp 469-490.
- [2] a) Scozzafava, A.; Owa, T.; Mastrolorenzo, A.; Supuran, C. T., *Curr. Med. Chem.* **2003**, *10*, 925-53; b) Shah, S. S. A.; Rivera, G.; Ashfaq, M. *Mini Rev. Med. Chem.*, **2013**, *13*, 70-86.
- [3] Nash, R. J.; Kato, A.; Yu, C.Y.; Fleet, G. W. *Future Med. Chem.* **2011**, *12*, 1513-21.

## P17 - A new approach towards anti-inflammatory drugs

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Two isoforms of cyclooxygenase (COX) exist and while COX-1 is constitutive, the expression of COX-2 is induced during inflammatory processes [1]. Commercially available non-steroidal anti-inflammatory drugs (NSAIDs) used for the treatment of inflammation are mostly non-selective, inhibiting both COX isoforms, showing gastrointestinal (GI) toxicity. Thus, studies towards COX-2 selective inhibition led to a new class of selective NSAIDs known as “coxibs”. Although coxib compounds benefit from the lack of GI toxicity, this class was reconsidered due to adverse cardiovascular events [2]. Thus, safer COXs selective inhibitors are needed. The discovery that COX overexpression is associated with some cancers triggered the investigations on the usage of anti-inflammatory drugs on chemoprevention and chemotherapy [3]. It was observed that COX-1 is overexpressed in a mouse model of epithelial ovarian cancer and that a selective COX-1 inhibitor (SC-560) attenuates its growth [4]. On the other hand the discovery that COX-2 is overexpressed on GI cancers boosted to the development of COX-2 inhibitors as chemopreventives [5]. This presentation will focus on the recent studies on a novel approach towards COX selective inhibition and detection. A system based on pegylated compounds (involving known inhibitors and novel synthesized compounds), containing a fluorescent probe, has been prepared and evaluated against COX (Fig. 1), and the results obtained will be discussed.

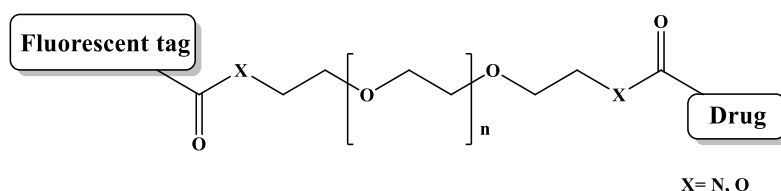


Fig. 1. Novel system prepared towards COXs selective inhibition.

**Acknowledgements:** We thank to the Fundação para a Ciência e Tecnologia for fellowship SFRH/BD/89518/2012.

[1] Smith, W.; DeWitt, D.; Garavito, R., *Annu Rev Biochem.* **2000**, 69, 145-182.

[2] Harirforoosh, S.; Asghar, W.; Jamali, F., *J Pharm Pharm Sci.* **2013**, 16 (5), 821-847.

[3] Sahin, I. H.; Hassan, M. M.; Garrett, C. R., *Cancer Letters* **2013**.

[4] Daikoku, T.; Tranguch, S.; Trofimova, I.; Dinulescu, D.; Jacks, T.; Nikitin, A.; Connolly, D.; Dey, S., *Cancer Res.* **2006**, 66 (5), 2527-2531.

[5] Wang, R.; Guo, L. J.; Wang, P.; Yang, W. J.; Lu, Y. Y.; Huang, Z. Y.; Tang, C. W., *Current Pharmaceutical Design* **2013**, 19 (1), 115-125.

## P18 - Synthesis of new hexacyclic steroids via [8+2] cycloaddition of diazafulvenium methides

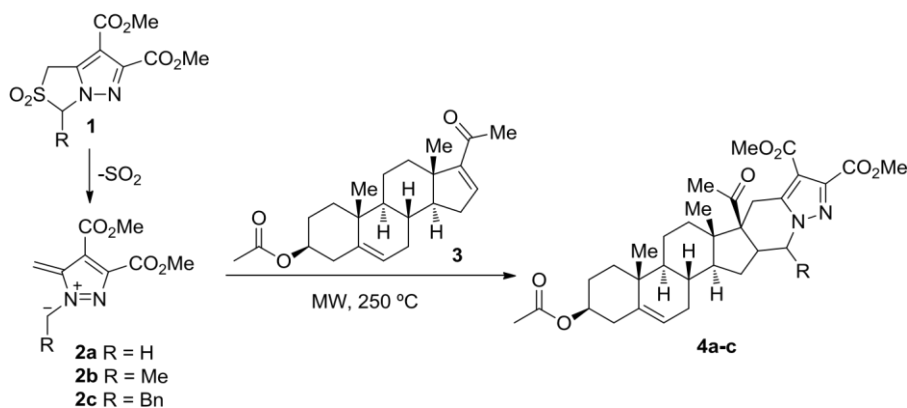
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Steroids are a widely important class of both naturally occurring and synthetic compounds with a great diversity of applications in human physiology and medicine.<sup>[1]</sup> Effectively, some steroids are important hormones, namely cortisone, progesterone, estradiol and testosterone. The most used steroids in medicine are cortisone and progesterone and their various synthetic derivatives. 16Dehydropregnenolone acetate (16-DPA) is a versatile building block for the hemisynthesis of different steroidal drugs, including corticosteroids or soft corticosteroids, anabolic steroids, sex hormones and oral contraceptives.<sup>[2]</sup> Thus, the reactivity of 16-DPA (**3**) towards diazafulvenium methides (**2**) was explored in order to develop a new strategy for the synthesis of steroid derivatives, in particular new hexacyclic steroids. We have previously demonstrated that diazafulvenium methide **2a**, generated from the SO<sub>2</sub> extrusion of 2,2-dioxo-1*H*,3*H*-pyrazolo[1,5-*c*][1,3]thiazole **1a**, participates in [8+2] cycloadditions with 16-DPA giving pyrazolo-annulated steroid **4a** stereoselectively.<sup>[3]</sup> The work was now extended to include the cycloaddition of 16-DPA with other diazafulvenium methides (e.g. **2b** and **2c**) which led to the stereoselective synthesis of new hexacyclic steroids (Scheme 1). From these reactions vinyl-1*H*-pyrazoles<sup>[4]</sup> derived from the intramolecular sigmatropic [1,8]H shift of diazafulvenium methides **2b** and **2c** were also isolated. Further details of this study will be disclosed.



**Scheme 1.** [8+2] Cycloaddition of diazafulvenium methides **2** with 16-DPA (**3**).

**Acknowledgements:** Thanks are due to FCT (Project PEst-OE/QUI/UI0313/2014; Grant SFRH/BPD/84413/2012) for financial support.

[1] Salvador, J.A.R., *et al*, *Nat. Prod. Rep.*, **2013**, 30, 324-374.

[2] a) Chowdhury, P.; *et al*, *J. Chem. Eng. Process Technol.* **2011**, 2, 117. b) Kumar, M.; *et al*, *Bioorg. Med. Chem. Lett.* **2011**, 21, 2232-2237.

[3] Catela, I.C. “*Preparação de Novos Derivados Esteroides Via Reações de Cicloadição Dipolar*”, MSc Tesis, Faculty of Pharmacy, University of Coimbra, Coimbra (**2013**).

[4] Pinho e Melo, T.M.V.D.; Nunes, C.M.; Soares, M.I.L.; Paixão, J.A.; Beja, A.M.; Silva, M.R. *J. Org. Chem.* **2007**, 72, 4406-4415.

## P19 - Gold nanoparticles coated with highly charged polymers.

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Free cations form complexes with a wide variety of ligands in solution. Recently, it has become necessary to take into account the impact of anthropogenic stabilized nanoparticles. These nanoparticles have greater stability than natural particles of similar size, thereby increasing the complexity of the mixtures which already exists in solution in natural water reserves.

So, in order to approach to the interactions between metal nanoparticles and organic matter in natural water reserves, we intend to study the behavior of gold nanoparticles coated with charged homopolymers. This charged nanoparticles will be used as new nanomaterial that can be usefull in modeling electrochemical processes of nanomaterials impact monitorization on the environment.

The monodispersed nanoparticles were obtained by citrate reduction of a gold salt ( $\text{HAuCl}_4$ ) and grown by further reduction with ascorbic acid in the presence of a surfactant, in order to prevent aggregation.

Three polymers of diferent weights were synthetized by Reversible Addition-Fragmentation chain Transfer (RAFT), using a dithioester as Chain Transfer Agent, having, then, their thiocarbonylthio functionality reduced to thiol, to allow the coating of the nanoparticles (Fig.1).

The nanoparticles coating were obtained by adding a solution of the required polymer to the nanoparticles solution, stirring and left overnight

Stable nanoparticles coated with three different sizes of a charged homopolymer were obtained. This nanoparticles were characterized by light scattering and Zeta potencial, and their complexation with several metals will be tested by polarography.

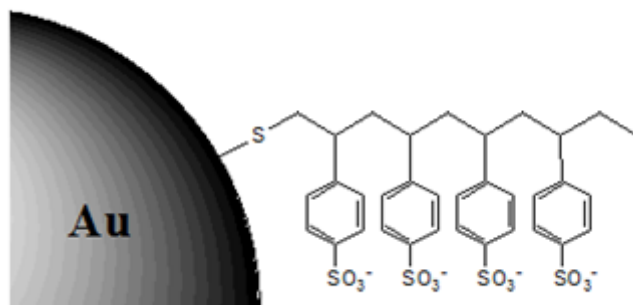


Figure 1 – Polymer linked to Au nanoparticle by an Au-S bond.

**Acknowledgements:** This work is supported by national Portuguese funding through FCT - Fundação para a Ciência e a Tecnologia, project ref. FCT-ANR/AAG-MAA/0065/2012 and PEst-OE\_QUI\_UI4023\_2011.

## P20 - Targeting triple-negative breast cancer cells with 6,7-bis(hydroxymethyl)-1*H*,3*H*-pyrrolo[1,2-*c*]thiazoles

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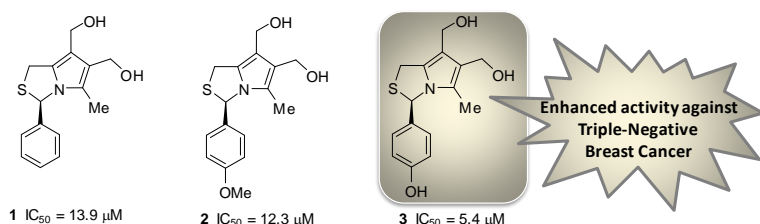
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In recent years we have studied chiral hydroxymethyl-1*H*,3*H*-pyrrolo[1,2-*c*]thiazoles (PT) as anti-proliferating agents against breast cancer [1,2], being chiral (3*R*)-6,7-bis(hydroxymethyl)-5-methyl-3-phenyl-1*H*,3*H*-pyrrolo[1,2-*c*]thiazole **1** the most promising scaffold for the design of new derivatives due to its good performance against MCF7 breast cancer cell lines (IC<sub>50</sub> = 1.0 μM). In an effort to produce new structures with better anticancer activity and that may give additional knowledge on SAR, based on structure **1**, we synthesized and evaluated the effect of replacing the phenyl substituent at C-3 by a 4-methoxyphenyl group **2** and by the more hydrophilic 4-hydroxyphenyl group **3**. The new PT derivatives were assayed for their *in vitro* cytotoxicity on several human breast cancer cell lines (MCF7, HCC1954 and HCC1806 cell lines). Particularly interesting were the results obtained for compound **3**, which prove to be the most promising compound regarding HCC1806 human cell line, a triple-negative (TN) breast cancer and one of the most challenging tumors in the clinical practice (Figure). It was demonstrated that the presence of a hydroxyphenyl group at C-3 improves the anti-cancer activity for the TN cell line. So far our studies have been limited to cytotoxicity of the compounds synthesized. Thus, in order to understand the mechanism of action and the impact on cancer biology, the effects of these compounds on cell survival, viability, cell cycle, DNA damage and expression of proteins related to cell death pathways were studied. PT **1** and **3**, the more promising anti-proliferating agents against HR<sup>+</sup> MCF7 cell line and TN HCC1806 cell lines, respectively, have been selected for this study. The reported results indicate that these compounds may induce DNA damage. Our studies in this family of compounds consolidate the potential of hydroxymethyl-1*H*,3*H*-pyrrolo[1,2-*c*]thiazoles for the therapy of, particularly the triple-negative breast cancer, an asset to continue with pre-clinic studies.



**Figure 1** - Cytotoxicity against HCC1806 triple-negative breast cancer human cell line (96 h).

**Acknowledgments:** Thanks are due to FCT (Project PEst-OE/QUI/UI0313/2014, SFRH/BD/44957/2008, SFRH/BD/61378/2009) for financial support.

[1] Soares, M. I. L.; Brito, A. F.; Laranjo, M.; Abrantes, A. M.; Botelho, M. F.; Paixão, J. A.; Beja, A. M.; Silva, M. R.; Pinho e Melo, T. M. V. D. *Eur. J. Med. Chem.* **2010**, *45*, 4676.

[2] Soares, M. I. L.; Brito, A. F.; Laranjo, M.; Paixão, J. A.; Botelho, M. F.; Pinho e Melo, T. M. V. D. *Eur. J. Med. Chem.* **2013**, *60*, 254.

## P21 - Synthesis of chitosan nanoparticles bearing folic acid conjugates for active cancer cell targeting

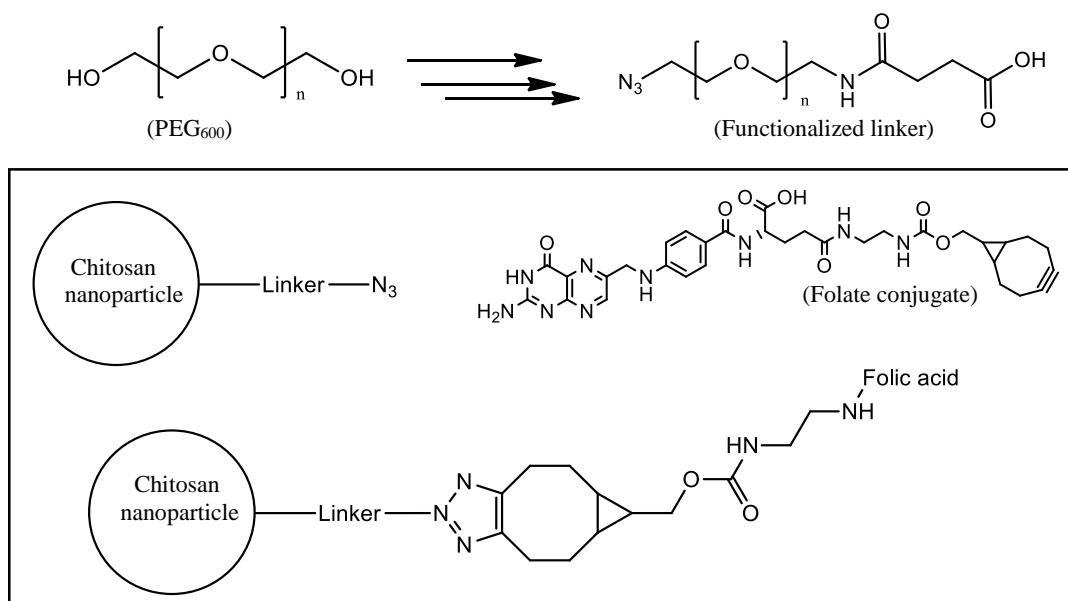
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A considerable percentage of tumor cell lines present an increased expression of folate receptors on their surface. Folic acid and folate conjugates present tropism for these receptors and have been employed to actively target this tumor cells, increasing therapeutic specificity and consequently decreasing side-effects [1]. We are developing a new approach to synthesize chitosan nanoparticles, which have been used in the field due to their favorable biological properties, bearing folic acid conjugates through a fast and selective copper-free 1, 3-dipolar alkyne/azide cycloaddition [2]. In this work the development of a functionalized PEG linker as substrate for the “click chemistry” reaction and its linkage to chitosan are one of the challenges followed by efficient nanoparticle formation and posterior conjugation with the folate derivate.



Scheme 1: General strategy for chitosan nanoparticles bearing folic acid conjugate synthesis

**Acknowledgements:** We thank the Fundação para a Ciência e Tecnologia for financial support (SFRH/BPD/73932/2010), RECI/CTM-POL/0342/2012)

[1] Xia, W.; Low, P. S. *J. Med. Chem.*, **2010**, 53, 6811

[2] Trindade, A. F.; Frade, R. F. M.; Macoas, E. M. S.; Graça, C.; Rodrigues, C. A. B.; Martinho, J. M. G.; Afonso, C. A. M. *Org. Biomol. Chem.*, **2014**, in press

## P22 - PGN - towards a fragment of bacterial peptidoglycan

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Oligosaccharides and glycoconjugates are abundant in nature and play an important role in biological systems, making them attractive for biological and chemical research development [1]. Indeed, the most relevant and naturally occurring glycoconjugates contain residues of 2-amino-2-deoxy- $\beta$ -D-glucopyranosyl (D-glucosamine) moieties connected to other residues *via* a 1,2-*trans*-glycosidic linkage. Particularly 2-*N*-acetamido-2-deoxyglycosides, are abundant in nature, contain glucosamine units that can be glycosylated through O-3, O-4, and O-6 positions [2].

The vertebrate and invertebrate innate immune system recognizes invading pathogens by some associated molecular pathways, such as the PGN (peptidoglycan) [3,4]. PGN is the major component of the bacterial cell wall and is constituted by glycan chains of alternating  $\beta$ (1-4)-linked *N*-acetylglucosamine (GlcNAc) and *N*-acetylmuramic acid (MurNAc) residues (Figure 1), cross-linked by short peptide bridges. In order to understand the role of the PGN in bacterial infections, fragments of homogeneous PGN are required, but their limited availability and difficult purification still remain a major obstacle for research development in this field.

Due to the increasing interest on these systems our research is focused on the development of efficient synthesis of glucosamine disaccharides building blocks to achieve the construction of PGN. The challenge lies on the regioselective protection of hydroxyl groups and on the stereoselective glycosylation of the glucosamine moieties [5-7]. Herein our recent advances on the PGN synthesis will be presented.

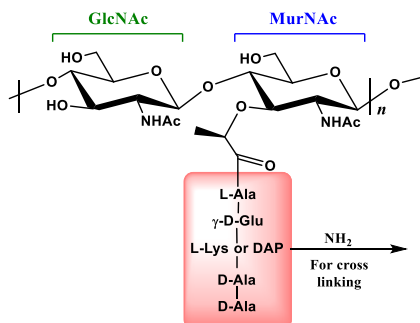


Figure 2 - Representation of a PGN unit

**Acknowledgements:** We thank the Fundação para a Ciência e Tecnologia for financial support for the projects PTDC/SAU-IMU/111806/2009 and PTDC/QEQ-QOR/2132/2012.

- [1] Ernst B.; Magnan J. L., *Nat. Rev. Drug Discovery* **2009**, 8, 661-677.
- [2] Bongat A. F. G.; Demchenko A. V., *Carbohydr. Res.* **2007**, 342, 374-406.
- [3] Filipe S. R.; Tomasz A.; Ligoxygakis P. *EMBO J.* **2005**, 6, 327-333.
- [4] Swaminathan C. P.; Brown P. H.; Roychowdhury A.; Wang Q.; Guan R. J.; Silverman N.; Goldman W. E.; Boons G. J.; Mariuzza R. A., *PNAS* **2006**, 103, 684-689.
- [5] Enugala R.; Carvalho L. C. R.; Marques M. M. B. *Synlett* **2010**, 18, 2711-2716.
- [6] Enugala R.; Carvalho L. C.; Pires M. J. D.; Marques M. M. B. *Chem. Asian J.* **2012**, 7, 2482-2501.
- [7] Enugala R.; Pires M. J. D.; Marques M. M. B. *Carbohydr. Res.* **2014**, 384, 112-118.

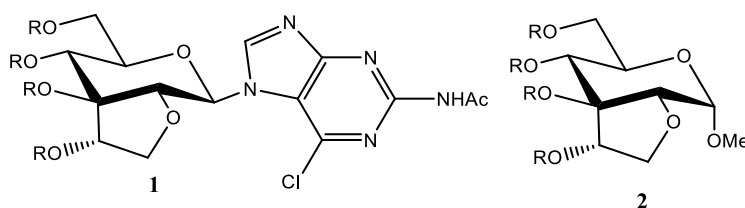
## P23 - Study on Wittig olefination for the synthesis of carbohydrate-based butyrylcholinesterase inhibitors

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The loss of cholinergic activity is a characteristic symptom of Alzheimer's disease (AD), and the therapy currently used involves inhibition of cholinesterases. Although selective inhibitors of acetylcholinesterase or dual inhibitors of both cholinesterases have demonstrated positive results in the early stages of the disease, they have proven ineffective in later stages. Selective inhibition of butyrylcholinesterase (BChE) increases acetylcholine levels, restores cognitive function and reduces amyloid fibrils,[1] and to the best of our knowledge there are no commercially available drugs based on these inhibitors. Hence our group has been engaged with the design of new, potent and selective inhibitors of BChE and presently we have synthesized a molecular entity that showed inhibitory levels on the same range as those of rivastigmine, a dual drug used to treat AD.[2] The unusual structural features of this compound, with a 2-acetamidopurine base N7-linked to a sugar residue which, by itself, is quite complex and contains a fused tetrahydrofuran ring (**1**), encouraged us to develop new methodologies aiming at an easy access to this type of structures, in particular to their sugar moiety. In this work we present a new synthetic procedure for the bicyclic sugar type **2** and analogues, where the key step is a stereoselective Wittig reaction, which outcome is controlled by the choice of protecting groups and the solvent. This is a simple and efficient methodology that allows an easy access to these complex bicyclic sugars starting from readily available precursors.



**Acknowledgments:** The authors thank FCT for Vasco Cachatra PhD grant (SFRH/BD/90359/2012) and for financial support of CQB Strategic Project Pest-OE/QUI/UI0612/2013.

[1] Schulze M., Siol O., Decker M., Lehmann J.: *Bioorg. Med. Chem.* **2010**, 20, 2946-2949.

[2] Marcelo F., Silva F. V. M., Goulart M., Justino J., Sinay P., Bleriot Y., Rauter A. P.: *Bioorg. Med. Chem.* **2009**, 17, 5106-5116.

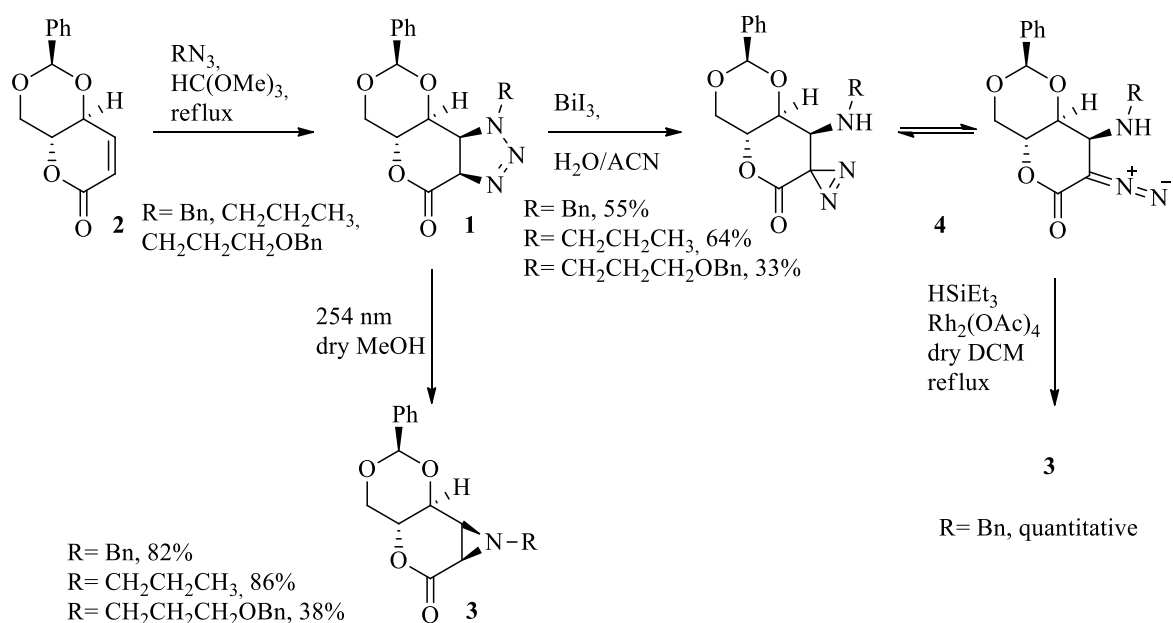
## P24 - Synthesis of aziridines from diazo-diazirine compounds.

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Triazolines **1** were obtained from  $\delta$ -lactone **2** and aliphatic azides with the objective of generating aziridine **3** which would be later used as synthon in the synthesis of aza-sugars.<sup>[1]</sup> Triazolines **1** were obtained in refluxing trimethyl orthoformate for 75 hours. <sup>1</sup>H NMR of the crude reaction material did not reveal the formation of the desired aziridine **3** by thermolysis. So, the synthesis of the aziridine was obtained by photolysis in a very small scale, which represented a constriction from the synthetic point of view. (Scheme 1)

Occasionally in an attempt to cleave the triazolines acetal moieties under water/acetonitrile reflux in the presence of a catalytic amount BiI<sub>3</sub> (0.1 eq.),<sup>[2]</sup> diazirine **4** was obtained, instead of the acetal cleavage.<sup>[3]</sup> With idea of finding the equilibrium of diazirine - diazo compound, the diazirine was reacted with triethylsilane in the presence of dirhuthenium tetraacetate with the aim of introducing the silane group in the place of the diazo group.<sup>[3]</sup> Aziridine **3** formed instead in a cleanly way allowing the scale up of the aziridine formation.



Scheme 1

**Acknowledgements:** We thanks to FCT, QREN, COMPETE and POPH for financial support and to the Portuguese NMR Network (Bruker Avance II 400).

[1] Blencowe, Anton; Hayes, Wayne *Soft Matter* **2005**, *1*, 178–205

[2] Bailey '07, Aaron D., "Green Chemistry Using Bismuth Salts Bismuth (III) Iodide Catalyzed Deprotection of Acetals and Ketals in  $H_2O$ " (**2007**). Honors Projects, Paper 6.

[3] Gupta, D.M., Cohen, C.M., Davies, H.M.L. *Org. Lett.*, **2013**, *15*, 24, 6120-6123.

## P25 - Exploring the 2-deoxypentopyranosides for potential application as antimicrobial agents: synthesis and surface activity

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The search for new drugs for pathogenic infections is currently a major topic of research as a result of the ongoing spread of multidrug-resistance. Other important issue relates to biohazard security matters and the lack of treatment. These facts demand an incessant investigation of new antibacterial agents with new mechanisms of action. We have introduced a new family of compounds structurally related to alkyl 2-deoxyglycosides, which exhibited a potent activity against *Bacillus* species<sup>[1-3]</sup>. These structural features may give insights onto the relationship between structure, surface activity and bioactivity of this family of compounds regarding *Bacillus cereus*, *Bacillus subtilis* and *Bacillus anthracis* and contribute to the study of their mechanism of action. A preliminary evaluation of the antibacterial activity on *B. species* showed that the most promising compound is dodecyl 2-deoxy- $\alpha$ -D-threo-pentopyranoside (compound type **6**). Hence, its surface activity and its scale up were also investigated. An underlying goal was the development of an easier and economical synthesis of the glycal used as glycosyl donor of the glycosylation reaction. Regarding the molecular diversity associated to derivatives synthesized from glycals, new strategies for their synthesis are of key importance. Glycosylation with **4** of a variety of alcohols led to compounds type **5** (Scheme 1), which were submitted to the Zémlen deacetylation to give **6** in good yields.<sup>[4]</sup> The structure of the isolated compounds was confirmed by spectroscopic analysis using NMR as a prime tool. The 2deoxyglycosides were subjected to surface activity studies and the results will be presented and discussed.



**Scheme 1:** Reagents and conditions: a) Ac<sub>2</sub>O, pyridine; b) CH<sub>3</sub>COOH/CH<sub>3</sub>COBr in MeOH; c) CH<sub>3</sub>COOH/CH<sub>3</sub>COBr, MeOH, Ac<sub>2</sub>O; d) Zn/NaH<sub>2</sub>PO<sub>4</sub>/acetone; e) TPFB, CnXmOH; f) NaOMe/MeOH

**Acknowledgements:** This work was supported by FEDER-QREN-SI I&DT co-promotion. The authors would like to thank the FCT for financial support ((PEst-OE/QUI/UI0612/2013).

1. Silva F., Goulart M., Justino J., Neves A., Santos F., Caio J., Lucas S., Newton A., Sacoto D., Barbosa E., Santos M. S., Rauter A. P., *Bioorg. Med. Chem.*, 16, 4083-4092 (2008)
2. Rauter A. P., Lucas S., Almeida T., Sacoto D., Ribeiro V., Justino J., Neves A., Silva F. V., Oliveira M. C., Ferreira M. J., Santos M. S., Barbosa E., *Carbohydr. Res.*, 340, 191-201 (2005)
3. Martins, A., Santos, M.S., Dias, C., Serra, P., Cachatra, V., Pais, J.P., Caio, J., Teixeira, V.H., Machuqueiro, M., Silva, M.S., Pelerito, A., Justino, J., Goulart, M., Silva, S.V., Rauter, A.P., *Eur. J. Org. Chem.*, 2013, 1448–1459 (2013).

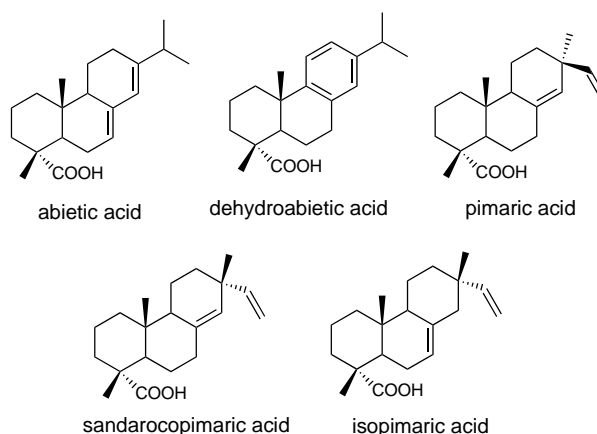
## P26 - Characterization of rosin samples using GC-MS and chemometrics analysis: origin and composition

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Rosin is a solid form of natural resin obtained from conifers and mainly pine trees. Derivatization of rosin is an important industrial process, because it is the feedstock for the production of adhesives, paper, print inks, paints and chewing gum, among others.

Rosin consists essentially in organic acids of hydrophenantrene derivatives, Scheme 1, and natural resin has a variable composition depending on the respective geographical origin and type of tree. The knowledge about the composition of rosin is essential for its industrial use.



Scheme 1. Components of Rosin

In this work, we present a chemical analysis of resinic acids of rosin, obtained from six portuguese companies, using GC-MS and <sup>1</sup>H-NMR techniques, and interpret the results on the basis of a chemometrics analysis that includes hierarchical cluster and principal component analysis. This allows characterize the feedstock, establishing similarity relations, and also geographical patterns based on composition.

**Acknowledgements:** The authors thank the Coimbra Chemistry Centre, funded by the Fundação para a Ciência e a Tecnologia (FCT), Portuguese Agency for Scientific Research, through the project PEst-OE/QUI/UI0313/2014 for financial support, and EuroYser, Respol, EuroChemicals, Resal, ProResina and Dercol for providing the samples.

- [1] Arvela, P., Holmbom, B.; Salmi, T.; Murzin, D. *Catal. Rev.*, **2007**, 49, 197.  
[2] SuSadhra, S.; Foulds, I. Gray, C. *Contact Dermat.*, **1998**, 39, 58

## P27 - $\varepsilon$ -Functionalization of 5-Substituted Furfurals Via Trienamine Intermediates

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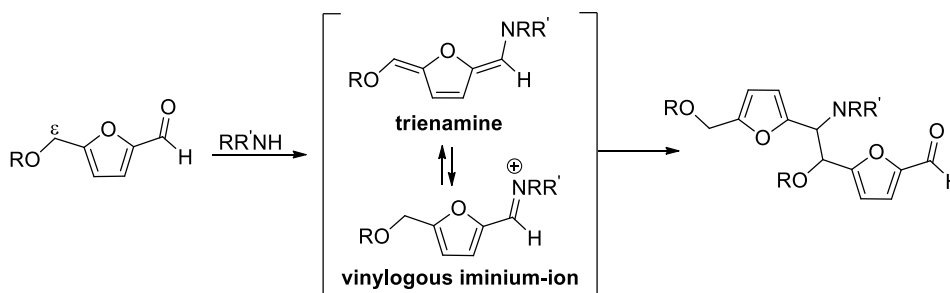
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Recently reported by Jørgensen *et al.*, [1] trienamine catalysis is emerging as a new activation mode as an extension of the well-known enamine catalysis [2]. In particular, trienamine activation by HOMO-raising have been demonstrated as a powerful strategy for modifications of 2,4-dienals. [3] To the best of our knowledge, linear-trienamines is mainly limited to Diels-Alder reactions through  $\beta,\varepsilon$ -functionalization. During our ongoing studies towards furanics modifications [4] we were glad to discover an unprecedented exclusive  $\varepsilon$ -functionalization of 5-substituted furfurals. Herein we would like to present the results on the reaction conditions optimization, reaction scope, and mechanistic details of this new methodology. [5]



**Acknowledgements:** We thank the Fundação para a Ciência e a Tecnologia (PEst-OE/SAU/UI4013/2011, SFRH/BD/73971/2010 and PTDC/QUI-QUI/119823/2010) and Fundação Calouste Gulbenkian (Programa de Estimulo à Investigação 2012) for financial support.

- [1] (a) Jia, Z. J.; Jiang, H.; Li, J. L.; Gschwend, B.; Li, Q. Z.; Yin, X.; Grouleff, J.; Chen, Y. C.; Jørgensen, K. A., *J. Am. Chem. Soc.* **2011**, 133, 5053; (b) Halskov, K. S.; Johansen, T. K.; Davis, R. L.; Steurer, M.; Jensen, F.; Jørgensen, K. A., *J. Am. Chem. Soc.* **2012**, 134, 12943;
- [2] For reviews see for example: (a) Mukherjee, S.; Yang, J. W.; Hoffmann, S.; List, B., *Chem. Rev.* **2007**, 107, 5471; (b) Barbas, C. F., *Angew. Chem. Int. Ed.* **2008**, 47, 42; (c) MacMillan, D. W. C., *Nature* **2008**, 455, 304.
- [3] For reviews see for example: (a) Kumar, I.; Ramaraju, P.; Mir, N. A., *Org. Bio. Chem.* **2013**, 11, 709; (b) Jiang, H.; Albrecht, L.; Jørgensen, K. A., *Chem. Sci.* **2013**, 4, 2287.
- [4] (a) Simeonov, S. P.; Coelho, J. A. S.; Afonso, C. A. M. *Chemsuschem* **2012**, 5, 1388; (b) Simeonov, S. P.; Coelho, J. A. S.; Afonso, C. A. M. *Chemsuschem* **2013**, 6, 997; (c) Subbiah, S.; Simeonov, S. P.; Esperanca, J. M. S. S.; Rebelo, L. P. N.; Afonso, C. A. M. *Green Chem.* **2013**, 15, 2849.
- [5] Coelho, J. A. S.; Trindade, A. F.; Afonso, C. A. M., *submitted*

## P28 - Studies interaction of copper(II) acetate with three different diaryl-3,4-dihydropyrimidine-2(1H)-thiones by microwave heating.

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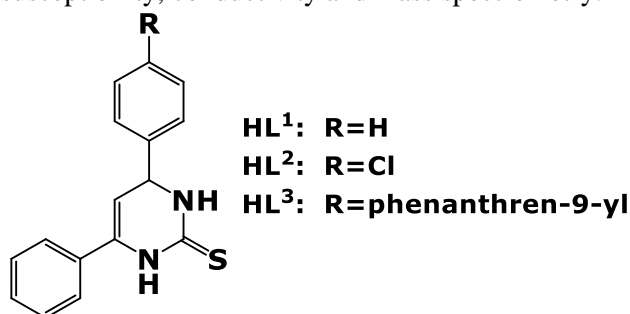
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Microwave irradiation has been applied as a non-conventional reaction condition in several areas of chemistry such as organic and polymer synthesis or analytical chemistry. However, microwave synthesis of coordination and organometallic compounds has been less explored[1].

Copper is an essential trace nutrient for organisms. It has been established that the properties of copper-coordinated compounds are largely determined by the nature of ligands and donor atoms bound to the metal ion. The potential use of these complexes have been attracted great interest due to their biological activity as antimicrobial, antiviral, anti-inflammatory and antitumor agents[3,4].

The copper complexes of 4,6-diaryldihydropyrimidinones were prepared by refluxing mixture of copper(II) acetate and the corresponding 3,4-dihydropyrimidine-2(1H)-thione in molar ratio (1:2). Using conventional heating copper(II) acetate dissolved in water, was slowly added in a stirred solution of the corresponding ligand HL<sup>1</sup>, HL<sup>2</sup> and HL<sup>3</sup> in ethanol for 24 h at 70 °C. Using microwave irradiation, the copper complexes were obtained in shorter reaction times. The empirical formula of the complexes was [Cu(L)(OAc)] for HL<sup>1</sup> and HL<sup>2</sup> and [Cu(L)<sub>2</sub>] for HL<sup>3</sup>. The characterization of three new complexes was carried out using different analysis techniques such as elemental analysis, IR and UV-visible spectroscopy, magnetic susceptibility, conductivity and mass spectrometry.



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[1] Kharissova, O. V.; Kharisov, B. I.; Ortiz Méndez, U.; Microwave-assisted Synthesis of Coordination and Organometallic Compounds In *Advances in Induction and Microwave Heating of Mineral and Organic Materials*, Grundas, S. Eds. Intech, Croatia, 2011

[2] Duncan, C.; White, A.R.; *Metallomics*, **2012**, 4, 127-138.

[3] Marzano, C.; Pellei, M.; Tisato, F.; Santini, C.; *Anti-cancer agents in medicinal chemistry*, **2009**, 9, 2, 185-211.

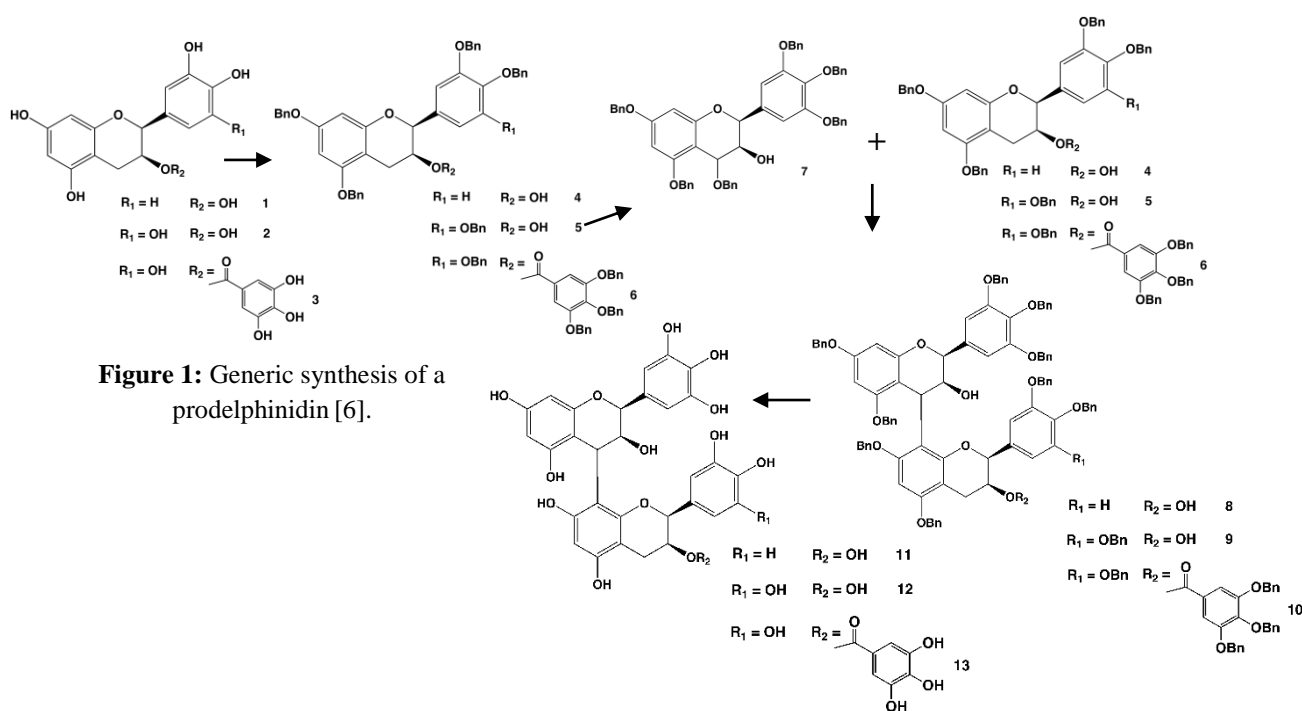
## P29 - Synthesis of Prodelphinidins

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Prodelphinidins are polymeric tannins composed mainly of gallicocatechin or epigallicocatechin units. They were found in barley, beer [1], pomegranate peels [2], redcurrant [3] and green tea [4]. The interest on this kind of compounds is growing due to their significant bioactivities [5a,b]. They are extremely difficult to identify and purify from nature and there are only a few standards to compare. Synthesis allows the access to sufficient amounts of compounds to perform chemical, biochemical and pharmacological studies and to have standards to compare and identify these compounds on natural sources. **Figure 1** shows a generic procedure of synthesis of a prodelphinidin, involving five steps. Briefly, the synthesis starts with the protection of (-)-epigallocatechin (**2**) hydroxyl groups, giving (-)-epigallocatechin4Bn (**5**) that will act as upper unit in the dimer; the second step is the protection of the down unit, (+)-catechin (**1**), giving (+)-catechin4Bn (**4**); the third step is to benzylate the upper unit at C4, giving (-)-epigallocatechin4Bn(Bn) (**7**); the fourth step is the condensation of both units giving epigallocatechin-catechin9Bn (**8**); and finally, the removal of the protection groups. Several methods were studied for the de-benzoylation since this is the most sensible step.



**Figure 1:** Generic synthesis of a prodelphinidin [6].

**Acknowledgements:** We thank the Fundação para a Ciência e Tecnologia for financial support through a Ph.D. grant (SFRH/BD/70053/2010).

1. Dvorakova, M., Moreira, M.M., Dostalek, P. Skulilova, Z., Guido, L.F., Barros, A.A. *J. Chrom. A*, **2008**, 1189, 398-405.
2. Plumb, G.W., de Pascual-Teresa, S., Santos-Buelga, C., Rivas-Gonzalo, J.C., Williamson, G. *Redox Report* **2002**, 7, 41-46.
3. Pascual-Teresa de, S., Santos-Buelga, C., Rivas-Gonzalo, J.C. *J. Agric. Food Chem.* **2000**, 48, 5331-5337.
4. Cheng, H.Y., Lin, C.C., Lin, T.C. *Antivir. Chem. Chemother.*, **2002**, 13 (4), 223-229.
5. a) Ferreira, D., Li, X.-C-, *Nat. Prod. Rep.*, **2000**, 17, 193. b) Ferreira, D., Li, X.-C-, *Nat. Prod. Rep.*, **2002**, 19, 517.
6. Ahmed, I., PhD Thesis, Paderborn, 200

## P30 - Synthesis and early ADME evaluation of a novel scaffold, Tetrahydro-6*H*-pyrido[3,2-*b*]azepin-6-one

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The synthesis and preliminary biological evaluation of novel 4-(trifluoromethyl)-5,7,8,9-tetrahydro-6*H*-pyrido[3,2-*b*]azepin-6-ones **6** is presented. The key step is a ring expansion of 4-(trifluoromethyl)-7,8-dihydroquinolin-5(6*H*)-ones **3** via a Beckmann rearrangement. The rearrangement opens up possibilities to access this novel and thus unexplored scaffold for medicinal chemistry. The biopharmaceutical profiling of these scaffolds revealed a strong structural dependency of the drug-like properties. This is reflected by the broad range in fasted state simulated intestinal fluid solubility values, permeability values across Caco-2 monolayers and intrinsic clearance values determined in human liver microsomes. The synthesis of this new trifluoromethylated scaffold starts with the formation of 3-aminocyclohex-2-en-1-one **2** from cyclohexane-1,3-dione **1**. This enamine is reacted with different 1-substituted-4,4,4-trifluoro-1,3-diones to the resulting 4-(trifluoromethyl)-7,8-dihydroquinolin-5(6*H*)-ones **3**. For the synthesis of the *O*-tosylated oximes **5**, the Beckmann rearrangement could be performed towards the desired trifluoromethylated scaffold **6**. Furthermore, the imidates **7** could also be isolated from the reaction mixtures.

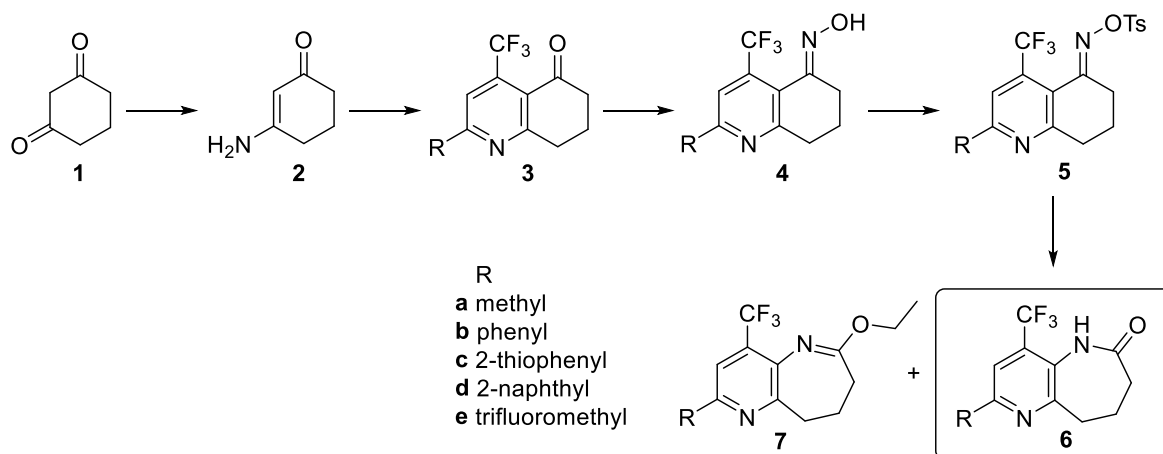


Figure 1 - Synthesis of the novel scaffold tetrahydro-6*H*-pyrido[3,2-*b*]azepin-6-one **6**.

**Acknowledgements:** This work was generously supported by IWT (Institute for the promotion of innovation by science and technology in Flanders – SBO project 100014).

## P31 - Catalytic wet peroxide oxidation of highly concentrated 4-nitrophenol solutions using metal-free graphene-based materials

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Graphene and its derivatives possess unique electronic, optical, thermal and mechanical properties that fascinated the scientific community in the last few years [1, 2]. At the same time, different carbon materials have been reported as metal-free catalysts for the catalytic wet peroxide oxidation (CWPO) of toxic and bio-recalcitrant organic pollutants, even when operating at high pollutant loads ( $5 \text{ g L}^{-1}$ ) [3]. In the present work, aiming to explore the structural and electronic transfer properties of graphene-based materials, exfoliated graphene oxide (GO) was prepared by the modified Hummers method [4, 5] using natural graphite as primary precursor, followed by chemical reduction processes using glucose (rGOG), hydrazine (rGOH) and vitamin C (rGOV). These rGO samples were subsequently tested as catalysts in the CWPO process, considering 4-nitrophenol (4-NP) as model pollutant, fed to the process in high concentration ( $5 \text{ g L}^{-1}$ ). In Figure 1 are the different conversion results measured for the produced rGO materials. They are all effective catalysts for the CWPO of  $5 \text{ g L}^{-1}$  4-NP solutions. The measured performances depend on their surface chemistry (better for less acidic materials) and on the amount of structural defects. Therefore, the results obtained may open a window of opportunity for the treatment of wastewaters with high pollutant concentrations by CWPO, which would be potentially more attractive for industrial applications than the typical conditions employed in CWPO, which consider pollutant concentrations in the range  $0.01\text{--}0.1 \text{ g L}^{-1}$ , and in few cases up to  $1 \text{ g L}^{-1}$ .

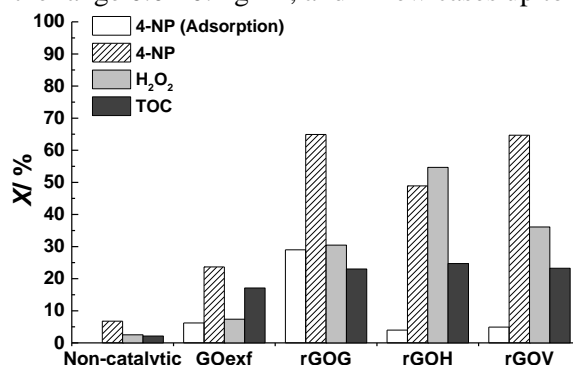


Figure 1 - 4-NP, TOC and H<sub>2</sub>O<sub>2</sub> conversion, obtained in CWPO runs performed during 24 h ( $T = 50 \text{ }^{\circ}\text{C}$ , pH 3,  $[\text{H}_2\text{O}_2] = 17.8 \text{ g L}^{-1}$  and catalyst loading =  $2.5 \text{ g L}^{-1}$ ). 4-NP adsorption removal is also shown for comparison.

**Acknowledgements:** Projects PTDC/AAC-AMB/110088/2009, PEst C/EQB/LA0020/2013, NORTE-07-0124-FEDER-0000015 and NEPCAT/n.º 38900 (co-financed by FEDER through COMPETE, QREN and ON2, and by FCT), and FCT Investigator Programme (IF/01501/2013).

[1] Machado, B.F.; Serp, P., *Catal Sci Technol* **2011**, 2, 54-75.

[2] Morales-Torres, S.; Pastrana-Martínez, L.M.; Figueiredo, J.L.; Faria, J.L.; Silva, A.M.T., *Environ Sci Pollut Res* **2012**, 19, 3676-3687.

[3] Domínguez, C.M.; Ocón, P.; Quintanilla, A.; Casas, J.A.; Rodríguez, J.J., *Appl Catal B Environ* **2013**, 140–141, 663-670.

[4] Hummers, W.S.; Offeman, R.E.; *J Am Chem Soc* **1958**, 80, 1339-1339.

[5] Pastrana-Martínez, L.M.; Morales-Torres, S.; Likodimos, V.; Figueiredo, J.L.; Faria, J.L.; Falaras, P.; Silva, A.M.T., *Appl Catal B Environ* **2012**, 123–124, 241-256.

## P32 - Production of alternative adsorbents by pyrolysis of paper mill sludge for the removal of pharmaceuticals from water

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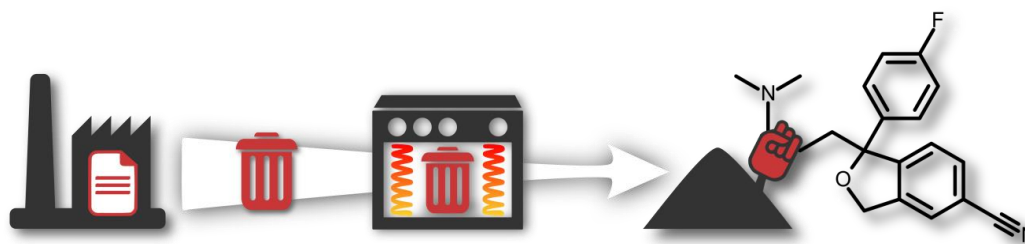
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The contamination of sewage treatment plants' effluents with pharmaceutically active ingredients is considered to be generalized; consequently, the discharge of those effluents is pointed out to be the main source of these pollutants into the environment, resulting in extensive contamination of water resources. In this context, the removal of pollutants from water by adsorption onto solid matrices is a very promising tool due to its effectiveness and versatility. However, commercially available activated carbons, usually used as adsorbents, are quite expensive making unfeasible generalized large scale applications.

In this regard, this work describes the production of alternative adsorbents from paper mill sludge and their application for the removal of a highly consumed antidepressant (citalopram) from water. The adsorbents were produced by pyrolysis of both primary and biological paper mill sludge at different temperatures and residence times, under inert atmosphere. The produced materials were fully characterized by elemental and proximate analyses, total organic carbon, Hg porosimetry, N<sub>2</sub> isotherms, FTIR, <sup>13</sup>C and <sup>1</sup>H solid state NMR, and SEM. Subsequently, batch kinetic and equilibrium experiments were carried out to describe the adsorption of citalopram onto the produced materials and onto a commercial activated carbon used for comparison purposes. Globally, the best results were obtained for the materials produced from primary paper sludge. In fact, the adsorption kinetics of the pyrolysed primary sludge is much faster than the commercially activated carbon while the adsorption capacity is approximately 5 times lower. These are very satisfactory performance indicators for a non-activated adsorbent, produced without applying environmentally aggressive methodologies (such as chemical activation). The described application for the primary paper mill sludge also constitutes an extra way of valorizing a relatively low value industrial waste, produced at large scale, with a possible application on the decontamination of highly polluted effluents (such as hospitals and pharmaceutical industries).



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### P33 - Biomimetic synthesis and characterization of new acridine derivatives

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The oxygenation mechanism performed by the prosthetic group of cytochrome P450 has inspired the use of metalloporphyrins as catalysts for oxidation reactions. Based on the fact that this monooxygenase mediates oxidations even of inert and apolar xenobiotic substrates, the metalloporphyrins have been used as biomimetic catalysts for the oxidation of polycyclic aromatic hydrocarbons, terpenes and alkylbenzenes. [1,2] Consequently, in this work, oxidative biomimetic catalysis was used to oxidize acridine, an hetero-polyaromatic compound, whose derivatives have many distinct applications, such as in anticancer therapy, luminescent probes or antimalarial drugs. The substrate was efficiently oxidized, in mild conditions, using  $\text{H}_2\text{O}_2$  as a green oxidant, in the presence of chloro [*meso*-tetrakis(2,6-dichlorophenyl)porphyrinate] manganese(III) ([Mn(TDCPP)Cl]) and ammonium acetate as the co-catalyst. [3] The reaction (Figure 1) proceeded at room temperature, leading to various derivatives functionalized on the peripheral positions of acridine, namely monoepoxydes, diepoxydes, tetraepoxydes, a hydroxylated derivative and two products derived from the non-catalytic epoxide opening by a nucleophilic attack. Depending on the reaction time and on the amount of oxidant added, different yields were obtained. These new compounds were characterized by NMR spectroscopy and mass spectrometry studies. Furthermore, computational theoretical calculations were also performed to confirm the structures of the new acridine derivatives and to understand the reactivity of the oxidation process. This reaction led to the formation of new easily functionalizable molecules that may have important properties for future biological and photochemical applications.

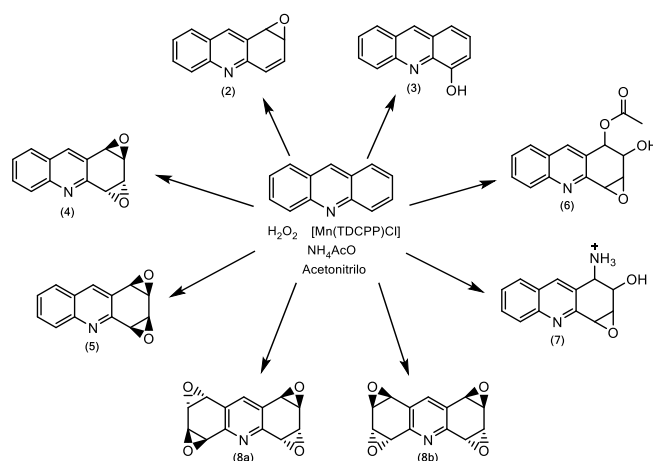


Figure 1 - Oxidation reaction of acridine catalyzed by [Mn(TDCPP)Cl] and products obtained.

**Acknowledgements:** This work was supported by FCT and FEDER through grant no. PEst-C/EQB/LA0006/2011 and project ref. PTDC/QUI-QUI/105304/2008.

- [1] McLain, J. L., Lee, J., Groves, J. T. In *Biomimetic Oxidations Catalyzed by Transition Metal Complexes*; Meunier, B., Ed.; Imperial College Press, London, 2000, pp 91-169.
- [2] Linhares, M.; Rebelo, S. L. H.; Simões, M. M. Q.; Silva, A. M. S.; Neves, M. G. P. M. S.; Cavaleiro, J. A. S.; Freire, C., *Appl. Catal. A* **2014**, 470, 427-433.
- [3] Rebelo, S. L. H.; Simões, M. M. Q.; Neves, M. G. P. M. S.; Silva, A. M. S.; Cavaleiro, J. A. S., *Chem. Commun.* **2004**, 608-609.

## P34 Theoretical structural studies for the development and synthesis of stereoselective aza-sugars with improved activity towards Golgi $\alpha$ -mannosidase II

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Most tumors show altered glycosylation patterns. Some of them are associated to cancer progression events, such as metastasis, tissue invasion, growth and non-recognition by the immune system.[1] [2] Golgi  $\alpha$ -mannosidase II (GMII) plays a key role in the N-glycosylation pathway, trimming two mannose residues. The inhibition of GMII leads to a decrease in cancer-associated oligossacarides, providing a potential target for chemotherapy. Swainsonine (1) is the most potent inhibitor of GMII known. However, it is known to have side effects resulting of Lysosomal  $\alpha$ -mannosidases (LM) inhibition, which is involved in glycoprotein degradation.[3]

In the present work, free energy calculations, using thermodynamic integration (TI) and molecular mechanics Poisson-Boltzmann surface area (MM-PBSA) were made to identify new derivatives of swainsonine which may be more selective or more potent.

It was found that solvation energy plays a major role in ligand binding. Azaswainsonines are not charged and due to solvation costs, most of them display higher affinity than swainsonine. The most effective azaswainsonine is 2. Other derivatives of swainsonine were conceived, and the one with highest affinity is 3. Swainsonine derivatives with more complex moieties were created in order to achieve selectivity between GMII and LM. Most of these molecules showed binding affinity similar to swainsonine. Compound 4 has higher affinity than swainsonine and shows selectivity. Some molecules displayed no selectivity despite having high affinity. Therefore, a commitment between selectivity and binding affinity is needed.

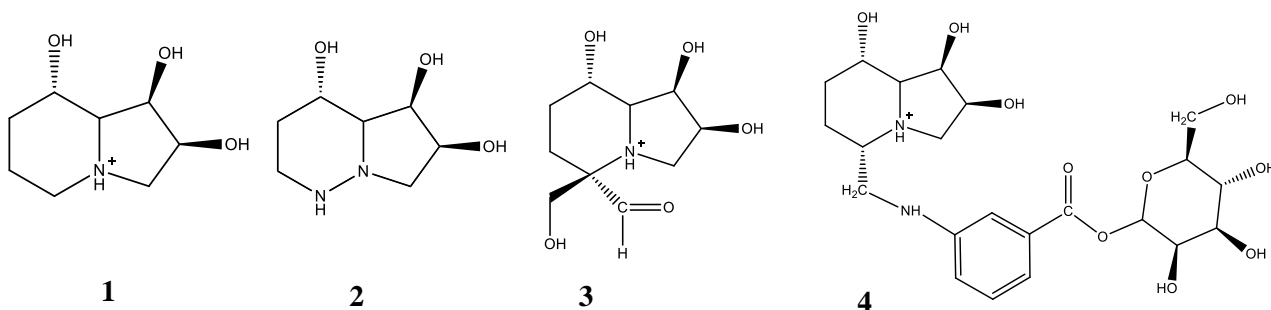


Figure 1: Structures of swainsonine and derivatives

[1] Dennis, J. W.; Laferte, S., *Cancer research* **1985**, 45 (12 Pt 1), 6034-40.

[2] van den Elsen, J. M.; Kuntz, D. A.; Rose, D. R., *The EMBO journal* **2001**, 20 (12), 3008-17.

[3] Shah, N.; Kuntz, D. A.; Rose, D. R., *Proceedings of the National Academy of Sciences of the United States of America* **2008**, 105 (28), 9570-5.

## P35 - Design of novel peptidomimetics using non-canonical Ac<sub>n</sub>c amino acids

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A series of  $\alpha,\alpha$ -disubstituted non-canonical constrained amino acids: Aib, Ac<sub>3</sub>c, Ac<sub>4</sub>c, Ac<sub>5</sub>c, Ac<sub>6</sub>c, (*S,S*)-Ac<sub>5</sub>c<sup>DOM</sup> and (*R,R*)-Ac<sub>5</sub>c<sup>DOM</sup> were investigated using molecular modeling methods. The helical propensity of these residues was investigated using Leucine-based, hexa- and nona-peptides. Our aim is to optimize the structural properties and function of novel peptidomimetics bearing these new amino acids [1-3]. Non-canonical amino acids are residues equivalent to the natural ones, however they are not encoded by DNA. It is hypothesized that these classes of amino acids are capable to induce specific types of secondary structure, more stable and structurally constrained [4, 5]. In this sense, the secondary structure properties of the peptides incorporating cyclic and non-cyclic  $\alpha,\alpha$ -disubstituted amino acids were investigated in water, chloroform and in trifluoroethanol/water mixture. We show that, in water, leucine nonapeptides carrying Ac<sub>5</sub>c and (*R,R*)-Ac<sub>5</sub>c<sup>DOM</sup> residues have high tendency to form  $\alpha$ -helical secondary structures. We also observe that the TFE/H<sub>2</sub>O mixture increases the population of  $\alpha$ -helical secondary structure for the hexapeptides, relative to the aqueous media. On the other hand, in chloroform, residues Ac<sub>5</sub>c, Ac<sub>6</sub>c, (*S,S*)-Ac<sub>5</sub>c<sup>DOM</sup> and (*R,R*)-Ac<sub>5</sub>c<sup>DOM</sup> induce the formation of  $3_{10}$ -helix secondary structures in leucine nonapeptides, in agreement with previous experimental reports [6]. In summary, we show that some of the non-canonical amino acids under study are strong helical inducers of our model peptide and, this effect is also dependent on the peptide size and solvent environment. These findings indicate that it is possible to incorporate some of these non-canonical amino acids in well-known peptides, with important biological functions, to improve their structural and functional characteristics, as well as increasing the enzymatic resistance in physiological conditions [7].

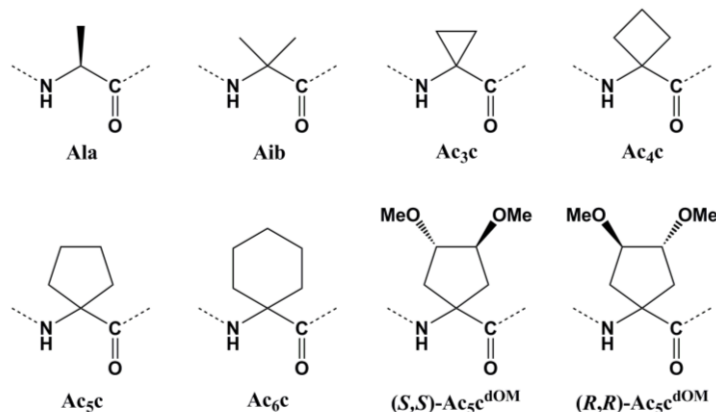


Figure 1. Amino acids incorporated on the Leucine-based, hexa- and nona-peptides.

- [1] Gentilucci, L.; Tolomelli, A.; Squassabia, F. *Curr. Med. Chem.* **2006**, 13, 2449.
- [2] Grauer, A.; Konig, B. *Eur. J. Org. Chem.* **2009**, 5099.
- [3] Vagner, J.; Qu, H. C.; Hruby, V. J. *Curr. Opin. Chem. Biol.* **2008**, 12, 292.
- [4] Toniolo, C.; Crisma, M.; Formaggio, F.; Peggion, C. *Biopolymers* **2001**, 60, 396.
- [5] Goodman, C. M.; Choi, S.; Shandler, S.; DeGrado, W. F. *Nat. Chem. Biol.* **2007**, 3, 252.
- [6] Demizu, Y.; Doi, M. et al., *Org. Biomol. Chem.* **2011**, 9, 3303-3312.
- [7] Oh, J. E.; Lee, K. H., *Bioorg. Med. Chem.* **1999**, 7, 2985-2990.

## **P36 - The cytotoxic bile acid DCA is able to change apoptotic signalling through modulation of mitochondrial membrane properties**

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Deoxycholic acid (DCA) and other hydrophobic bile acids induce apoptosis at submicellar concentrations, while bile acids such as ursodeoxycholic acid (UDCA) and its taurine conjugate (TUDCA) display cytoprotective properties. The mechanisms that trigger these opposite signaling effects are still unclear. Recent studies have confirmed that cytotoxic bile acids decrease membrane order in membrane model systems and in purified plasma membrane vesicles, suggesting that cytotoxic action could be achieved through modulation of plasma membrane structure. Using fluorescence microscopy methodologies, we have shown that upon uptake, bile acid analogues accumulate in intracellular membranes and display remarkably low plasmalemmal levels. Incubation of hepatocytes with both classes of bile acids resulted in a dramatic decrease in intracellular membrane order, as a result of bile acid accumulation during uptake. Bile acids also accumulated in mitochondria, but only DCA induced changes in the membrane order of isolated mitochondria. Importantly, DCA induced significant permeabilization in outer mitochondrial membrane (OMM) biomimetic liposomes, while cytoprotective molecules had a low impact on permeability even at high concentrations. Our results are consistent with the presence of cellular compensatory mechanisms, which work against the moderate loading of bile acids in the plasma membrane, but that are unable to balance the increase in membrane fluidity induced by bile acids in intracellular membranes. Our findings suggest that DCA interaction with the OMM is critical in the activation of apoptosis.

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## P37 - Synthesis of choline sulfonate buffers and their effect on cytochrome c dissolution and oxidation state

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Ionic Liquids (ILs) have been widely recognized as “green” alternatives to molecular solvents. The combination of organic ions with a variety of anions allows the preparation of distinct ILs, whose properties can be tuned based on their composition.[1] One example is the design of ionic liquids that behave as buffers. IL buffers, as the name suggests, are ILs capable of regulating the pH, whether being used as neat solvents or as co-solvents in aqueous or non-aqueous systems. Biological buffers, namely Good’s buffers [2] represent several advantages over the use of more common buffers such as phosphate, TRIS, borate, glycylglycine among others. The main advantages and characteristics of Good’s buffers are: a pKa between 6.0 and 8.0, high solubility in water, no absorbance at wavelengths longer than 230nm, no effect on biochemical reactions, and stable against enzymatic and non-enzymatic degradation. Based on these properties Good’s buffers seem to be excellent candidates to be used in conjugation with choline cations for the synthesis of IL buffers with enhanced properties. Seven choline sulfonates with buffering properties were prepared in good yields (74-94%) and high purity by reacting choline hydroxide with different Good’s buffers. Choline sulfonate buffers containing hydroxyl group-rich cations appeared to be liquid at room temperature. Cytochrome c was used as model protein for dissolution studies in these choline buffers. It was found that complete solubilization of this protein in most of the choline sulfonate buffers can be obtained through addition of 21-31% (w/w) of water. In this hydrated choline sulfonate, cyt c is solubilised in its reduced form. [3]

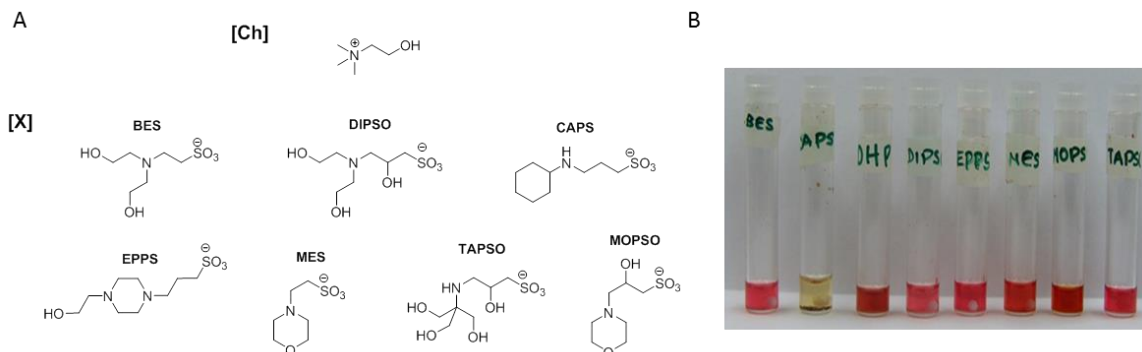


Figure 1 - A) Chemical structure of choline buffers synthesized in this work. B) Cytochrome c (0.3mg/mL) dissolved in hydrated choline buffers

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[1] Wei, Di; Ivaska, A.; *Analytica Chimica Acta*, **2008**, 607, 126-135.

[2] Good, N. E.; Winget, G.D.; Winter, W.; Connolly, T. N.; Izawa, S.; Singh, R. M. M.; *Biochemistry*, **1966**, 5, 467.

[3] Matias, S. C.; Rocha, A.; Teixeira, R.; Fonseca, L. P.; Lourenço, N. M. T.; **2014** (submitted)

## P38 - Enzymatic Isomerisation of Glucose to Fructose by Glucose Isomerase (Sweetzyme®): A High School Experiment

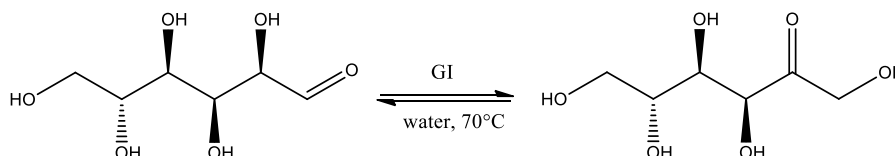
Andreia P. C. da Rosa<sup>1</sup>, Svilen P. Simeonov<sup>1</sup>, and Carlos A. M. Afonso<sup>1</sup>

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The demand for sustainable and environmentally benign chemical processes makes enzymes a very attractive alternative as catalysts for industrial application. Considering that the enzyme catalysis is an important part of biochemistry, it also represents a learning subject worldwide since the first years of middle and high school education programs. Supporting theoretical training, some laboratory techniques are available to demonstrate the concepts of enzyme mechanisms and kinetics.

The production of High-Fructose Corn Syrup (HFCS) a mixture of glucose and fructose, used since the 70s as a substitute for refined sugar in various food products (beverages, baking, canning) is one of the most important industrially established processes catalysed by glucose isomerase (GI). This isomerisation has been extensively studied over the years, being easily carried with very satisfactory outcomes [1] and is an interesting topic from educational point of view since it can introduce the students to a real industrial process as well as to the benefits and drawbacks of the enzyme catalysed transformations. Moreover, in contrast with some other practical student classes that often require expensive or specific equipments (such as HPLC or spectrophotometry) and complicated or time consuming procedures, not suitable for school applications, the enzymatic isomerization of glucose require basic equipment and doesn't include any hazardous chemicals. The analysis of the enzymatic isomerisation by GI can be performed by using a commercial blood glucometer [2] which avoids the purchase of other equipment, often inaccessible to most schools. The experiments have been performed successfully by high level school students (10<sup>th</sup> year) in a 2h laboratory session, starting from either glucose or fructose. The results were discussed in terms of the kinetics of the isomerization and the students were introduced to the reversible chemical reactions and equilibrium concept.



**Figure 2.** Isomerization of glucose to fructose catalyzed by GI

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[1] Bhosale, S. H.; Rao, M. B.; Deshpande, V. V., *Microbiol. Rev.* **1996**, 60, 280-300

[2] Heinzerling, P.; Schrader, F.; Schanze, S. *J. Chem. Edu.* **2012**, 89, 1582–1586

## P39 - Synthesis and biological studies of new antimicrobial 2,6-dideoxy-arabino-hexopyranosides

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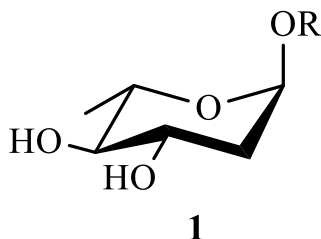
New antibacterial drugs are increasingly needed, once the present available therapies are becoming less effective with its continuous use, mainly due to the rising numbers of multi-resistant strains of pathological bacteria. In order to respond to this need and other problems concerning human health, chemistry and biology are collaborating more than ever in a new paradigm for drug discovery.

In the present work, a new family of compounds based on 2,6-dideoxy-arabino-hexopyranosides (Scheme 1), was studied for its selective antimicrobial activity towards *Bacillus* spp.. The rational synthesis of analogues and their effects on the bacterial metabolism will be presented and discussed.

The methodologies used for the biological studies were based in microdilution assays [3], evaluating the antimicrobial activity and the effects of the compounds presence in several aspects of bacterial metabolism.

The synthetic strategy was based on reaction of 3,4-di-O-acetyl-1,5-anhydro-6-deoxy-1-arabino-hex-1-enitol (trivial name: 6-deoxy-1-glucal) with a variety of alcohols catalyzed by triphenylphosphane hydrobromide.[1,2] Also, the synthesis of the 2-iodo analogue was carried out using *n*-iodosuccinimide as catalyst for the glycoconjugation and simultaneous iodination of position 2. This product can act as cold compound for several biological studies (for example, biodistribution studies) requiring a radiolabeled analogue.

This research provided important insights into the key structural features for the bioactivity and the mechanism of action of this family of compounds.



Scheme 1. Structure-type of the 2,6-dideoxy glycosides presented in this work.

**Acknowledgements:** We thank QREN for financial support of the Project QREN-SI I&DT co-promotion FACIB – Project nr. 21547, and Fundação para a Ciência e a Tecnologia for financial support of João Pais PhD grant SFRH/BDE/51957/2012.

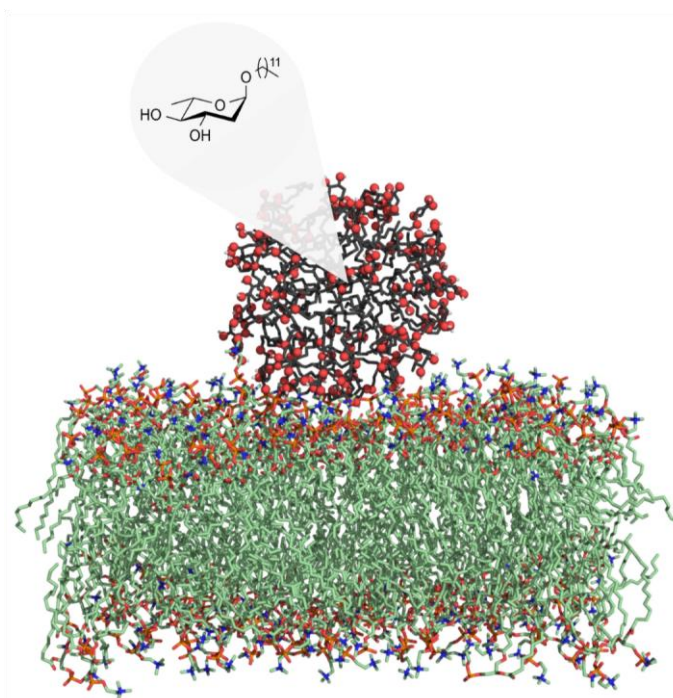
- [1] Rauter, A. P., Martins, A., Caio, J., Pais, J., Serra, P., Santos, M. S., Gonçalves, A., Justino, J., Dias, R., Tenreiro, R., Sugar derivatives as inhibitors of *Bacillus* species, process for their preparation and utilization. *Patent PCT/IB2012/050123*, submitted in **2012**.
- [2] Silva, F., Goulart, M., Justino, J., Neves, A., Santos, F., Caio, J., Lucas, S., Newton, A., Sacoto, D., Barbosa, E., Santos, M. S., Rauter, A. P., *Bioorg. Med. Chem.* **2008**, *16*, 4083.
- [3] Rauter, A. P., Lucas, S., Almeida, T., Sacoto, D., Ribeiro, V., Justino, J., Neves, A., Silva, F. V. M., Oliveira, M. C., Ferreira, M. J., Santos, M. S., Barbosa, E., *Carbohydr. Res.* **2005**, *340*, 191.

## P40 - Interaction of antibacterial sugar-based surfactants with model lipid membranes: insights from molecular dynamics simulations

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Carbohydrate-based surfactants are well known for their use in membrane protein crystallography and feature many other applications. Interestingly, many alkyl glycosides also display relevant biological activities. In this context, we have reported the synthesis of a new family of alkyl deoxy glycosides that exhibit potent bactericidal activity [1]. Although their mechanism of action is yet not known, experimental data suggests that aggregation into micelles is a key feature that modulates bioactivity. Because surfactant antibiotics are known to target bacterial membranes, destabilizing their biophysical properties through solubilization, leading ultimately to disruption, we were encouraged to study the interaction of these molecules with lipid bilayers. In this work, we present an approach to describe glycoside micelle/phospholipid membrane systems (see Figure) at the atomic level through molecular dynamics simulations, which we applied to dodecyl 2,6-dideoxy- $\alpha$ -L-arabino-hexopyranoside and other structurally related glycosides. Their aggregation into equilibrated micelles was studied for different numbers of monomers and their relative stabilities were analyzed. We subsequently performed molecular dynamics on several micelle/membrane systems, using DMPC as a model phospholipid, and the results observed provide insights on the processes underlying the adsorption/fusion of glycosides into lipid bilayers. In our ongoing research, we are also studying the effect of these molecules on the biophysical properties of membranes by simulating glycoside/lipid binary mixtures.



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[1] A. Martins, M. S. Santos, C. Dias, P. Serra, V. Cachatra, J. Pais, J. Caio, V. H. Teixeira, M. Machuqueiro, M. S. Silva, A. Perelito, J. Justino, M. Goulart, F. V. Silva, A. P. Rauter, *Eur. J. Org. Chem.* **2013**, 8, 1448-1459 and references cited therein.

## P41 - Ligand interactions with transthyretin amyloid fibrils

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Transthyretin (TTR) is a homotetrameric plasma protein implicated in the deposition of amyloid fibrils in pathologies such as Familial Amyloid Polyneuropathy (FAP), Familial Amyloid Cardiomyopathy (FAC) and Senile Systemic Amyloidosis (SSA) [1]. The identification of compounds with the ability to bind to amyloid aggregates and amyloid fibrils is a crucial step in the development of new probes for the detection of amyloid deposits in medical imaging. The aim of this study is to establish a methodology to quantify the association constants and binding mode of small molecules towards TTR amyloid aggregates and fibrils. We investigated the binding of Thioflavin-T (ThT), a probe known to interact with amyloid, using saturation transfer difference (STD) NMR to set up an experimental protocol useful to detect the binding mode of new compounds to TTR amyloid fibrils. In addition, we used fluorescence spectroscopy and took advantage of the large fluorescence enhancement of ThT upon binding to amyloid fibrils to develop fluorescence competition assays to quantify the association of non-fluorescent ligands to these fibrils.

**Acknowledgements:** This work was funded by projects PTDC/QUI-QUI/122900/2010 and Pest-C/SAU/LA0001/2013-2014 through the ERDF - European Regional Development Fund and the COMPETE Program and by National Funds through FCT - Fundação para a Ciência e a Tecnologia and RNE-ANBIOQ (Rede Nacional de Estágios Voluntários). NMR data was obtained at the Nuclear Magnetic Resonance Laboratory of the Coimbra Chemistry Centre ([www.nmrccc.uc.pt](http://www.nmrccc.uc.pt)), Universidade de Coimbra, supported in part by grants REEQ/481/QUI/2006, RECI/QEQ-QFI/0168/2012 and OE/QUI/UI0313/2014.

### References:

- [1] Brito, R. M., Damas, A. M., & Saraiva, M. J. (2003). Amyloid formation by transthyretin: from protein stability to protein aggregation. *Current Medicinal Chemistry-Immunology, Endocrine & Metabolic Agents*, 3(4), 349-360.

## **P42 - Molecular crowding effects on thermotropic properties of the different lipid bilayers**

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Membranes delimit cells and organelles controlling their aqueous content and the communication between these two media.

The cytoplasm has a high concentration of small molecules, macromolecules and supramolecular assemblies where a significant fraction of the water is involved in solvation and does not behave as bulk water. The limited availability of water and distinct properties affect the structure and dynamics of macromolecules and supramolecular structures and this is generally described as molecular crowding effects.

One common agent of molecular crowding is trehalose, a non-reducing disaccharide. The role of crowding agents in stabilizing the molecular structure of native proteins are well known as well as its importance in the preservation of biomembranes in conditions of dehydration and/or very low temperatures. However the effect on the properties of hydrated membranes and normal temperatures has been the subject of few studies and is not well characterized.

In this work, we have evaluated the molecular crowding effects, generated by trehalose under excess water conditions, on the thermotropic properties of different lipid bilayers. The lipid compositions studied were mixtures of DMPC:DSPC, SpM:Chol and POPC:SpM (at different molar ratios) corresponding to membranes in the gel, liquid ordered or liquid disordered phase as well as with coexistence of the distinct phases. The effects at the membrane interface and hydrophobic core were characterized by fluorescence anisotropy of NBD-DMPE and TMADPH, respectively. To complement those results, fluorescence lifetimes of NBD-DMPE in POPC, SpM and DSPC were also measured.

It is observed a significant increase in the width of the phase transitions indicating stabilization of phase coexistence by 1M trehalose in the aqueous solution. This effect is particularly relevant for membranes with coexistence of liquid-disordered and gel phases.

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## P43 - Separation of free fatty acids from deodorizer distillates using choline hydrogen carbonate and supercritical carbon dioxide

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Olive oil deodorizer distillate (OODD) is a low market value by-product of the olive oil refining process. It contains up to 40% by weight of squalene, the rest being free fatty acids (FFA), fatty acids alkyl esters and, in small amounts, tocopherols and sterols. The highest added-value of OODD is its content in squalene, a triterpenic polyunsaturated hydrocarbon. The main applications of squalene and its hydrogenated form (squalane) are as moisturizing or emollient agent, and as an adjunctive in vaccines and cancer therapies. Owing to the high content in squalene, up to 60% by weight, deep-sea sharks liver oil has been its primary source. However environmental concerns regarding the declining of marine animal population have intensified the search of more sustainable sources [1,2]. The high content in squalene and the low market value of OODD makes it a desirable alternative. One of the main problems of deodorizer distillates is the effective and selective removal of FFA from the remaining added-value components [3]. A two-step novel strategy for the valorization of olive oil deodorizer distillate is presented, based on the use of choline hydrogen carbonate and supercritical carbon dioxide (scCO<sub>2</sub>). In the first step, the FFA present in OODD were neutralized with choline hydrogen carbonate. Due to their ionic character, the choline carboxylates formed are insoluble in scCO<sub>2</sub>. Therefore in the second step, the reaction mixture was subjected to extraction with scCO<sub>2</sub> at 15 MPa, 313 K and a gas flow rate of 2 mL min<sup>-1</sup>, yielding an extract with a maximum FFA content of ca. 3% (w/w). No auxiliary solvents are necessary in either step and all by-products of the neutralization step (H<sub>2</sub>O, CO<sub>2</sub> and choline carboxylates) are benign. In addition, the choline carboxylates can be of interest to the cosmetic industry as biocompatible soaps [4].

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- [1] Ruivo, R., Couto, R., Simões, P. C., *Separation and Purification Technology* **2008**, 59, 231237.
- [2] Spanova, M., Daum, G., *European Journal of Lipid Science and Technology* **2011**, 113, 12991320
- [3] Ruivo, R., Couto, R., Simões, P. C., *Journal of Chemical and Engineering Data* **2007**, 52, 566570.
- [4] Klein, R., Muller, E., Kraus, B., Brunner, G., Estrine, B., Touraud, D., Heilmann, J., Kellermeier, M., Kunz, W., *RSC Advances* **2013**, 3, 23347-23354.

## P44 A Computational Study on the Catalytic Mechanism from the Human Pancreatic $\alpha$ -Amylase: The Glycosylation and Deglycosylation Steps

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Starch is the most common carbohydrate in human diet and it consists of a large chain of glucose units. It is the energy reservation for most green plants and there are great quantities of this carbohydrate in some edible plants such as potatoes, corn and wheat. There is a wide range of enzymes, called  $\alpha$ -amylases that catalyze the hydrolysis of starch to yield lower molecular weight sugars acting on the  $\alpha(1-4)$  glycosidic linkages. In this work we studied the catalytic mechanism of the human pancreatic  $\alpha$ -amylase (HPA). We have studied its reaction mechanism with atomistic detail using the QM/MM ONIOM methodology with B3LYP/6-31G (d): amber level of theory.

We demonstrated that the HPA catalytic mechanism consists of two steps, in which the first mechanistic step (glycosylation step) consists on breaking the glycosidic bond that culminates in the formation of a covalent intermediate. Furthermore, the second step (deglycosylation step) completes the hydrolysis of the sugar.

We have demonstrated the relevant role of the three catalytic amino acids, two aspartate residues and a glutamate (D197, E233, and D300) during catalysis. It is also shown that the rate limiting step is the glycosylation and its activation energy is in agreement with the experimental values obtained for many glycosidase enzymes.

**Acknowledgements:** Support from UNICAL PhD fellowship is acknowledged

[1] Jayaraj, S.; Suresh, S.; Kadeppagari, R., *Starch* **2013**, 65, 535-542.

[2] Rydberg, E.H.; Li, C.; Maurus, R.; Overall, C.M.; Brayer, G.D.; Withers, S.G., *Biochemistry* **2012**, 41, 4492-4502.

[3] Brás, N.F.; Fernandes, P.A.; Ramos, M.J., *JCTC* **2010**, 6, 421-433.

## **Physical Chemistry**

## P45 - Solid State Investigation of 1,2-Cyclohexanedimethanol Isomers

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Dihydroxyl cyclohexane derivatives are a class of compounds that present rich polymorphism. For instance two of the dihydroxylated derivatives *cis*-1,2 and *cis*-1,4-cyclohexanediols show cubic plastic crystal mesophases[1-3]. For the isomer *trans*-1,2-cyclohexanediol two polymorphic forms have been identified one of which is metastable[2] while for *trans*-1,4-cyclohexanediol isomer three solid forms were identified[4,5].

1,2-Cyclohexanedimethanol differs from 1,2-cyclohexanediol only in two methylene groups placed between a cyclohexane carbon atom and the hydroxyl group, which may confer more flexibility to the molecule.

In this communication an investigation on the polymorphism of *trans*-1,2, *trans*-(1*R*,2*R*) and *cis*-1,2-cyclohexanedimethanol isomers is undertaken.

A combined approach using differential scanning calorimetry, polarized light thermomicroscopy and X-ray diffraction has been employed in the results interpretation.

For racemic *trans*-1,2-cyclohexanedimethanol two crystalline polymorphic forms and a vitreous form were identified. For *trans*-(1*R*,2*R*)-cyclohexanedimethanol enantiomer two polymorphic forms were found. Two crystal structures, one for *trans*-1,2 and one for *trans*-(1*R*,2*R*) enantiomer were resolved by X-ray single crystal diffraction.

For *cis*-1,2-cyclohexanedimethanol isomer a crystalline form and a vitreous phase were identified.

**Acknowledgements:** The Coimbra Chemistry Centre is supported by the Fundação para a Ciência e a Tecnologia (FCT), Portuguese Agency for Scientific Research, through the project PEst-OE/QUI/UI0313/2014.

[1] Maria, T. M. R.; Costa, F. S.; Leitão, M. L. P.; Redinha, J. S., *Thermochim. Acta*, **1995**, 269, 405-413.

[2] Leitão, M. L. P.; Castro, R. A. E.; Costa, F. S.; J. S. Redinha, *Thermochim. Acta*, **2001**, 378, 117-124.

[3] Bebiano, S. V. S.; Rosado, M. T. S.; Castro, R. A. E.; Ramos Silva, M.; Canotilho, J.; Maria, T. M. R.; Eusébio, M. E. S., *J. Molec. Struct., Polymorphism and disorder* special issue, in press.

[4] Maria, T. M. R.; Castro, R. A. E.; Bebiano, S. V. S.; Ramos Silva, M.; Beja, A. M.; Canotilho, J.; Eusébio, M. E. S., *Cryst. Growth Des.*, **2010**, 10, 1194-1200.

[5] Steiner, T.; Saenger, W. J., *Chem. Soc., Perkin Trans.* **1998**, 2, 371-377.

## P46 - Experimental and computational energetic study of 1-R-2-phenylindole (R=H, CH<sub>3</sub>, C<sub>2</sub>H<sub>5</sub>)

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Indole derivatives constitute a large family of bicyclic aromatic systems which are known to actively take part in the synthesis of complex natural products widely found in living systems. Proper understanding their role on the biological activity depends crucially on our ability to obtain reliable thermochemical data concerning the formation and dissociation of the respective chemical bonds. Following our previous work [1,2], we report now a combined experimental and computational study of 2-phenylindole and two alkyl 2-phenylindole derivatives (Figure 1).

The standard ( $p^\circ = 0.1$  MPa) molar energies of combustion,  $\Delta_c U_m^\circ$ , of the three compounds, in the crystalline state, were determined, at  $T = 298.15$  K, using a static bomb combustion calorimeter. The vapor pressures as a function of the temperature were also measured for those compounds, by using the Knudsen effusion technique, and the standard molar enthalpies of sublimation at the mean temperature of the range of vapor pressure measurements were derived from the Clausius-Clapeyron equation, and corrected to  $T = 298.15$  K using an estimated value for  $\Delta_{cr}^\circ C_{p,m}$ . From the experimental results, the standard ( $p^\circ = 0.1$  MPa) molar enthalpies of formation in the condensed and gaseous phases, at  $T = 298.15$  K, of 2-phenylindole, 1-methyl-2-phenylindole and 1-ethyl-2-phenylindole were derived. Additionally, computational calculations for the three compounds were performed using density functional theory (DFT) with the hybrid functional B3LYP together with the 6-31G(d) and the 6-311+G(2df,2p) basis sets. In order to get more reliable estimates of the thermochemical parameters of the title systems, standard molecular orbital calculations at the G3(MP2) level were also conducted. Enthalpies of formation, obtained using appropriate working reactions, were calculated and compared with experimental data.

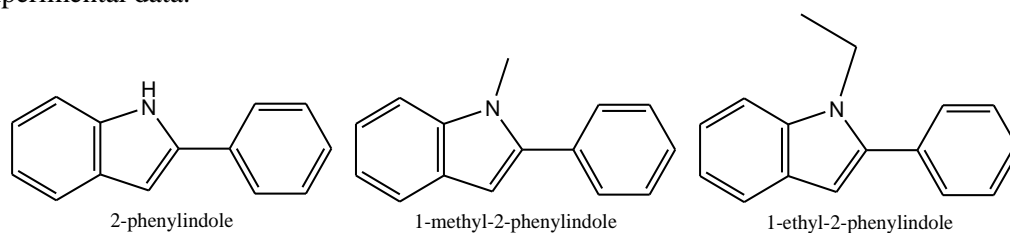


Figure 1. Structural formula of the compounds studied

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[1] Amaral, L. M. P. F.; Carvalho, T. M. T.; Cabral, J. I. T. A.; Ribeiro da Silva, M. D. M. C.; Ribeiro da Silva, M. A. V., *J Therm Anal Calorim* **2014**, 115, 803-810.

[2] Carvalho, T. M. T.; Amaral, L. M. P.; Ribeiro da Silva, M. D.M.C. *Energetic study of 1-R-phenylindole (R=H,CH<sub>3</sub>,C<sub>2</sub>H<sub>5</sub>)*. Book of Abstracts 11<sup>o</sup> Encontro Nacional de Química-Física (11ENQF), 9-10 Maio 2013, Universidade do Porto, Portugal, P.D21, pp 129.

## P47 - Polymorphism of *cis* and *trans*-1,3-Cyclohexanediol Isomers

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Cyclohexanediol derivatives, despite the simplicity of their molecular structures, show a complex solid state phase behaviour. For *cis*-1,2 and *cis*-1,4-cyclohexanediol isomers cubic plastic crystal phases were identified [1,2,3]. For *trans*-1,2 and *trans*-1,4-cyclohexanediol isomers several polymorphic forms were found and two of the *trans*-1,4 isomer crystalline structures solved [1,2,4,5].

In this communication an investigation on the polymorphism of *cis*-1,3 and *trans*-1,3-cyclohexanediol isomers is undertaken.

A multidisciplinary investigation using differential scanning calorimetry, polarized light thermal microscopy, infrared spectroscopy and X-ray diffraction analysis was performed. The crystal structure of an anisotropic solid phase of *trans*-1,3-cyclohexanediol was resolved by X-ray single crystal diffraction. This polymorph gives rise to a plastic crystalline phase on heating.

For the *cis*-1,3 isomer two polymorphic phases were identified.

**Acknowledgements:** The Coimbra Chemistry Centre is supported by the Fundação para a Ciência e a Tecnologia (FCT), Portuguese Agency for Scientific Research, through the project PEst-OE/QUI/UI0313/2014.

[1] Maria, T. M. R.; Costa, F. S.; Leitão, M. L. P.; Redinha, J. S., *Thermochim. Acta*, **1995**, 269, 405-413.

[2] Leitão, M. L. P.; Castro, R. A. E.; Costa, F. S.; J. S. Redinha, *Thermochim. Acta*, **2001**, 378, 117-124.

[3] Bebiano, S. V. S.; Rosado, M. T. S.; Castro, R. A. E.; Ramos Silva, M.; Canotilho, J.; Maria, T. M. R.; Eusébio, M. E. S., *J. Molec. Struct., Polymorphism and disorder* special issue, in press.

[4] Maria, T. M. R.; Castro, R. A. E.; Bebiano, S. V. S.; Ramos Silva, M.; Beja, A. M.; Canotilho, J.; Eusébio, M. E. S., *Cryst. Growth Des.*, **2010**, 10, 1194-1200.

[5] Steiner, T.; Saenger, W. J., *Chem. Soc., Perkin Trans.* **1998**, 2, 371-377.

## P48 - Luminescent $\gamma$ -Cyclodextrin Inclusion Compounds With Eu(III) Nitrates Complexes

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The interaction of cyclodextrins (CDs) with europium complexes is an important phenomenon because, in the resulting inclusion compounds, the CD host can be considered as a second-sphere ligand non-covalently bonded to the first sphere ligand(s). This offers the possibility of finely modifying the properties of the guest with respect to their photoluminescent properties [1]. In this context, luminescent inclusion compounds between  $\gamma$ -CD and the europium nitrates complexes  $\text{Eu}(\text{NO}_3)_3(\text{phen})_2$  and  $\text{Eu}(\text{NO}_3)_3(\text{ephen})_2$  with different neutral ligands (phen: 1,10-phenanthroline and ephen: 5,6-epoxy-5,6-dihydro-[1,10]phenanthroline) were prepared and characterized by FTIR, Raman, thermogravimetric analysis, UV-Vis and photoluminescence spectroscopies. The vibrational results were also analyzed by DFT calculations. The luminescent results in ethanolic solution reveal some changes in the characteristic  ${}^7\text{D}_0 \rightarrow {}^7\text{F}_{0-4}$  transitions of the Eu complexes upon their incorporation (Figure 1), reinforcing the idea mentioned above.

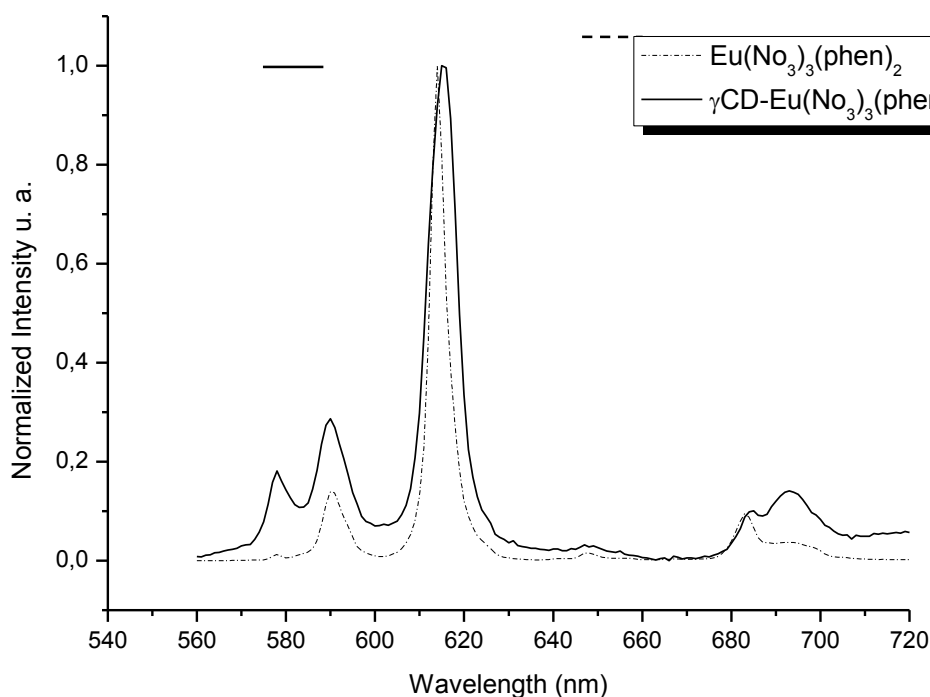


Figure 1 - Emission spectra of the  $\text{Eu}(\text{NO}_3)_3(\text{phen})_2$  complex ( ) and  $\gamma\text{CD-Eu}(\text{NO}_3)_3(\text{phen})_2$  inclusion compound ( ) in ethanolic solution (both excited at 266 nm).

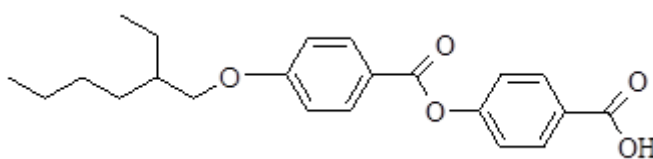
- [1] Fernandes, J. A.; Braga, S. S.; Pillinger, M.; Ferreira, R. A. S.; Carlos, L. D.; Hazell, A.; Ribeiro-Claro, P.; Gonçalves, I. S., *Polyhedron* **2006**, 25, 1471-1476.

## P49 - Investigation of Surface Characterisation of 4-[4-(2-Ethylhexyloxy)Benzoyloxy]Benzoic Acid Thermotropic Liquid Crystal By Inverse Gas Chromatography

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Liquid crystals (LCs) have been studied for many years not only because of their technological importance but also because of their extraordinary physical properties such as dielectric and optical anisotropy, flow properties, and response to external fields [1]. The surface properties of liquid crystals are very important for the performance of liquid crystal displays and devices. These properties, which is of vital importance for the alignment of the LCs and thus for the appearance and operation of these devices, depends, in addition, on the solid surface-liquid crystal interactions [2]. The presence of acidic and basic centers on the molecule surface increases the specific intermolecular interactions with solvents and other molecules [3]. So it is very important to determine the surface energy and the quantity of acid-base character of compound. Inverse gas chromatography (IGC) has become powerful technique for in evaluating the properties of solids and liquids. It provides access to several physico-chemical properties of such materials including their surface energy, phase transitions, crystallinity, acid-base characteristics and determining of the transition temperatures of liquid crystals. In this study, the dispersive surface energy,  $\gamma_s^D$  were obtained from the slope of a plot of the logarithm of the net retention volume of a series of alkanes as  $RT \ln V_N$  versus the product of their molecular area and root-squared surface tension as  $a(\gamma_L^D)^{0.5}$ . The specific Gibbs free energies,  $\Delta G_{sp}$  of adsorption of polar probes were determined by subtracting the Gibbs free energies of alkanes from those of polar solvents. The specific enthalpy,  $\Delta H_{sp}$  of adsorption of a solvent, which was obtained from temperature dependence of  $\Delta G_{sp}$  was correlated with the donor number,  $DN$  and the modified acceptor number,  $AN^*$  of the polar solvents to quantify the acidic  $K_A$  and basic  $K_D$  parameters of the LC surface.



**Figure 1.** Chemical structure of 4-[4-(2-Ethylhexyloxy)Benzoyloxy]Benzoic Acid

- [1] Manohar, R.; Pandey, K. K.; Srivastava, A. K.; Misra, A. K.; Yadav, S. P., *J. Phys. Chem. Solids* **2010**, 71, 1311-1315.
- [2] Komitov, L.; Ichimura, K., *Mol. Cryst. and Liq. Cryst.* **2001**, 360, 161-192.
- [3] Cakar, F.; Yazici, O.; Sakar, D.; Cankurtaran, O.; Karaman, F., *Optoelectron. Adv. Mat.* **2011**, 5, 821-826.

## P50 - Calcium phosphate mineralization with a sulfonated polyaniline derivative

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Calcium phosphate (CaP) is most important compound for biomedical applications including artificial bone and dental materials. Bioinspired and biomimetic mineralization of CaP, that is, the precipitation of CaP from aqueous solution in the presence of organic or polymeric growth modifiers, has become one of the major tools to fabricate well-defined CaP/organic hybrids. Depending on the polymer chemistry, molecular weight, pH, and polymer concentration, a wide variety of CaP crystal phases, crystal shapes, and particle sizes can be generated [1,2]. At several initial pH and polymer concentrations, organic/inorganic hybrid particles of calcium phosphate were synthesized by precipitation from calcium chloride solution including the sulfonated polyaniline as a template by means of disodium hydrogen phosphate. It was observed that different types of structures were obtained by polymer concentration and variation of pH (Figure 1).

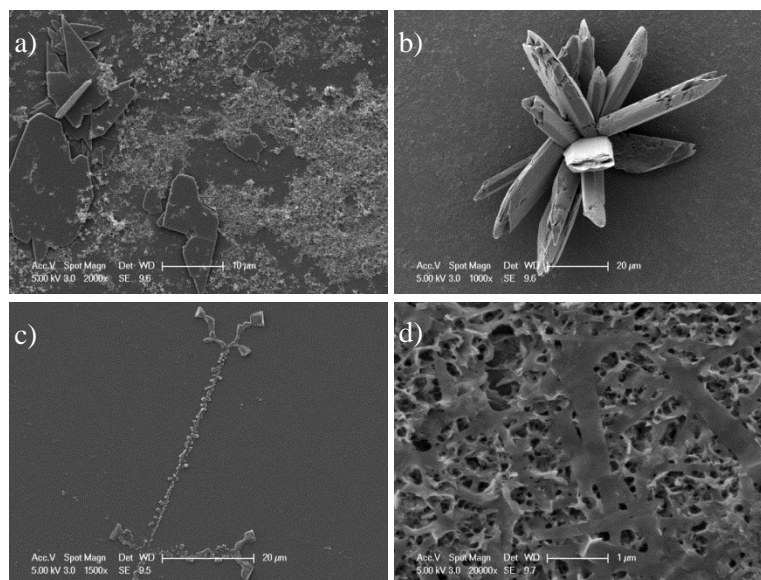


Figure 1 - Scanning electron micrographs of the calcium phosphate particles obtained without polymer at pH: 7 (a) and in the presence of 1.0 g/L polymer at the following pHs: 3 (b); 7 (c) and 10 (d)

**Acknowledgements:** The research was supported by The Scientific and Technological Research Council of Turkey (TUBITAK-107T697) and Scientific Research Projects Centre of Yildiz Technical University (29-01-02-DOP03)

[1] Shkilnyy, A.; Friedrich, A.; Tiersch, B.; Schöne, S.; Fechner, M.; Koetz, J.; Schlöpfer, C.-W. and Taubert, A. *Langmuir* **2008**, 24, 2102–2109.

[2] Antonietti, M.; Breulmann, M.; Göltner, C. G.; Cölfen, H.; Wong, K. K. W.; Walsh, D.; Mann, S. *Chem.-Eur. J.* **1998**, 4, 2493–2500.

## P51 - ROMP based Boron Nitride Composites

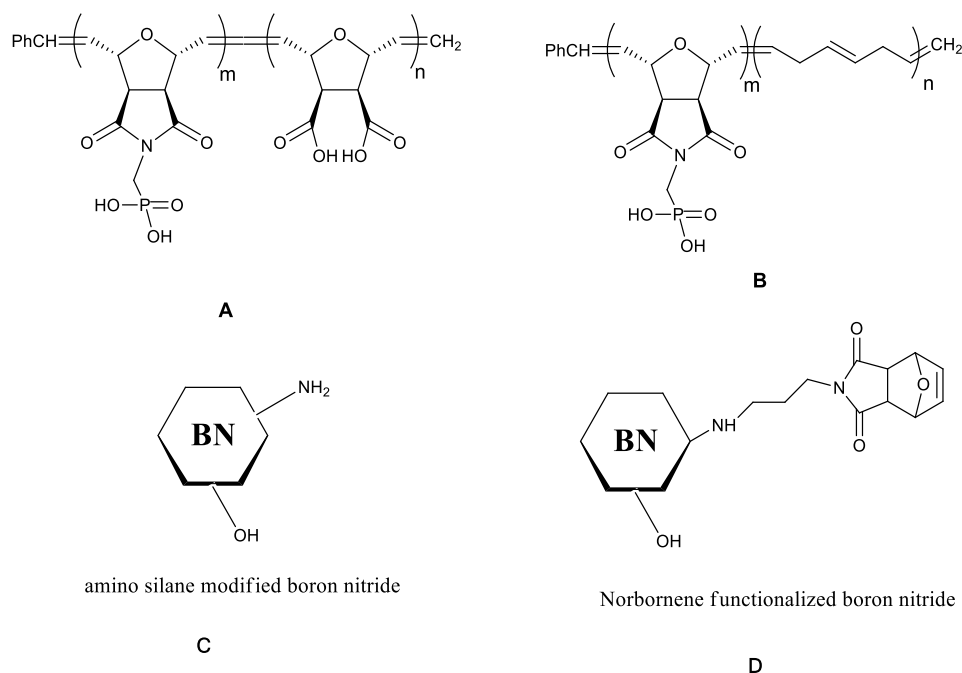
Keziban Hüner<sup>1</sup>, Alper Aşçı<sup>1</sup>, Y. Voynich<sup>2</sup>, Lina L. Sartinska<sup>2</sup>, Tarik. Eren<sup>1</sup>

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Nowadays, synthesis and development of inorganic-organic hybrid polymer composites play an important role in scientific studies. The mechanical and thermal properties of polymers and composite structures can be altered through the use of various kinds of fillers. In this project one- and two-dimensional nanostructure of boron nitride will be used as a reactive filler in the polymer matrix. Project objective is to develop physical, A new kind of high performance composites with high thermal conductivity, low coefficient of thermal expansion and low dielectric loss was successfully developed based on using amino silane functionalized hexagonal boron nitride (hBN) in situ synthesis of ROMP (Ring Opening Metathesis Polymerization). Carboxylic acid and phosphonic acid containing ROMP polymers are synthesized and mixed with different ratio of hBN. Surface initiated ROMP polymers is also investigated by using bromoocanorbornen monomer with reaction of amino silane containing hBN. The effects of hBN and its content on the thermal conductivity, dielectric properties, and thermal resistance of cured composites, are systematically investigated and discussed.



**Figure 1:** Used Monomers in the ROMP based Boron Nitride Composites.

## P52 - METHACRYL FUNCTIONALIZED BORON NITRIDE / POLYSTYRENE COMPOSITES AND INVESTIGATION OF DIELECTRIC PROPERTIES

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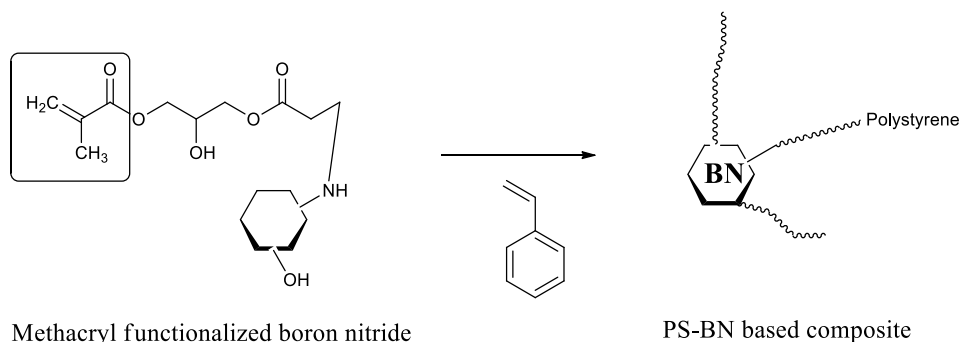
<sup>1</sup> Yildiz Technical University, Chemistry Department, Istanbul, Turkey

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Nowadays, synthesis and development of inorganic-organic hybrid polymer composites play an important role in scientific studies. The mechanical and thermal properties of polymers and composite structures can be altered through the use of various kinds of fillers. In this project one- and two-dimensional nanostructure of boron nitride will be used as a reactive filler in the polymer matrix. Project objective is to develop physical, A new kind of high performance composites with high thermal conductivity, low coefficient of thermal expansion and low dielectric loss was successfully developed based on using methacryl functionalized hexagonal boron nitride (hBN) in situ synthesis of polystyrene. The effects of hBN and its content on the thermal conductivity, dielectric properties, and thermal resistance of cured composites, are systematically investigated and discussed. Methacryl groups on the surface of hBN, which supply desirable interfacial adhesion of hBN in the polystyrene matrix with a good dispersion of hBN in the composite. With the increase of the hBN content, the thermal conductivity increases linearly and dielectric loss gradually decreases and becomes more stable over the whole frequency from 40 Hz to 1 MHz. In the case of the composite with 40, 20 and 10 wt% hBN, dielectric constant were between 2.00-3.00 value in the respective frequency range. These attractive integrated properties suggest that methacryl functionalized hBN and polystyrene composites are high performance insulating materials, which show great potential in applications, especially for electronics and aerospace industries.



**Figure 1:** Methacryl Functionalized Boron Nitride Used in the Polystyrene Synthesis

## P53 - MIPs-based e-tongue for the detection of quaternary ammonium salts.

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A sensor is a device which detects a variable quantity, and converts the measurement into analyzable signals. Common fields of utilization of these devices include clinical diagnostics, occupational safety, medical engineering, process measuring engineering, and environmental analysis. Important aspects of good sensors are sensitivity, selectivity, and reproducibility.<sup>[1]</sup> The sensitivity of an electrochemical sensor can be improved by rearranging an electrode surface with a suitable cavity to accumulate the target analyte.<sup>[2]</sup>

Molecularly imprinted polymers (MIPs) are beneficial to use as sensors because they can be specific for a type of molecule to quantify. The process of preparation of MIPs consists essentially in assembling selective binding sites in synthetic polymers. A MIP-based sensor reduces the number of false positives by the above mentioned characteristics (Fig. 1).<sup>[3]</sup>

In this work two types of MIP-based sensor arrays, using different quaternary ammonium salts (QAs) as MIP target. The prepared arrays are able to distinguish the identity of incident molecules from any of the different quaternary ammonium salts solutions studied, with high levels of confidence (>80%).

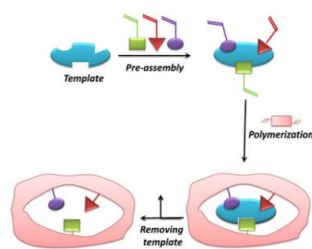


Fig. 3 - MIP Syntheses<sup>[3]</sup>

**Acknowledgements:** The research leading to these results has received funding from the European Union Seventh Framework Programme [FP7/2007-2013] under grant agreement n° 312411. This work is funded (or part-funded) by the ERDF – European Regional Development Fund through the COMPETE Programme (operational programme for competitiveness) and by National Funds through the FCT - Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project FCOMP - 01-0124-FEDER-022701. Project "NORTE-07-0124-FEDER-000058" is financed by the North Portugal Regional Operational Programme (ON.2 – O Novo Norte), under the National Strategic Reference Framework (NSRF), through the European Regional Development Fund (ERDF), and by national funds, through the Portuguese funding agency FCT.

[1] Ahammad, A. J. S.; Lee, J. J.; Rahman M.A., *Sensors* **2009**, 9, 2289-2319.

[2] Popa, D. E.; Buleandă, M.; Mureșeanu M.; Ionică, M.; Tănase, I. G., *Rev. Roum. Chim.* **2010**, 55, 123-130.

[3] Malitesta, C.; Mazzotta, E.; Picca, R. A.; Poma, A.; Chianella, I.; Piletsky S.A., *Anal Bioanal Chem* **2012**, 402:1827-1846.

## **P54 - Temperature dependence of the phosphorescence and of the thermally activated delayed fluorescence of $^{12}\text{C}_{70}$ and $^{13}\text{C}_{70}$ in amorphous polymer matrices. Is a second triplet involved?**

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Fullerenes  $\text{C}_{60}$ ,  $\text{C}_{70}$  and some of their derivatives exhibit a strong thermally activated delayed fluorescence (TADF).<sup>[1,2]</sup> In the TADF mechanism, after excitation and once attained  $\text{S}_1$ , intersystem crossing (ISC) to the triplet manifold occurs, followed by a second ISC from  $\text{T}_1$  back to  $\text{S}_1$ , and then by fluorescence emission.<sup>[3]</sup> The  $\text{S}_1\text{-T}_1\text{-S}_1$  cycle may repeat itself a number of times before fluorescence finally takes place, however this mechanism is operative in the absence or presence, in very low concentrations, of molecular oxygen, otherwise the triplet state is quenched.<sup>[4]</sup> For this reason, fullerenes, namely  $\text{C}_{70}$ , can be used as very sensitive oxygen sensors.<sup>[5]</sup> Recently, TADF became relevant in the Organic Light-Emitting Diode (OLED) field, leading to outstanding results.<sup>[6]</sup> In this work, the phosphorescence and thermally activated delayed fluorescence (TADF) lifetimes of  $^{12}\text{C}_{70}$  and  $^{13}\text{C}_{70}$ , in two different glassy hydrocarbon polymers, were measured between  $-200\text{ }^\circ\text{C}$  and  $100\text{ }^\circ\text{C}$ . The temperature dependence of the lifetimes is equally well described by a three-state mechanism (ground state,  $\text{S}_0$ , and two excited states in thermal equilibrium,  $\text{T}_1$  and  $\text{S}_1$ , the lifetime of  $\text{T}_1$  being temperature dependent) and by a four-state mechanism (ground state,  $\text{S}_0$ , and three excited states in thermal equilibrium,  $\text{T}_1$ ,  $\text{T}_2$ , and  $\text{S}_1$ , all with temperature independent lifetimes). The estimated  $\text{S}_1\text{-T}_1$  and  $\text{T}_2\text{-T}_1$  energy gaps (four-state mechanism) are in good agreement with spectroscopic measurements. These and the determined quantum yield of triplet formation,  $0.997 \pm 0.001$ , are found to be essentially independent of the polymer matrix and of the isotopic composition of the fullerene. On the other hand, the lifetimes of both  $\text{T}_1$  and  $\text{T}_2$  (four-state mechanism) are weakly dependent on the polymer matrix but strongly vary with the fullerene isotopic composition, nearly doubling when going from  $^{12}\text{C}_{70}$  to  $^{13}\text{C}_{70}$ . A parameter useful for the characterization of TADF, the on-set temperature  $\text{T}_0$ , is also introduced.

**Acknowledgements:** This work was carried out within project PTDC/QUI-QUI/123162/2010 (FCT, Portugal). AF and TP were supported by research grants from projects PEst-OE/CTM/LA0024/2013 and PTDC/QUI-QUI/123162/2010, respectively.

- [1] Berberan-Santos, M.N. and J.M.M. Garcia, *Journal of the American Chemical Society*, 1996. 118(39): p. 9391-9394.
- [2] Salazar, F.A., A. Fedorov, and M.N. Berberan-Santos, *Chemical Physics Letters*, 1997. 271(4-6): p. 361-366.
- [3] Parker, C.A., *Photoluminescence of Solutions*, 1<sup>st</sup> Ed.; Elsevier Publishing Co. Amsterdam, 1968.
- [4] Baleizao, C. and M.N. Berberan-Santos, *J Fluoresc*, 2006. 16(2): p. 215-9.
- [5] Nagl, S., et al., *Angew Chem Int Ed Engl*, 2007. 46(13): p. 2317-9.
- [6] Méhes, G., Nomura, H., Zhang, Q., Nakagawa, T. and Adachi, C. (2012), *Angew. Chem. Int. Ed.*, 51: 11311–11315.

## P55 - Tautomerism in 2-mercaptoimidazole: an experimental X-ray diffraction, FTIR and theoretical study

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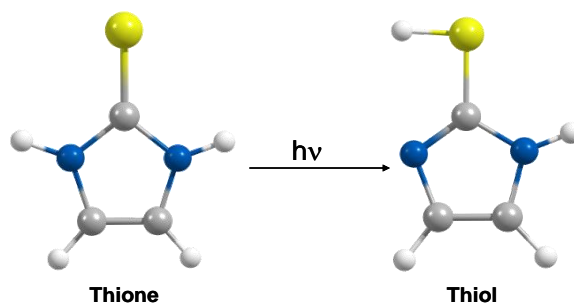
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2-Mercaptoimidazole (MIZ) plays many important roles in various biochemical processes and is a prominent ligand for transition metal ions. It shows good resistance to both chemical reduction and oxidation, being also commonly used as corrosion inhibitor [1].

MIZ may exist as two tautomeric species, the thione and thiol forms (see Figure; note that the compound is usually known by the name of its thiol form). Although considerably much less studied than its oxygen analogue, the thione-thiol tautomerism has been attracting vast experimental and theoretical interest. In this study, the molecular structure and infrared spectra of MIZ tautomeric forms were studied by infrared spectroscopy and quantum chemistry calculations (MP2 and DFT).

Gaseous monomeric MIZ was produced by sublimation of the solid compound, and isolated in an argon matrix at ~15 K. It was shown that in the gas phase the compound exists exclusively in the thione tautomeric form, which could be successfully trapped in the studied argon matrices and then characterized by infrared spectroscopy and theoretical calculations. The sole observation of the thione form of MIZ in the cryogenic matrices is in consonance with the theoretical calculations, which predict this form as being more stable than the thiol form by more than 30 kJ.mol<sup>-1</sup>. In the crystalline state, the compound exists also in its thione tautomeric form, as shown by both X-ray structural diffraction data and infrared spectroscopy.



Upon *in situ* UV ( $\lambda = 290$  nm) irradiation of the matrix-isolated thione form of the compound, its phototautomerization into the thiol form was observed. The identification of the photoproduct species was achieved by comparison of the IR spectrum emerging upon irradiation of the matrix with the theoretically predicted spectrum for the MIZ thiol tautomer.

[1] S. Chandra, J. Chowdhury, M. Ghosh, G.B. Talapatra., *J. Phys. Chem. A*, 116, **2012**,10934.

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## **P56 - Transport properties of ephedrine hydrochloride through poly(vinyl alcohol) matrices - a simple method for enantiometric differentiation.**

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Equilibrium and transport properties have been investigated of ephedrine, a class of sympathomimetic amines, through cryogel membranes of poly(vinyl alcohol) (PVA). The effect of the PVA (10 to 18 % (wt/v)) on the release properties of ((1S,2R)-(+)-ephedrine hydrochloride has been discussed on the basis of partition-diffusion and power-law models. The effect of PVA concentration on the swelling degree of PVA-ephedrine matrices have been measured, allowing the estimation of the volume fraction of polymer in the gel. Based on these values, ephedrine release rate constants, computed by using a first-order kinetics approach, have been modeled by using free volume and hydrodynamic-scaling models. There is no significant effect on the release constants or mechanism of transport of ((1S,2R)-(+)-ephedrine hydrochloride from previously loaded cryogel PVA membranes. However, from these studies it is suggested that ephedrine has a great affinity for the gel phase, involving particularly ephedrine-ephedrine interactions.

Differences in the release properties of the ephedrine isomers (1S,2R)-(+)- and (1R,2S)-(-)-ephedrine as their hydrochlorides, have also been studied at different temperatures. Over the temperature range studied (20-37 °C), ephedrine release rates correlate with the Arrhenius function. The release kinetic constants and, consequently, the corresponding activation energies, show a marked discrimination between the two ephedrine isomers. This has been confirmed by the analysis of the network parameter as predicted by the equilibrium swelling theory of Flory-Rehner. This suggests that PVA cryogel membranes possess high potential for enantiomeric differentiation.

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## P57- Photochemical studies of new aminosquarylium dyes

David S. Conceição<sup>1\*</sup>, Diana P. Ferreira<sup>1</sup>, V.C. Graça<sup>2</sup>, P.F. Santos<sup>2</sup>, L.F. Vieira Ferreira<sup>1</sup>  
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Squarylium dyes have been studied extensively in the past due to their numerous advantageous optical properties that enable applications including imaging technologies and photoconducting devices, sensing and photodynamic therapy (PDT) [1].

These properties include strong absorption ( $>10^5 \text{ M}^{-1}\text{cm}^{-1}$ ) within the so-called “phototherapeutic window” (650 – 800 nm), relatively high fluorescence quantum yields and lifetimes, good quantum yield of the conversion of triplet oxygen to cytotoxic singlet oxygen and also the possibility of tailoring these photochemical properties with appropriate structural functionalization [2].

In this work, we present two new groups of benzothiazole- and benzoselenazole-derived squaraine dyes, with some structural variations in the length of the *N,N'*-dialkyl groups. The photochemical characterization of all dyes was performed and some parameters were evaluated such as: singlet oxygen quantum yields, fluorescence quantum yields and lifetime distribution analysis [3]. The laser flash photolysis (LFP) technique provided new information related to the transient species formed.

The effect of two different counter-ions ( $\text{CF}_3\text{SO}_3^-$  and  $\text{I}^-$ ) was also addressed by these techniques providing new insights about the dyes and also about possible applications in PDT/imaging technologies.

**Acknowledgements:** Thanks are due to FCT, Portugal, for the funding project Pest OE/CTM/LA0024/2013.

[1] Beverina, L.; Salice, P.; *Eur J Org Chem*, **2010**, 7, 1207-1225.

[2] Ferreira, D. P.; Conceição, D. S.; Ferreira, V. R. A.; Graça, V. C.; Santos, P. F.; Ferreira, L. F. V.; *Photochem Photobiol Sci*, **2013**, 12, 1948-1959.

[3] Conceição, D. S.; Ferreira, D.

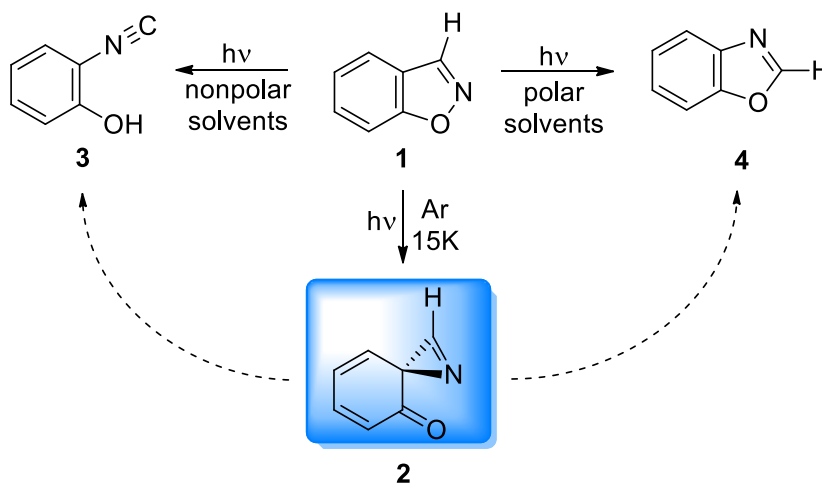
## P58 - Capture of an Elusive *spiro-2H*-Azirine: A Key Intermediate in the Photochemistry of 1,2-Benzisoxazole

Sandra M. V. Pinto,\* Cláudio M. Nunes, Igor Reva and Rui Fausto

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Photochemistry of 1,2-benzisoxazole **1** is known to show an interesting solvent dependence.<sup>[1]</sup> Irradiation of **1** in a nonpolar medium leads mainly to 2-cyanophenol **3** whereas in polar medium leads mostly to 1,3-benzoxazole **4** (see Scheme). Based on quenching and sensitization studies it has been suggested that **3** is formed from initial  $\pi,\pi^*$  excitation of **1** and that **4** is formed from an  $n,\pi^*$  excitation. Continuing our investigations on the photochemistry of heterocyclic compounds by tuneable UV-laser irradiation and low temperature matrix isolation,<sup>[2,3]</sup> we now turn our attention to 1,2-benzisoxazole **1**. Preliminary studies on the irradiation of matrix isolated **1** with UV light at  $\lambda = 280$  nm allowed us to capture the elusive *spiro-2H*-azirine **2** for the first time. We performed the characterization of **2** by IR spectroscopy with the support of theoretical calculations at B3LYP/6-311++G(d,p) level. The key role of the *spiro-2H*-azirine **2** reactive intermediate in the photochemistry of **1** is under investigation. Still, our data clearly indicate that a new mechanism needs to be proposed to correctly describe the photochemistry of 1,2-benzisoxazole **1**.



**Acknowledgements:** These studies were partially funded by the Portuguese “Fundação para a Ciência e a Tecnologia” (FCT), FEDER, and projects PTDC/QUI-QUI/111879/2009, PTDC/QUI-QUI/118078/2010. The Coimbra Chemistry Centre is supported by the FCT through the project PEst-OE/QUI/UI0313/2014. C.M.N. acknowledges the FCT for the Postdoctoral Grant No. SFRH/BPD/86021/2012.

[1] Ferris, J. P.; Antonucci, F. R. *J. Am. Chem. Soc.* **1974**, 96, 2014-2019.

[2] Nunes, C. M.; Reva, I.; Fausto, R. *J. Org. Chem.* **2013**, 78, 10657-10665.

[3] Nunes, C. M.; Araujo-Andrade, C.; Fausto, R.; Reva, I. *J. Org. Chem.* **2014**, 79, Accepted.

DOI: 10.1021/jo402744f.

## P59 - Dissecting the Jacobsen Catalysts Using Principal Component Analysis.

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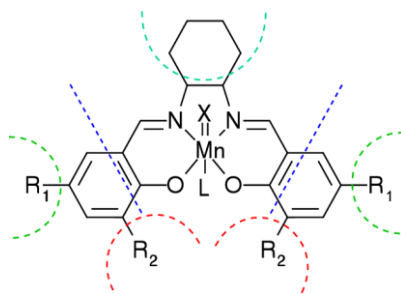
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The theoretical study of the Jacobsen catalyst has been traditionally performed using truncated models for the salen ligand[1]. In this work, different truncated models (see Figure) for this catalyst were studied using X3LYP/triple- $\zeta$  valence basis set calculations[2], with the aim of understanding the effects of truncation, metal oxidation, axial coordination, substitution on the aromatic rings of the salen ligand and chirality of the diimine bridge. To achieve this goal, geometric and structural data, obtained from these calculations, were subjected to Principal Component Analysis (PCA) and PCA with orthogonal rotation of the components (rPCA). The results demonstrated that the differences between salen and acacen' complexes account for about 11% of the variance in the data, and are mostly related to the magnitude of the natural charges on the atoms common to both ligands. Variations in the spin state and oxidation state of the metal centre account for larger fractions of the total variance (up to 22% and 15%, respectively). Other effects, such as the nature of the diimine bridge or the presence of alkyl substituent in the 3,3' and 5,5' positions of the aldehyde moiety, were found to be less important in terms of explaining the variance within the data set.

A matrix of discriminants was compiled using the loadings of the principal and rotated components that best performed in the classification of the entries in the data. The scores obtained from its application to the data set were used as independent variables for devising linear models of different properties. Predictive linear models, for the energy difference between the singlet and quintuplet states, the energy involved in the oxidation of these complexes to their oxo-derivatives and the spin densities at the oxo ligand of these latter compounds were successfully derived using this approach.



Different truncation schemes applied to Jacobsen-type catalysts ( $R_1, R_2 = \text{H, Me, or } ^t\text{Bu}$ ).

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[1] McGarrigle, E. M. and Gilheany, D. G., *Chem. Rev.* **2005**, 105, 1563-1602.

[2] Teixeira, F., Mosquera, R. A., Melo, A., Freire, C. and Cordeiro, M. N. D. S., *Int. J. Quantum Chem.* **2014**, 114, 525-533.

# P60 - 4-Methylbenzylidene camphor: A computational study of its structure and energetics

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The raising awareness of the harmful effects of ultraviolet (UV) solar radiation has increased the production and consumption of sunscreen products which contain organic and inorganic molecules named UV filters that absorb, reflect or scatter UV radiation thus minimizing negative human health effects.

4-Methylbenzylidene camphor (4MBC) is an organic UV filter commonly used in sunscreens and many personal care products due to its ability to protect human skin against UVB solar radiation. 4MBC can exist as a (*E*)- or (*Z*)- isomer (Figure 1) due to an exocyclic carboncarbon double bond. In sunscreen formulations the (*E*) isomer predominates but under light exposure isomerization occurs from (*E*) to (*Z*).<sup>[1,2]</sup>

In this study we have performed density functional theory calculations with the B3LYP hybrid functional and two basis sets: 6-31G(d) and 6-311G(d,p) to obtain the gas-phase molecular structure and energetics of the (*E*)- and (*Z*)- isomers of 4MBC. To obtain more accurate energy values we have also used the G3(MP2)//B3LYP method.

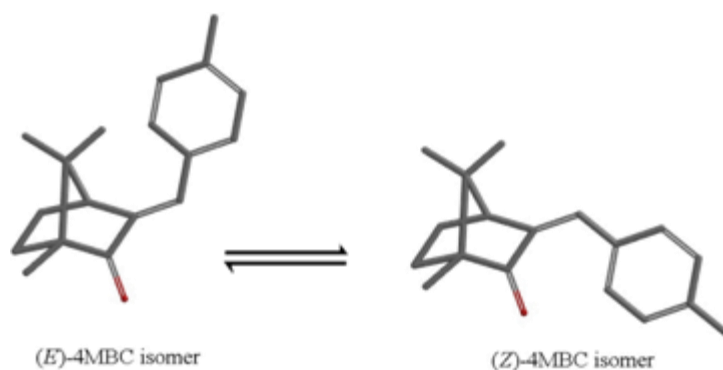


Figure 1 - Isomerization of UVB filter 4-methylbenzylidene (4MBC).

## References

- [1] Buser, H. R.; Muller, M. D.; Balmer, M. E.; Poiger, T.; Buerge, I., *Environ. Sci. Technol.* **2005**, 39, 3013-3019.
- [2] Ferreira, P.J.O., Pinto da Silva, L., Miranda, M.S., Esteves da Silva, J.C.G., *Comput. Theor. Chem.* **2014**, 1033, 63-73.

## P61 - Matrix Isolation FT-IR Spectroscopic and Theoretical Study of 2-Chloro-6-Fluorobenzoic Acid

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2-Chloro-6-fluorobenzoic acid (CFA) was isolated in low temperature matrices and its infrared spectrum was interpreted with help of DFT(B3LYP)/6-311++G(d,p) calculations. The monomer of the compound has been predicted by the theoretical calculations to possess 3 different conformers (see Figure). The most stable conformer (*CFA1*) has its carboxylic acid moiety in the intrinsically most stable configuration (*syn*) with an F...C-C=O dihedral equal to 110°. In this conformation, the sterically more relevant carboxylic acid oxygen atom stays closer to the fluorine atom than to the chlorine atom, whereas the sterically less relevant carbonyl oxygen atom is directed towards the bigger chlorine atom. The second and third conformers of CFA are higher in energy than *CFA1* by ca. 17 kJ mol<sup>-1</sup> and bear a *trans* carboxylic acid moiety. In one of these conformers (*CFA2*) the OH group points to the fluorine atom, while in the other (*CFA3*) this group points to the chlorine atom; according to the calculations, the corresponding F...C-C=O and Cl...CC=O dihedral angles are 129.5° and 106.8°, which are essentially determined by the relative sizes of the F and Cl atoms. The calculations also indicate that in both *CFA2* and *CFA3* conformers no intramolecular H-bond interactions exists between the *trans* carboxylic acid moiety and the *ortho* halogen substituents.

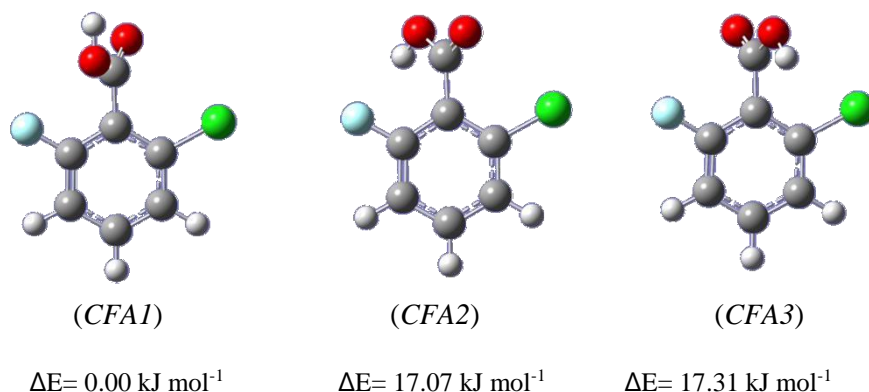


Figure 1 - The infrared spectrum of the compound isolated in cryogenic matrices are assigned, and the effects of irradiating the matrices in different ranges (NIR, UV-vis) investigated.

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## P62- Photodegradation of Naproxen

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Environmental pollution has become a major problem, and is a challenge for humans to ensure our planet survives for future generations.

The presence of pharmaceuticals and personal care products in the environment is an emerging concern. In aquatic environments and drinking water they are potential health risks through toxicity, resistance development in pathogenic bacteria, etc showing resistance to chemical/biological degradation into the water chain [1-3].

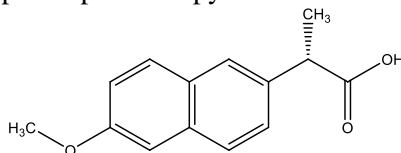
Non-steroidal anti-inflammatory drugs (NSAIDs) are the most widely available drugs globally, with ibuprofen and naproxen as the most important examples. AOPs are a viable method for the degradation of NSAIDs through non-selective reaction with HO<sup>•</sup>.

Photocatalytic processes using TiO<sub>2</sub> catalyst is the most widely used system, mainly due to low cost and good stability [2, 4].

Naproxen [(S)-6-methoxy- $\alpha$ -methyl-2-naphthalene acetic acid] (Fig.1) is a non-steroidal anti-inflammatory drug widely used for mild to moderate pain relief and treatment of osteo- and rheumatoid arthritis. It inhibits the cyclooxygenase enzyme, preventing biosynthesis of certain prostaglandins [5]. We have prepared nanoparticles of TiO<sub>2</sub> powder as photocatalysts by sol-gel methods in acid conditions (HCl) using tetraisopropoxide of titanium calcinated at 500°C [6]. These were characterized by X-ray diffraction, BET adsorption isotherm, diffuse reflectance spectroscopy (DRS), FTIR and scanning electronic microscopy (SEM).

Their photoactivity was tested in the degradation of naproxen compared with direct photodegradation at different wavelengths and TiO<sub>2</sub> Degussa using a Duran immersion cylindrical reactor fitted with a Heraeus TQ150 medium pressure mercury vapour lamp.

The kinetics was followed by absorption spectroscopy and HPLC-DAD.



**Fig. 1.** Chemical structure of Naproxen.

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- [1] Legrini, O.; Oliveros, E.; Brau, A.M., *Chem. Rev.* **1993**, 93, 671-698.
- [2] Burrows, H.D.; Canle, M.L.; Santaballa, A.J.; Steenken, S., *J. Photochem. Photobiol. B-Biol.*, **2002**, 67, 71-108.
- [3] Azenha, I. M.E.; Romeiro, A.; Sarakha, M.: Photodegradation of pesticides and photocatalysis in the treatment of water and waste. In *Applied Photochemistry*; Evans, R.C; Douglas, P.; Burrows H.D, Eds.; Springer: Netherlands, 2013; pp 247-266.
- [4] Konstantinou, I.K.; Albanis, T.A., *Appl. Catal. B: Environ.*, **2004**, 49, 1-14.
- [5] Adhoum, N.; Monser, L.; Toumi, M.; Boujlal, K., *Anal Chem Acta*, **2003**, 495, 69-75.
- [6] Mehriza, D.A.; Gharbani, P.; Tabatabaii, S.M., *J. Iran. Chem. Soc.*, **2009**, 2, 145-149.

## P63 - CdSe Nanocrystals as Activators in Peroxyoxalate Chemiluminescence Reaction

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In the last years, semiconductor nanoparticles have attracted a lot of scientific attention due to their unique optical and electronic properties, which are highly dependent on size, shape and composition [1, 2, 3]. They can find applications in the optoelectronic, photovoltaic and biomedical fields [4]. Recently, several studies involving their chemiluminescence behavior were also reported in the literature [5, 6]. In this work, CdSe nanocrystals (figure 1) coated with different organic ligands were synthesized and their role as potential activators in the peroxyoxalate chemiluminescence (POCL) reaction was investigated. The nanocrystals were tested in a system containing hydrogen peroxide and oxalic ester as oxidant and source of high-energy intermediates, respectively. Physicochemical and photochemical properties of the synthesized nanoparticles are compared based on absorption, emission and chemiluminescence spectra.



Figure 1. Oleic acid-capped CdSe nanocrystal samples viewed under ultraviolet irradiation ( $\lambda_{\text{ex}} = 366 \text{ nm}$ ).

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- [1] Donegá, C., *Chem. Soc. Rev.* **2011**, 40, 1512.
- [2] Peng, X.; Manna, L.; Yang, W.; Wickham, J.; Scher, E.; Kadavanich, A.; Alivisatos, A., *Nature* **2000**, 404, 59.
- [3] Li, Y. X.; Yang, P.; Wang, P.; Huang, X.; Wang, L., *Nanotechnology* **2007**, 18, 225602.
- [4] Michelle, D.R.; Ming-Young, H., *Acc. Chem. Res.* **2010**, 43, 621-630
- [5] Poznyak, S. K.; Talapin, D. V.; Shevchenko, E. V.; Weller, H., *Nano Lett.* **2004**, 4, 693.
- [6] Wang, Z.; Li, J.; Liu, B.; Hu, J.; Yao, X.; Li, J., *J. Phys. Chem. B* **2005**, 109, 23304.

## **Materials Sciences and New Technologies**

## P64 - Novel magnetic gold recyclable nanocatalyst for the reduction of nitroaromatic compounds

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Nanosized metal particles have been attracting considerable interest in various research fields owing to their fantastic physical, chemical and biological properties, being applied in a myriad of new advanced applications such as catalysis, organic synthesis or low-temperature CO oxidation.[1,2] Gold nanoparticles (Au NPs) are remarkable scaffolds in a wide variety of applications due to their unique physical and chemical properties,[3] and occupy a pivotal position in green catalysis, namely in reductive catalysis of chlorinated or nitrogenated hydrocarbons.[2] However, Au NPs tend to aggregate [4] due to their high surface energy, which leads to a reduction of their activity restraining their applications. To overcome this disadvantage, the immobilization of Au NPs on solid supports has been reported as a potential strategy to improve their stability and also to facilitate the recycling of the catalyst. In literature, several works reported that Au NPs immobilized on solid supports present enhanced catalytic activity when compared with free Au NPs. In particular, magnetic nanosupports for Au NPs are one of the best solutions to their immobilization since they improve the catalyst stability, efficiency and recyclability, being easily separated from the reaction medium by application of an external magnetic field [5]. In the present work, we prepared novel magnetic gold nanocatalysts through the *in situ* synthesis of Au NPs on MnFe<sub>2</sub>O<sub>4</sub>@SiO<sub>2</sub> magnetic nanosupport functionalized with two organosilanes (3-aminopropyltriethoxysilane and 3-mercaptopropyltrimethoxysilane, Figure 1). The catalytic activity of the two nanocomposites was evaluated on the reduction of 4-nitrophenol (4NP) and 4-nitroaniline (4NA), selected as model systems. The nanomaterials were characterized by Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), thermogravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD) and SQUID magnetometry. The catalytic tests were monitored by UV-Vis and confirmed the potential of both nanocatalysts in the nitroaromatics reduction with outstanding stability upon recycling/reuse and the advantage of magnetic separation from the reaction medium. The characterization of the magnetic nanocatalysts by FTIR and XPS after the catalytic studies proved their high stability.

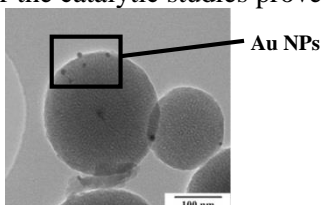


Figure 1 - TEM micrograph of Au NPs anchored on the silane-functionalized MnFe<sub>2</sub>O<sub>4</sub>@SiO<sub>2</sub> nanosupport.

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- [1] Xu, Z.; Hou, Y.; Sun, S., *J. Am. Chem. Soc.* **2007**, 129, 8698–8699.
- [2] Li, J.; Liu, C.; Liu, Y., *J. Mater. Chem.* **2012**, 22, 8426–8430.
- [3] Zhu, M.; Aikens, C.M.; Hollander, F.J.; Schatz, G.C.; Jin, R., *J. Am. Chem. Soc.* **2008**, 130, 5883–5885.
- [4] Zheng, J.; Dong, Y.-L.; Wang, W.; Ma, Y.; Hu, J.; Chen, X., *Nanoscale* **2013**, 5, 4894–4901.
- [5] Chang, Y.C.; Chen, D.H., *J. Hazard. Mater.* **2009**, 165, 664–669.

## P65 - How to improve the memory on PDLC films

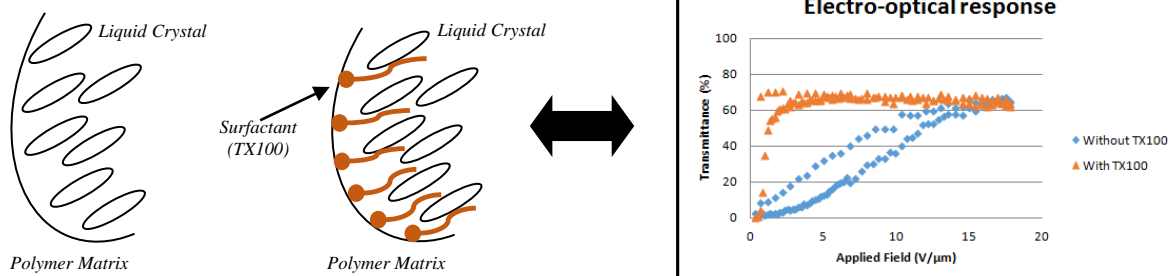
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Polymer-dispersed liquid-crystal films (PDLC) can be electrically switched from an opaque state to a transparent state. It has been shown that in some systems applied external electric field causes a transparent state that can be retained after the field is off; this is called Permanent Memory Effect (PME). The polymer matrix of the PDLC is based on monomers, such as Tri(ethylene glycol) dimethacrylate and poly(ethylene glycol) dimethacrylate with molecular weight of 875 which were thermal polymerized using  $\alpha,\alpha$ -azobisisobutyronitrile as initiator. Different aspects were investigated, such as the study of the dynamics of the ON/OFF state transition using a high-frequency alternate voltage and the attempt to minimize the liquid crystal anchorage force to the polymer matrix using TX100 as an additive. The polymeric matrix morphology was analyzed by scanning electron microscopy. Finally, the ON/OFF response of the PDLC films was studied. This part of the work was done with the goal to understand what was the impact of the increased amount of TX100 on the orientation and disorientation time of the LC molecules. Additionally, a fitting model <sup>[1][2]</sup> was developed in order to describe the orientation and disorientation kinetic of the system. It was verified that the increase amount of TX100, decreases the initial anchorage force of the LC molecules to the polymeric matrix<sup>[3]</sup>. This reflects on the increase of the permanent memory effect and decrease of the E90 of the PDLC films, verified also with the decrease of the average elastic constant, K, from the fitting model.



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[1] Doane, J. W.; Wu, B.; Erdmann, J.H.; Doane W.; (2006). *PDLC shutters: where has this technology gone?*, Kent State University, Liquid Crystal Institute Department of Physics, 33, 1313-1314.

[2] Wu, B.; Erdmann, J.H.; Doane, J.W.; (2006). *Response times and voltages for PDLC light shutter*, Kent State University, Liquid Crystal Institute Department of Physics, 33, 1315-1322.

[3] Kim, B., & Woo, J. (2007). *Surfactant Effects on Morphology and Switching of Holographic PDLCs Based on Polyurethane Acrylates*. ChemPhysChem 8, 175-180.

## P66 - Vacuum deposition of Thin Films for Organic Electronics

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Thin films of organic semiconductors (OSCs) are used in numerous electronic applications with great significance in materials science and printed electronics, such as organic light-emitting diodes (OLEDs), organic field-effect transistors (OFETs), organic light-emitting transistors (OLETs) and organic photovoltaic cells (OPVs). Vacuum deposition is one of the most efficient methods to produce thin films of charge transport and electroluminescent materials. Controlling the assembly of organic semiconductors is a promise field for the improvement of performance of materials involving intermolecular charge transport, which is directly related with solid-state packing of the organic semiconductors.<sup>[1]</sup> In this work we have studied and explored the properties of some hole transport materials, electron transport materials, and electroluminescent materials. The topographic morphological analysis of thin films, composites and hybrid materials with ionic liquids (ILs) obtained by vacuum deposition is presented (Figure 1).

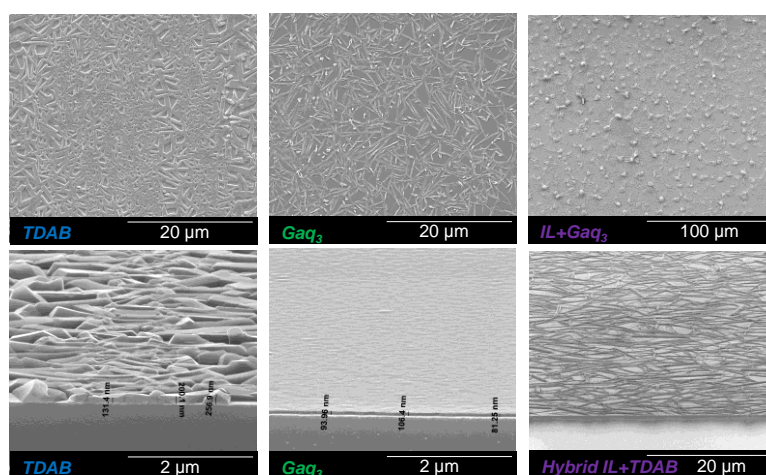


Figure 1 -Thin films of TDAB (hole transport material), Gaq<sub>3</sub> (electroluminescent material); composite thin films of IL and Gaq<sub>3</sub> and hybrid thin films of IL and TDAB.

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[1] Costa, J.C.S.; Santos, L. M. N. B. F., *J. Phys. Chem. C* **2013**, *117*, 10919.

## P67 - Comparisons on the Dispersion Efficiency of Various Surfactants For Single- and Multi-Walled Carbon Nanotubes

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Carbon nanotubes (CNTs) have a strong tendency to aggregate into bundles due to inter-tube van der Waals attractions. However, for most technical applications, individual dispersion and alignment of CNTs are strictly required.

In this work, we aimed at a comparative study of the dispersion efficiency of different ionic surfactants for carbon nanotubes in aqueous solution, using also ultrasonication as the mechanical dispersive method. The ultrasonic acoustic vibration causes exfoliation of CNTs, favoring the adsorption of the surfactant hydrophobic chains onto the CNT surface [1, 2]. Electrostatic repulsions from the surfactant-decorated tubes should further facilitate the colloidal stability of the CNT dispersion [3, 4].

The mass concentration of dispersed CNTs was determined by UV-Vis absorption spectroscopy. The critical micelle concentration (*cmc*) of the surfactants in neat water was previously determined by conductimetry. Single and multi-walled CNTs were used, while the surfactants encompassed anionic (SDBS and SDS) and cationic ones (DTAB, TTAB, CTAB and CPyCl). The CNT dispersions were prepared as a function of surfactant concentration under experimental conditions that were strictly controlled and reproducible.

It was found that for a given surfactant, the concentration has a significant effect on dispersing ability, and that the *cmc* (and hence the presence of micelles in solution) has a key role in the process [3]. Moreover, it was observed that the degree of dispersion is strongly dependent on the molecular structure of the surfactant, for instance, on the presence of aromatic groups, and length and volume of the polar group the hydrocarbon chain. This study thus contributes to a molecular-level understanding of the role of surfactants as dispersing agents for CNTs.

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[1] Britz, D.A. ; Khlobystov, A.N., *Chem. Soc. Rev.* **2006**, 35, 637–659.

[2] Vaisman, L., Wagner, H.D.; Marom, G., *Adv. Colloid Interface Sci.* **2008**, 128, 37– 46.

[3] Silva, B.F.B.; Marques, E.F. *Encyclopedia of Colloid and Interface Science: Surfactant Self-Assembly*, in Tadros, T. Eds.; Springer Berlin Heidelberg, 2013; pp. 1202–1241.

[4] Fernandes, R.M.F.; Buzalo, M.; Shtein, M.; Pri-Bar, I.; Regev, O.; Marques, E.F.; Furó, I., *J. Phys. Chem. C*, **2014**, 118, 582–589.

## P68 - Ion Reduction in Metallic Nanoparticle Nucleation

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Recently, we have shown how silver and gold NPs can be generated on cellulose films [1, 2]. The cellulose films used in those studies were rather thin: films were deposited onto GaAs substrates, by spin-coating, issuing ultrathin layers around 7 nm thick covering over 85 % of the substrate. Both atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS) characterization have shown that the substrate coverage was not complete. A few holes exist. Therefore, a direct contact of the metallic ion solution (used as metal precursor) with the substrate cannot be ruled out. Thence, it is worth to analyze the possible role of the substrate on the metallic ion reduction. Substrates of interest are, for instance, glass and gold, or semiconductors, such as GaAs and Si.

The effect these substrates on the eventual reduction of Ag and Au ions from aqueous solutions of AgNO<sub>3</sub> and HAuCl<sub>4</sub>·3H<sub>2</sub>O salts, was studied. Surfaces were characterized by XPS and AFM. Results show that the substrate has an active role in the metallic ions reduction, as shown for Si, GaAs and, surprisingly, also for gold substrates.

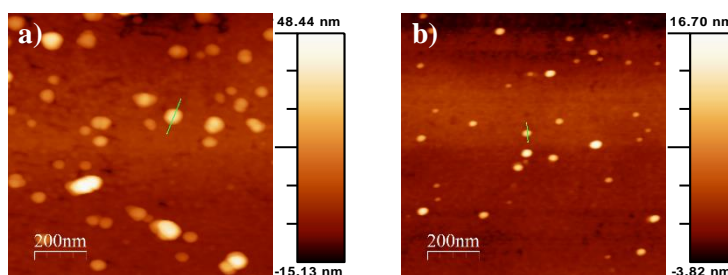


Figure 1: AFM images for (a) GaAs and (b) Si substrate after the interaction of the substrates with the aqueous salt of silver.

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- [1] S. Boufi, A. M. Ferraria, A. M. Botelho do Rego, N. Battaglini, F. Herbst, M. Rei Vilar, *Carbohydr. Polym.* **2011**, 86 (4), 1586-1594.
- [2] A. M. Ferraria, S. Boufi, N. Battaglini, A. M. Botelho do Rego, M. Rei Vilar, *Langmuir*, **2010**, 26, 1996-2001.

## P69- Intrinsic CO<sub>2</sub> adsorption on porphyrin materials: the effect of acid/basic groups

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The increase of greenhouse gases in earth's atmosphere, and the consequent influence this has on climate change at a global level, has been of concern to society and has resulted in great efforts to reduce their emission, and resultantly protect the planet's climate. The concentration of these gases has now achieved worrying levels and without immediate action the situation unlikely to improve. However, laws have now been passed to limit maximum emissions of greenhouse gases into the atmosphere and treaties between several countries like the "Quito Protocol", later continued by the "Doha Amendment", whose objectives are focused on the reduction and stabilization of the CO<sub>2</sub> concentration at the atmosphere have also been created. Nevertheless, a lot must be achieved to attain controlled levels and, in this area, there has been an intensification of investigations worldwide [1,2]. Porphyrins are important compounds both due to its ubiquity in nature, where they play vital roles as catalysts and gas carriers, and also in science and technology where they are used as catalysts, dyes, advanced materials and pharmaceutical drugs [3-5]. Porphyrins can crystallise in robust multiporous structures with interesting optical properties that can be used as material for host inclusion [6]. In the last decade the use of elaborated multiporous materials had a significant advance in the way of presenting zeolites, porous polymers and metal-organic frameworks with interesting gas absorption properties [7]. Among those processes, the gases sequestering, namely CO<sub>2</sub> and other greenhouse gases, is a subject of growing importance in environmental chemistry [8]. The design and synthesis of efficient CO<sub>2</sub> sequestering materials involves the planning of large aromatic structures with large intermolecular channels and a balanced presence of hydrophobic motifs (to allow CO<sub>2</sub> passage) and polar motifs to permit CO<sub>2</sub> sequestering at room temperature. The porphyrins with carboxylic and amino groups appended in the *meso* positions have these characteristics and can be a good choice for CO<sub>2</sub> sequestering crystalline materials [9]. In this communication we present the synthesis, characterization and the evaluation of CO<sub>2</sub> adsorption of tetrakis (4-carboxyphenyl)porphyrin and tetrakis (4-aminophenyl)porphyrin at 5 bar will be presented, along with structure/activity interaction.

**Acknowledgements:** This work was supported by Fundo Europeu de Desenvolvimento Regional - QREN- COMPETE through projects PTDC/AAC-CLI/098308/2008 and project PTDC/AAC-CLI/118092/2010 and financial support SFRH/BD/61637/2009 (Joana de Almeida e Silva) of FCT.

### References:

- [1] Contribution of Working Group I to the "Fourth Assessment Report of the Intergovernmental Panel on Climate Change", Cambridge Press University, 2007 (www.ipcc.ch)
- [2] [http://unfccc.int/essential\\_background/convention/items/6036.php](http://unfccc.int/essential_background/convention/items/6036.php) acedido a 14 de Março de 2014.
- [3] Lee, S. J., Hupp, J. T.; *Coord. Chem. Rev.*, **2006**, 250, 1710-1723.
- [4] Sobral, A. J. F. N., Justino, L. L. G., Santos, A. C. C., Silva, J. A., Arranja, C. T., Silva, M. R., Beja, A. M.; *J. Porphyr. Phthalocya.*, **2008**, 12, 845-848
- [5] Muthukumar, P., John, S. A., *Sensors and Actuators B*, 74 (2012), 74-80.
- [6] Matsunaga, S., Endo, N., Mori, W., *Eur. J. Inorg. Chem.* (2011) 4550-4557.
- [7] Krishna, R., Baten, J. M., *Sep. Purif. Technol.*, 87 (2012) 120-126.
- [8] Lu, C-M., Liu, J., Xiao, K., Harris, A., *Chem. Eng. J.*, 156 (2010) 465-470.

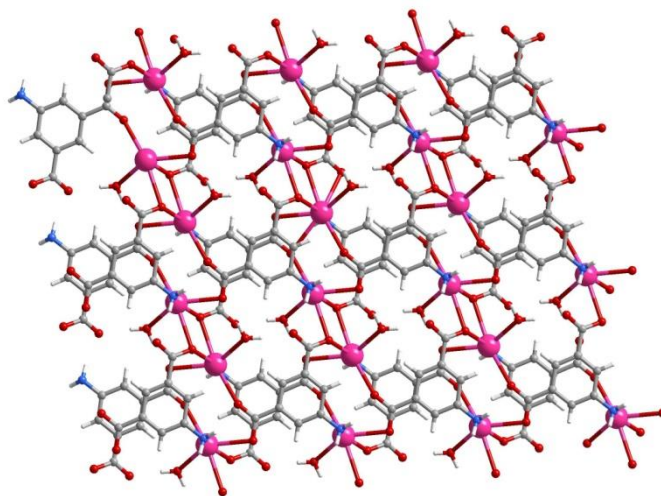
## P70 - Alkaline-earth metals and 5-aminoisophthalic acid-based coordination polymers

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Coordination polymers, also named metal-organic frameworks (MOFs) are a class of interesting materials composed of organic ligands coordinated to inorganic clusters or ions, which properties may be tuned by an appropriate selection of the ligand, co-ligand, the metal centers and the reaction conditions. These materials should be robust, possess a geometrically well-defined structure and synthetically modifiable linkers (ligands).[1] Along the years MOFs have become increasingly important in the field of materials chemistry due to their properties and wide range of applications. Nowadays their applicability in several areas like drug delivery, optics, catalysis, magnetism, sensing and adsorption/separation of gases is common.[2] Considering the latest advances in the synthetic protocols associated to alkaline-earth metals, these metal ions became an interesting alternative to lanthanides as metal clusters [3]. In this work we present a series of coordination polymers based on 5-aminoisophthalic acid (H<sub>2</sub>aip) and the alkaline-earth metals, Ca(II) and Ba(II): [Ca(aip)(H<sub>2</sub>O)<sub>2</sub>](H<sub>2</sub>O) (**1**), [Ba(aip)(H<sub>2</sub>O)] (**2**) (see Figure), [Ca(aip)(phen)(H<sub>2</sub>O)](H<sub>2</sub>O) (**3**) and [Ba<sub>2</sub>(aip)<sub>2</sub>(phen)<sub>2</sub>(H<sub>2</sub>O)<sub>7</sub>](phen)<sub>2</sub>(H<sub>2</sub>O)<sub>2</sub> (**4**). All the materials were synthesized using a similar protocol of conventional heating, they were characterized by elemental analysis, FT-IR and single crystal X-ray diffraction (XRD). Compounds **1**, **3** and **4** feature a 1D MOF structure, while the material **2** is a 2D MOF.



Representation of an individual layer (2D structures) of compound **2**.

**Acknowledgements:** The authors thank the Fundação para a Ciência e a Tecnologia (FCT, Portugal), the European Union, QREN, FEDER, and COMPETE for financial support through the projects PEstC/EQB/LA0006/2011 and Operation NORTE-07-0124-FEDER-000067-Nanochemistry. Further acknowledgements to FCT due to the R&D project PTDC/CTM/100357/2008 and the fellowship SFRH/BD/79702/2011 (CQ).

[1] Furukawa, H.; Cordova, K. E.; O’Keeffe, M.; Yaghi, O. M., *Science*, **2013**, 341, 1230444.

[2] Dey, C.; Kundu, T.; Biswal, B. P.; Mallick, A.; Banerjee, R., *Acta Cryst.*, **2014**, B70, 3-10.

[3] Harder, S. *Chem. Rev.*, **2010**, 110, 3852-3876.

## P71 - Electrochemical behavior of novel synthesized ionic liquids

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Ionic liquids (IL) have been receiving in the last decades, and even more recently, an enormous amount of interest as they have shown very interesting physicochemical properties. They are characterized by high thermal stability, relatively broad electrochemical window, good electrical conductivity, usually negligible vapor pressure and limited solubility in various solvents. These features have prompted their usage in several organic synthesis [1], capacitors [2], solar [3] and fuel cells [4], nano-elements [5], among several other applications. However, one of its drawbacks is the cost of production, therefore our group is interested in developing novel cheap ionic liquids. Until this moment, two new ILs have been synthesized and their chemical/electrochemical characterization is under course.

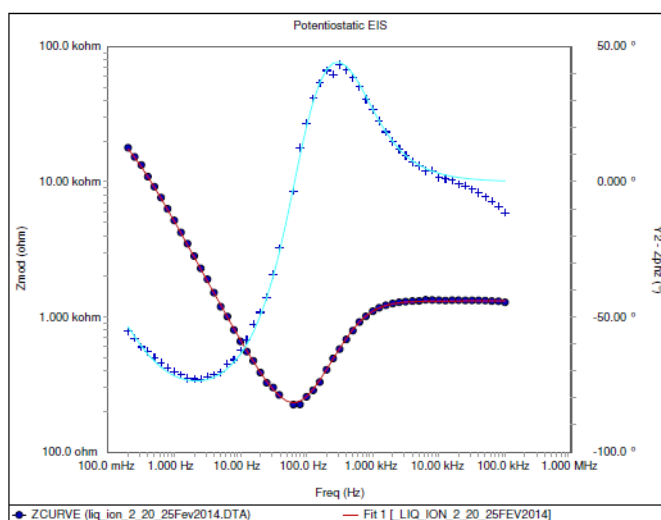


Figure 1 - Electrochemical impedance spectra of one of the synthesized ionic liquids.

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[1] Le Boulair, V.; Grée, R., *Chem. Commun.*, **2000**, 22, 2195–2196.

[2] Lewandowski, A.; Swiderska, A., *Solid State Ionics*, **2003**, 161, 243-249.

[3] Wang, P.; Zakeeruddin, S. M.; Comte, P.; Exnar, I.; Gratzel, M., *J. Am. Chem. Soc.*, **2003**, 125, 1166-117.

[4] de Souza, R. F.; Padilha, J. C.; Gonçalves, R. S.; Dupont, J., *Electrochem. Commun.*, **2003**, 5, 728-731.

[5] Wang, Y.; Yang, H., *Chem. Eng. J.*, **2009**, 147, 71-78.

## P72 - Development of green composites based on polycaprolactone and pine wood fibres for extrusion and injection molding processing technologies

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Awareness that “green chemistry” can contribute to reduce the environmental deterioration through the use of chemical products and processes that reduce or eliminate the generation of hazardous substances has motivated the active search for biodegradable renewable products and more efficient processing technologies [1]. Wood plastic composites (WPC) represent a growing field of interest on the research for sustainable and environmentally benign products for various industries, such as the aerospace, automotive, construction or packaging production [2]. Composite materials made of biodegradable thermoplastic polymers (such as polycaprolactone) and plant fibers (such as wood fibers) enable the recycled use of raw materials with reduced creation of waste, constituting sustainable alternatives to other conventional materials. Moreover, these green composites combine interesting mechanical and physical properties that may be tailored according to the pretended end products [1,2]. This study concerned the synthesis and characterization of composite materials made of polycaprolactone (PCL) and pine wood fibers, being optimized for processing by extrusion or by injection molding [3]. PCL with different molecular weights and wood fibres sieved to different size ranges were tested and characterized using techniques such as FTIR (chemical composition), DSC-TGA (thermal behaviour) and SEM (size/morphology). Torque rheometry was used to evaluate the effect of the reinforcement elements concentration in the composite, according to the fibres’ size distributions. The obtained composites, with adequate compositions for the selected processing technologies, were characterized regarding physical and mechanical properties. This study also involved the surface modification of wood fibres with SiO<sub>2</sub> to reduce their hydrophilic character and enhance the adhesion with the polymeric hydrophobic matrix [4].

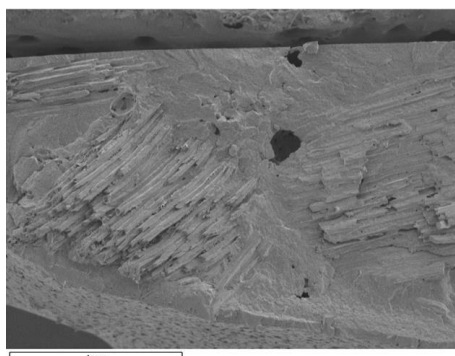


Figure 1 - Composite of PCL 50 KDa and wood (fibres size of 140-280 µm).

- [1] Anastas, P.T., Kirchhoff, M.M., *Accounts of Chem Res* **2002**, 35 (9), 686–694.
- [2] Ashori, A., *Bioresource Technol* **2008**, 99, 4661–4667.
- [3] Nitz, H.; Semke, H.; Landers, R.; Mülhaupt, R., *J App Polymer Sci* **2001**, 81(8), 1972–1984.
- Unger, B.; Buckner, M.; Reinsch, S.; Hubert, T, *Wood Sci Technol* **2013**, 47, 83–104.

## P73 - Functional Polymer Nanoparticles for Boron Scavenging

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Resin based methacrylates functionalized with 1,2-propanediol amino functions have shown to be efficient chelants of boron from wastewater [1]. Here, is presented an alternative process for boron chelation through the co-polymerization of modified methacrylates in thermosensitive core-shell nanoparticles (Figure 1). A methyl methacrylate (MMA) core and a shell composed by a copolymer of the thermosensitive monomer N-isopropylacrylamide (NiPAAM), with the positively charged monomer 2-aminoethyl methacrylate hydrochloride AEMH and a methacrylate modified with one, two or three diol groups [2], were prepared through emulsion polymerization. The aforementioned modified methacrylates were synthesized to test different boron chelating efficiencies. Mono diol methacrylate was obtained by acidification of glycidyl methacrylate. The methacrylate with two diol functions – di-(1,2-propanediol)aminoethyl methacrylate (DPAEM) – was synthesized through basic catalysis using AEMH and glycidol. Optimization of three diol methacrylate synthesis is still going on.

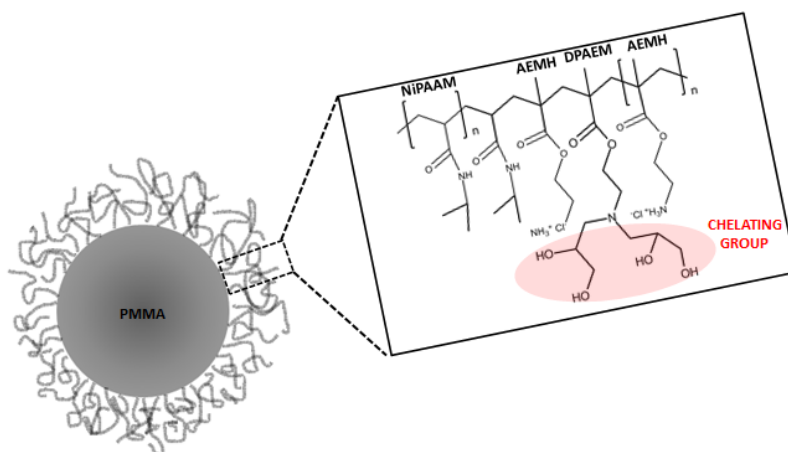


Figure 3- Polymer nanoparticles with a PMMA core and a co-monomer polymer shell of NiPAAM, AEMH and methacrylate bearing two 1,2-propanediol amino functions.

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[1] Senkal, B. F.; Bicak, N. *Reactive & Functional Polymers*. **2003**, 55, 27–33.

[2] Moura, L. M.; Martinho, J. M. G.; Farinha, J. P. S. *Chem. Phys. Chem.* **2010**, 11, 1749 – 1756.

## P74 - Hybrid aerogel powders prepared from water glass at atmospheric pressure

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The outstanding properties of silica based aerogels encouraged continued efforts for the development of these materials since Kistler's pioneering work. They are highly porous, extremely light (densities in the range 3-500 kg.m<sup>-3</sup>), nanostructured, non-flammable, and excellent thermal insulators (thermal conductivity in the range 0.01–0.02 W.m<sup>-1</sup>.K<sup>-1</sup>) [1].

The synthesis and process and parameters are determined by the required physical form (monolithic, powder, coating) and physicochemical properties of the final aerogel. Modifications towards hydrophobicity and lipophilicity are particularly appealing for applications in which stability towards moisture is essential.

Aiming at short processing time and low production costs, a simple method for the synthesis of hydrophobic silica-based aerogel powders has been proposed, using the same precursor as Kistler (sodium silicate without prior ion exchange) and, as co-precursor for organic modification, hexamethyldisilazane (HMDZ) [2]. Silylated hydrogels are prepared by adding HNO<sub>3</sub> and HMDZ to sodium silicate (water glass) under constant stirring. Gelation proceeds at room temperature and is followed by a one-step solvent exchange, immersing the gel in *n*-hexane. Ambient pressure drying further contributes to reduce costs and render the process safer.

The present work aimed at optimizing the hybrid aerogel yield, maximizing the lipophilicity/hydrophobicity ratio and minimizing density, by a selective control of the synthesis parameters: Na<sub>2</sub>SiO<sub>3</sub>:HNO<sub>3</sub>:HMDZ molar ratios, stirring speed and period, aging, washing and drying steps.

The effects of the process conditions on the physical properties of the final aerogel powders were analyzed by N<sub>2</sub> adsorption-desorption isotherms at 77 K, tapping density and water contact angle measurements. The molecular structures were characterized by diffuse reflectance infrared (DRIFT) spectroscopy. The efficiency of surface modification was proven by the relatively high intensities of the -Si(CH<sub>3</sub>)<sub>3</sub> related bands in the DRIFT spectra (Figure 1).

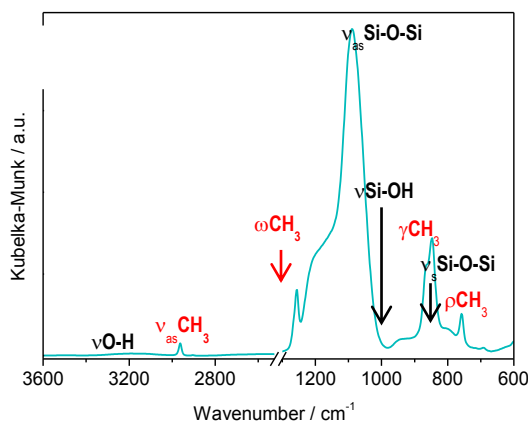


Figure 4. DRIFT spectrum of a hydrophobic/lipophilic hybrid aerogel.

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- [1] Aegerter, M. A.; Leventis, N.; Koebel, M. M. (Eds), *Aerogels Handbook*, Springer Science+Business Media, New York, 2011.
- [2] Bhagat, S.D.; Kim, Y.; Suh, K.; Ahn, Y.; Yeo, J.; Han, J., *Micropor. Mesopor. Mater.* **2008**, 112, 504-509.

## P75 - Fluorescent pH-Sensitive Nanoparticles

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The pH of eukaryotic cells is assumed to be neutral, but this is only true for the cytosol and nucleus. Due to the high compartmentalization of eukaryotic cells, intracellular pH can vary from 4.7 in the lysosomes to around 8 at the mitochondria.[1] Changes in intracellular pH regulate a number of cell processes, including apoptosis and pathogenesis of chronic wounds.

In particular, fluorescent indicators are valuable tools for measuring changes in intracellular pH, providing the sensitivity required for these pH variations inside living cells. The typical fluorescent probes used for these type of measurements are based on fluorescein and its derivatives, which exhibit multiple pH dependent equilibria but their leakage from cells is quite easy. The fluorescent sensor used for intracellular pH measurements should be non-toxic, it should have excitation and emission in the visible to near range suitable for detection by fluorescence microscopy and its stability over time must be high. Perylenediimide (PDI) derivatives have been widely used as industrial pigments for tissues and paints. The synthesis of PDI derivatives, starting from the commercially available perylene-3,4,9,10-tetracarboxylic acid dianhydride, allows the introduction of substituents in the imide group (affecting the aggregation, solubility or immobilization) or in the bay region (substituents affecting electronic and optical properties).[2] PDI derivatives show interesting properties, such as near-unity fluorescence quantum yield, excitation in the visible region, strong and reversible electron-accepting character, high thermal, oxidative and photochemical stability and high electron mobility. Due to the versatility of this family of molecules, in this communication we present the synthesis of new PDI derivatives incorporating groups sensitive to proton concentration in the bay region and alkoxysilane groups in the imide group to allow their incorporation in silica nanoparticles (SiNPs). This incorporation increases the stability of the sensor and allows the preparation of multiresponsive nanostructures.

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[1] Casey, J. R.; Grinstein, S.; Orlowski, J., *Nature Reviews Molecular Cell Biology* **2010**, 11, 50-61.

[2] Huang, C.; Barlow, S.; Marder, S.R., *J. Org. Chem.* **2011**, 76, 2386-2407.

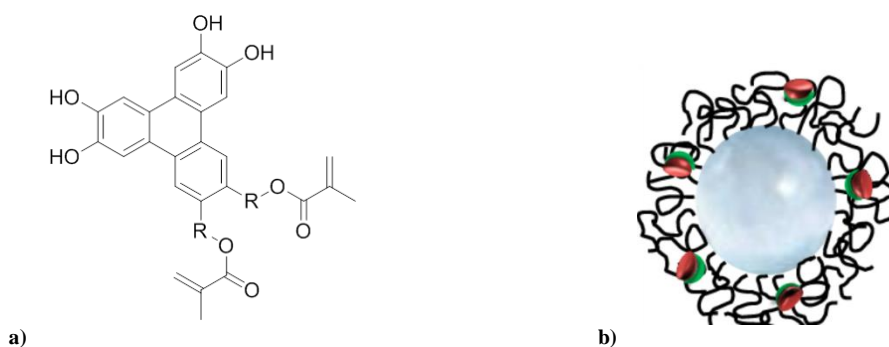
## P76 - New fluorescent hexahydroxytriphenylene metal ion sensors

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Boron is beneficial to human health and agriculture in trace quantities, but becomes toxic both to humans and crops in excessive quantities. Boron compounds are used in many industrial applications, including the fabrication of soaps and detergents, glass and ceramics, insecticides, fertilizers and pharmaceutical drugs, which increases the boron content in water due to residual water discharges [1]. According to World Health Organization recommendations, boron concentrations in water for human consumption should be below 2.4 ppm [2]. Sensitive methods for the analysis of boron content in water, with a detection limit in the ppb range rely on large equipment, with relatively few examples of optical boron sensors described in the literature [3]. In the present work, we synthesize new fluorescent boron sensors with chelating ability, based on 2,3,6,7,10,11-hexahydroxytriphenylene (which features a high sensitivity and specificity for boron even at very low sensor concentration [4]), with a methacrylate motif (figure 1a), that will subsequently allow the polymerization of the sensor, incorporating it in smart polymer nanoparticles [5] in order to remove the boron content of aqueous systems (figure 1b).



**Figure 1.** a) Structure of the synthesised optical boron sensor derived from hexahydroxytriphenylene; b) Schematic representation of the final nanomaterial (blue, nanoparticle core; black, polymeric shell; green, boron sensor; brown, chelated boron).

**Acknowledgements:** We wish to thank Fundação para a Ciência e a Tecnologia (FCT), Project PTDC/CTM-NAN/115110/2009.

- [1] Batayneh, A. T. *Int. J. Environ. Sci. Technol.* **2012**, 9, 153-162.
- [2] World Health Organization. *Guidelines for drinking-water quality*. 4th ed. World Health Organization, **2011**.
- [3] Takahashi, T, Yawata, S, Hoshino, H. *Anal. Bioanal. Chem.*, **2008**, 391, 1101-1106.
- [4] Farinha, J. P. S., Baleizão, C. M. C., Alves, S. P. C. (Instituto Superior Técnico). PT106766. February 06 **2013**;
- [5] Borlido, L., Moura, L., Azevedo, A. M., Roque, A. C. A., Aires-Barros, M. R., Farinha, J. P.S. *Biotechnol. J.* **2013**, 8, 709-717.

## P77 - Themoresponsive fluorescent polymers as temperature sensor in the physiological range

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Optical sensors exploiting the fluorescence temperature dependence of either intensity or lifetime have been widely explored.[1] The use of temperature fluorescence based sensors in real applications is very simple because they can work with cheap excitation sources such as LEDs, and the signal can be collected in intensity, time or phase modes. Additionally, they exhibit a very fast response and reversibility.

Stimuli-responsive polymers are particularly interesting materials, giving the possibility to control the polymer expanded/collapsed state in water by using an external stimuli, such as temperature.[2] Water-soluble biocompatible copolymers of 2-(2-methoxyethoxy)ethyl methacrylate and oligo(ethylene oxide)methacrylate exhibit a lower critical solution temperature (LCST) that can be accurately tuned by adjusting the ratio of the two monomers.[3]

Herein we present the preparation of these themoresponsive co-polymers labeled with different pyrene derivatives using atom transfer radical polymerization (ATRP), and the LCST tuned to ca. around 37°C. The collapse/expansion of the polymer chains changes the pyrene excimer-to-monomer intensity ratio, providing a very sensitive remote temperature sensing platform. Additionally, the intensity of the monomer is temperature independent, allowing the internal calibration of the sensor system.

**Acknowledgements:** This work was partially supported by Fundação para a Ciência e a Tecnologia (FCT-Portugal) and COMPETE (FEDER) within project RECI/CTM-POL/0342/2012, and PEst-OE/CTM/LA0024/2013. S. A. acknowledges a postdoctoral grant from FCT, Portugal (SFRH/BPD/74654/2010).

[1] McDonagh, C.; Burke, C. S.; MacCraith, B. D. *Chem. Rev.* **2008**, 108, 400-422. ([articles](#))

[2] Roy, D.; Cambre, J. N.; Sumerlin, B. S. *Progress in Polymer Science* **2010**, 35, 278-301. ([articles](#))

[3] Lutz, J.-F. J. *Polym. Sci: Part A: Polym. Chem.* **2008**, 46, 3459-3470. ([articles](#))

## P78 - Hybrid Mesoporous Silica Smart Nanocontainers

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A large decrease in the side effects of a drug can be obtained if it is efficiently delivered in a timely manner and in the needed location only.[1] By combining therapeutic and diagnostic (theranostic) functionalities with targeting capabilities and large surface areas, nanoparticles provide an ideal vehicle for personalized medicine. Mesoporous silica nanoparticles (MSNs) are characterized by an ordered pore system of 2-8nm diameter, pore volumes above 1mL/g and particle size from 40nm to several hundred nanometers. The preparation of fluorescent hybrid MSNs requires the presence of a fluorescent molecule during the synthesis, which becomes aligned with the pores, thus impervious to aggregation and self-quenching effects. The MSNs external surface can be selectively functionalized to immobilize polymers or (bio)molecules for possible targeting or sensing, and the pore is available for solvent diffusion, allowing the incorporation of different molecules.[2] The main objective of our work is to develop hybrid MSNs with combined diagnostic and therapeutic functionalities, carrying fluorescent beacons for traceability and imaging, featuring a smart release control mechanism, and able to accommodate large drug loads and deliver their cargo on demand to a desired location. This communication is focused on the preparation of fluorescent MSNs incorporating a fluorescence perylediimide derivative (PDI) in the wall structure (MSN-PDI) and polymerized them with a temperature-responsive polymer shell (MSN-PDI-POLY). These new hybrid nanoparticles open up interesting possibilities for the development of a traceable drug delivery system.[3]

**Acknowledgements:** This work was partially supported by Fundação para a Ciência e a Tecnologia (FCT-Portugal) and COMPETE (FEDER), projects PTDC/CTM- NAN/2354/2012, RECI/CTM-POL/0342/2012, and PEst-OE/CTM/LA0024/2013. T.R. and A.S. also thank FCT for Pos-Doc (SFRH/BPD/96707/2013) and PhD grants (SFRH/BD/89615/2012).

[1] Kelkar, S.S.; Reineke, T.M. *Bioconjugate Chem.* **2011**, 22, 1879-1903.

[2] Soler-Illia, G.J.A.A.; Azzaroni, O. *Chem. Soc. Rev.* **2011**, 40, 1107-1150.

[3] Rodrigues, A.S; Ribeiro, T.; Fernandes, F.; Farinha, J.P.S.; Baleizão, C. *Microsc. Microanal.* **2013**, 19, 1216-1221.

## P79 - Polymer diffusion on the surface of carbon nanotubes as probed by NMR

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Carbon nanotubes (CNTs) are unique materials with a plethora of potential applications, such as reinforcement in composite materials, drug delivery, energy storage and molecular electronics. However, due to their high aspect ratio and polarizability, pristine CNTs are prone to form bundles, a fact that hinders most of the applications since individual nanotubes are required. One way to overcome this drawback is through noncovalent dispersion of CNTs. In this case amphiphilic molecules are employed to disperse CNTs in aqueous solution, with the hydrophobic parts adsorbing onto the nanotube surface while the hydrophilic parts interacting with the solvent.<sup>1,2</sup>

In this work, we investigate by <sup>1</sup>H NMR diffusometry the dynamics of the molecular interaction, in aqueous dispersion, between Pluronic F127 (PEO)<sub>100</sub>-(PPO)<sub>70</sub>-(PEO)<sub>100</sub> and CNTs. The diffusional decays obtained are not single exponential indicating that the polymer is in two states: free in solution and bound to nanotube (Figure 1. a). One is able to estimate the residence time of the polymer on CNT surface to be within the range 100-400 ms. Furthermore, and significantly, the molecular displacement of the polymer along the CNT surface is measurable, yielding a self-diffusion coefficient one order of magnitude lower than in the bulk solution (Figure 1. b). Plausibly, the hydrophobic PPO block is adsorbed onto CNT surface, while the PEO expands to the solvent, promoting the dispersion of the CNT in water.<sup>3</sup>

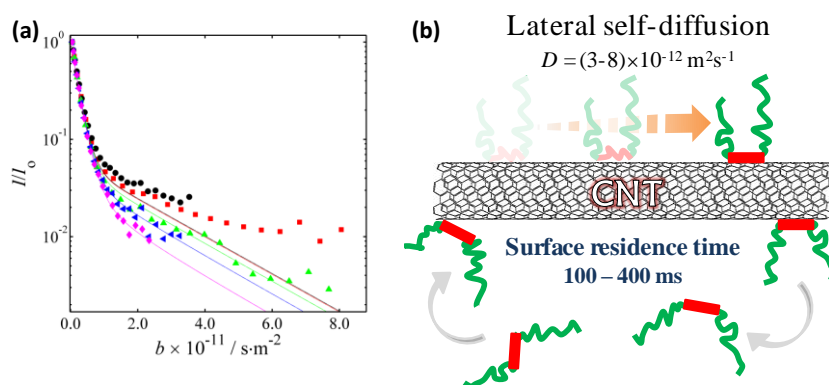


Figure 1. (a) Diffusional <sup>1</sup>H signal decay, at different diffusion times ( $\Delta$ ), of the methylene protons of F127 in aqueous SWNT dispersion. (b) Schematics of the dynamics equilibrium between the free and adsorbed Pluronic F127 at CNT surface.

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[1] Kharissova, O. V.; Kharisov, B. I.; de Casas Ortiz, E. G. *RSC Adv.* **2013**, *3*, 24812-24852.

[2] Frise, A. E.; Pages, G.; Shtein, M.; Pri Bar, I.; Regev, O.; Furó, I. *J. Phys. Chem. B* **2012**, *116*, 2635-2642.

[3] Fernandes, R. M. F.; Buzaglo, M.; Shtein, M.; Pri Bar, I.; Regev, O.; Marques, E. F.; Furó, I. *J. Phys. Chem. C* **2014**, *118*, 582-589.

## **P80 - Corrosion of Magnesium Alloys in Physiological Media**

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Biocompatible metallic materials play an essential role as medical implants and, among them, the use of magnesium alloys as a new class of biomaterials for orthopaedic implants has been emphasized in recent years. These alloys combine multiple interesting and useful attributes, such as biocompatibility and superior mechanical properties, with high tensile and compressive strength and a Young's modulus similar to cortical bone. However, some key issues still lack a precise study and improvement. Problems such as in vivo resorption being too rapid, too localized and unpredictable; and the fact that Mg corrosion produces hydrogen gas which may accumulate adjacent to the implant in the body still need to be overcome.

In this work characterization of three different magnesium alloys (WE54, AZ31 and RZ5) regarding their electrochemical behaviour in contact with simulated body fluids was carried out. Particular attention was focused on the effect of specific ions present on physiological media. Good agreement was observed between the results obtained from electrochemical techniques and those from SEM and XPS examinations.  $\text{Mg}(\text{OH})_2$  and calcium-phosphate compounds are the main corrosion products, which, despite the little protectiveness against degradation, confer excellent biocompatibility properties to the material.

# P81 - Poly[Ni(salen)]/TiO<sub>2</sub> nanocomposite films with enhanced photo-induced properties

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Nanohybridization of a conducting organic polymer and a metal oxide semiconductor has recently been recognized as one of the most attractive combinations for organic/inorganic composite structures [1]. These materials, termed as polymeric nanocomposites, have the advantage of combining the properties of the constituents into a single material, and find several applications, such as in electrochromic devices [2]. Conducting polymers have attracted considerable interest in the field of electrochromic materials and devices, due to their small response times, high optical contrasts and the ability to modify their structure to create multicolor electrochromes [3]. However, in some cases, they have poor electrochemical stability, thus limiting their usage in a variety of applications and their successful commercialization. The preparation of hybrid materials between the conducting polymers and inorganic nanoparticles can be an alternative to overcome these drawbacks. In this work, polymeric nanocomposites based on a metallo-organic polymer - poly[Ni(salen)]-type film - and TiO<sub>2</sub> semiconductor nanoparticles were prepared and their electrochromic behaviour under UV light irradiation was evaluated. The poly[Ni(salen)]-type films were obtained by the oxidative electropolymerisation of the respectively Ni(II) *salen* complexes [4]. The TiO<sub>2</sub> nanoparticles were prepared by a sol-gel method described in literature [5], and were characterized by powder X-Ray Diffraction (PXRD), X-Ray Photoelectron Spectroscopy (XPS) and Transmission Electron Microscopy (TEM). The polymeric nanocomposites were prepared by co-deposition of the electroactive polymer and TiO<sub>2</sub> nanoparticles by cyclic voltammetry, using flexible polyethylene terephthalate coated with indium-tin oxide (ITO/PET) as working electrode. The as-prepared films were characterized by cyclic voltammetry, UV-Vis Spectroscopy *in situ* and chronoamperometry under UV light irradiation ( $\lambda = 365$  nm), in order to evaluate the influence of UV radiation on redox behavior and electrochromic properties of the polymeric films; film morphology was characterized by Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy (SEM/EDS). The new polymeric nanocomposites showed a polyelectrochromic behaviour and enhanced electrochemical stability under UV light.

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- [1] Takagi, S.; Makuta, S.; Veamatahau, A.; Otsuka, Y.; Tashibana, Y., *J. Mater. Chem.* **2012**, 22, 22181-22189.
- [2] Zhu, J.; Wei, S.; Zhang, L.; Mao, Y.; Ryu, J.; Mavinakuli, P.; Karki, A. B.; Young, D. P.; Guo, Z., *J. Phys. Chem. C* **2010**, 114, 16335-16342.
- [3] Saxena, A. P.; Deepa, M.; Joshi, A. G.; Bhandari, S.; Srivastava, A. K., *Appl. Mater. Interfaces* **2011**, 3, 1115-1126.
- [4] Branco, A.; Pinheiro, C.; Fonseca, J.; Tedim, J.; Carneiro, A.; Parola, A. J.; Freire, C.; Pina, F., *Electrochem. Solid-State Lett.* **2010**, 13, J114-J118.
- [5] Mashid, S.; Askari, M.; Ghamsari, M. S., *J. Mater. Process. Technol.* **2007**, 189, 296-300.

## P82 - Novel Photochromic Hybrid Nanosilicas: Fabrication and Characterization

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Hybrid nanomaterials have been facing a fast development and constitute an interesting research topic on account of their versatile properties and wide range of applications. These properties can be achieved through the combination of the components at a molecular level.[1] Organic-inorganic smart materials are an important class of multifunctional, nanostructured and innovative scaffolds that has been attracting considerable attention due to the ability to combine, in a single material, the advantages of organic (lightweight, flexibility, tunable functionality) and inorganic (high thermal and mechanical resistance) compounds.[2,3] These dynamic materials have an important advantage over their static counterparts: they present specific functionalities that can be reversibly “switched on” and “off” in response to an external stimulus.[2] In particular, photochromic organic-inorganic materials are among the most studied smart systems owing to their versatile light-switchable features and potentialities for a variety of areas including optical memories, optical switches and photochromic inks.[3] Among the most important classes of reversible photochromic compounds are naphthopyrans, spiropyrans and spiroxazines. The UV-light activation of these compounds promotes a chemical reaction that leads to the formation of one or more species with different absorption spectra, which, in the absence of light, return to the initial form with variable speed.[4] The incorporation of these organic moieties onto silica nanomaterials constitutes a potential strategy to improve their robustness while taking advantage of the nanosized properties of the silica. The aim of this work was to prepare novel hybrid silica nanoparticles with photoswitchable properties through their functionalization with photochromic organic compounds. Silica nanoparticles with ~100 nm particle size were functionalized with two different photochromic organic compounds, a spiropyran and a naphthopyran, by post-grafting. The model and functionalized nanomaterials were characterized by Fourier transform infrared spectroscopy (FTIR), thermogravimetry (TG) and colorimetry. The new hybrid nanomaterials showed reversible photochromic properties, changing their color when exposed to ultraviolet irradiation ( $\lambda=365$  nm), and fading back to their initial color after removal of the ultraviolet source.

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[1] José, N.M.; Prado, L.A.S.A, *Quim. Nova* **2005**, 28, 281–288.

[2] Klajn, R., *Chem. Soc. Rev.* **2014**, 43, 148–184.

[3] Pardo, R.; Zayat, M.; Levy, D., *Chem. Soc. Rev.* **2011**, 40, 672–687.

[4] Sousa, C.M.; Berthet, J.; Delbaere, S.; Coelho, P.J., *J. Org. Chem.* **2013**, 78, 6956–6961.

## **Analytical Chemistry**

## **P83 - Application of gas-diffusion microextraction for high-performance liquid chromatographic analysis of volatile compounds in bread**

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In this work a novel extraction approach for volatile and semi-volatile compounds in solid samples is presented. The gas-diffusion microextraction device used (GDME) consists in a Teflon module with a microporous hydrophobic membrane (PTFE) at its bottom that, due to its hydrophobicity avoids the passage of the aqueous solvent but allows the diffusion of volatile compounds. This extraction device was recently patented [1]. So far, GDME has only been used for the extraction of compounds from liquid samples, especially in beverages [2,3]. This work intends to enlarge the application field of GDME to solid samples. To highlight this possibility, the GDME approach was applied to the chromatographic analysis of  $\alpha$ -dicarbonyl compounds in different types of fermented foods, particularly bread, since these compounds are important fermentation markers and their determination is useful to assess the quality of such product. In a single step, a derivatizing reaction, an extraction and an enrichment of the analyte is achieved allowing a very simple instrumental detection. The influence of several parameters of the methodology was studied, such as temperature and time of extraction, acceptor derivatizing solution's volume and concentration, among others. We were able to determine the content of vicinal diketones (especially diacetyl) on several types of bread. LOD and LOQ for the proposed methodology ranged from 6.0 to 11.5  $\mu\text{g Kg}^{-1}$  and 19.9 to 38.5  $\mu\text{g Kg}^{-1}$  for diacetyl, pentane-2,3-dione and hexane-2,3-dione, respectively. Using vicinal diketones data from different bread origins we are trying to identify correlations between vicinal diketones profile and bread type.

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- [1] Rodrigues, J. A.; Gonçalves, L. M.; Pacheco, J. G.; Barros, A. A., PT Patent 104789, **2011**.
- [2] Ramos, R.M.; Pacheco, J.G.; Goncalves L.M.; Valente I.M.; Rodrigues J.A.; Barros A.A., *Food Control* **2012**, 24, 220-224.
- [3] Valente, I. M.; Santos, C. M.; Gonçalves, L. M.; Rodrigues, J. A.; Barros, A. A., *Analytical Methods* **2012**, 4, 2569-2573.

## **P84 - Simultaneous determination of different aldehydes in *Quercus suber* L. cork by gas-diffusion microextraction and high-performance liquid chromatography**

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A headspace gas-diffusion microextraction method was developed for the simultaneous analysis of several aldehydes found in cork-stoppers made from cork oak (*Quercus suber*). The gas-diffusion microextraction device (GDME) was recently patented [1] and, so far, has been used for the extraction of volatile compounds from liquid samples, mainly beverages [2]. In this work we intend to apply this extraction device to solid samples. The GDME consists in a Teflon module of small dimensions that contain at its bottom a microporous hydrophobic membrane that allows the diffusion of volatile compounds from the sample to an acceptor solution, which should be a derivatizing reagent. Cork extracted from *Quercus suber* L. is the premier raw material used for production of stoppers commonly used in wine bottles and can play a crucial role in wine sensory profile since stoppers are in direct contact with wine. Since cork is a naturally extracted product, it is prone to contaminations from microorganisms or from chemicals during stopper's processing [3]. In this work it is intended to study the aldehyde profile variation throughout the industrial processing of cork-stoppers as well as the final product used for bottling. Aldehydes were extracted from sample using the GDME device, derivatized with 2,4-dinitrophenylhydrazine (DNPH) and analyzed by high-performance liquid chromatography with UV detection (HPLC-UV). Several extraction parameters were studied and optimized such as the temperature and time of extraction, acceptor derivatizing solution's volume as well as linearity, reproducibility and repeatability for each aldehyde. Using this methodology we were able to identify and quantify several aldehydes in the raw material, in different cork stoppers and we are trying to evaluate the significance of its appearance with the industrial treatment applied to the cork in its transformation in cork stoppers.

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- [1] Rodrigues, J. A.; Gonçalves, L. M.; Pacheco, J. G.; Barros, A. A., PT Patent 104789, **2011**.
- [2] Ramos, R.M.; Pacheco, J.G.; Goncalves L.M.; Valente I.M.; Rodrigues J.A.; Barros A.A., *Food Control* **2012**, 24, 220-224.
- [3] Pereira, C. S.; Marques, J. J.; San Romão, M.V., *Critical Reviews in Microbiology* **2000**, 3, 147-162.

## P85 - Photodegradation of 17 $\beta$ -estradiol and 17 $\alpha$ -ethinylestradiol: Kinetic studies and effect of humic substances

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Estrogens 17 $\beta$ -estradiol (E2) and 17 $\alpha$ -ethinylestradiol (EE2) are steroid hormones excreted by humans and animals and therefore enter the environment mainly through discharge of domestic sewage effluents and disposal of animal waste. Numerous studies, performed in different countries, show evidence of their presence in influents and effluents of sewage treatment plants and in receiving waters. These compounds are considered endocrine disruptors since they may interfere with the normal function of the endocrine system and may represent serious risks, particularly to the aquatic population, even at concentrations as low as ng L<sup>-1</sup>. Therefore, their presence in the aquatic environment has emerged as a major concern for the international scientific community. Even though, to correctly evaluate the real ecological impact of these pollutants, it is important to take into consideration their fate and persistence in aquatic environment. Photodegradation is known to be one of the most important factors affecting the environmental persistence of pollutants, especially in waters exposed to sunlight. Pollutants can undergo direct photolysis (by absorbing photons able to induce a chemical transformation) or indirect photolysis (when phototransformation is induced indirectly by chromophores present in natural waters) [1]. Humic substances are ubiquitously found in the aquatic environment and are able to induce photochemical reactions. In this work, the direct and indirect photodegradations of E2 and EE2 under simulated solar radiation were studied. Indirect photodegradation was evaluated using different fractions of humic substances (humic acids, fulvic acids and XAD-4). Both hormones are resistant to direct photodegradation. However, all the tested fractions of humic substances were responsible for a noticeable increase in the photodegradation rates. For instance, for 60 min of irradiation, humic substances induced a photodegradation of EE2 between 22 and 43%, while direct photodegradation was about 7.5% only. Furthermore, different concentrations of humic substances were tested and the same behavior was observed: the presence of humic substances accelerate the photodegradation of both hormones. Also, real water samples were subjected to the same simulated solar irradiation to better assess the fate and persistence of these hormones in the environment.

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[1] Calisto, V.; Domingues, M.R.M.; Esteves, V.I., *Water Res* **2011**, 45, 6097-6106.

## P86 - Removal of the antidepressant fluoxetine from water by activated carbons produced from paper mill sludge

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Nowadays, the extent of wastewater contamination by antidepressants like fluoxetine is well-known, being necessary to develop remediation processes to remove these compounds from contaminated waters [1, 2]. The use of activated carbon as adsorbent is well established as an effective technique used to remove pollutants from waters. The production of activated carbon from industrial biowastes has been exploited in various applications as an alternative to the expensive commercial activated carbons with the additional advantage of the valorisation of such residues [3]. In this work three activated carbons were produced using as precursor primary paper mill sludge. Chemical activation was performed using three different activation agents, KOH, NaOH and ZnCl<sub>2</sub>. The precursor was impregnated with the activation agent at 1:1 ratio (w/w) and pyrolysed in controlled atmosphere under predefined conditions. The characterization of the obtained materials was made by means of total organic carbon analysis (TOC), Fourier infrared spectroscopy with attenuated total reflectance (FTIR-ATR), proximate and ultimate analysis, scanning electron microscopy (SEM), Hg porosimetry and BET isotherms. The adsorptive capacity was tested for the compound fluoxetine-HCl using batch equilibrium experiments. The results were compared to the results for primary sludge pyrolysed under the same conditions (without activation) and also to a commercial activated carbon as reference. Among the produced materials, the carbon activated with ZnCl<sub>2</sub> has the higher BET surface area and percentage of carbon. The adsorption capacities of the reference and the produced activated carbons have the same order of magnitude, however, in general, the latter present lower removal efficiencies for low fluoxetine concentrations and their efficiency increases for higher antidepressant concentrations.

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[1] Calisto, V. and Esteves, V.I., *Chemosphere* **2009**, 77, 1257.

[2] Nabais, J.; Mouquinho, A.; Galacho, C.; Carrott, P.J.M.; Carrott, M.M.L., *Fuel Processing Technology* **2008**, 89, 549.

[3] Crini, G., *Bioresource Technology* **2006**, 97, 1061.

## P87 - Removal of Fish Anesthetic (MS-222) from Water by Adsorption using Pyrolysed Industrial Residues

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During their life cycle, farmed fish are always subjected to handling and confinement operations, such as netting, weighing, shorting, vaccination, transport and slaughter. In some cases, mainly for research purposes, the fish are even subjected to invasive procedures such as small incisions. All of these situations compromise the farmed fish welfare causing stress and anxiety and, consequently, they compromise the normal work of the exploitation activity. Thus, it may be necessary to immobilize or anesthetize the fish using approved veterinary anesthetics. Tricaine (MS-222) is the most used fish anesthetic in the world. However, once this kind of pharmaceuticals are administrated by inhalation, i.e., solubilized on the tank's water, the resulting water is contaminated. Moreover, the treatment methods applied in recirculation aquaculture systems (RASs) and wastewater treatment plants (WWTPs) were not designed to remove organic pollutants, such as pharmaceutically active compounds. Thus, additional treatments should be applied to remove such kind of pollutants. In this work, the adsorptive removal of MS-222 from water using biochar has been investigated as an alternative low cost solution. Different biochars were produced using as a starting material industrial and agricultural biowastes, namely primary paper mill sludge, eucalyptus bark, grape seeds, peach stones, walnut shells, olive waste and peanut shells. Each of them was pyrolysed in a muffle under inert atmosphere, at a temperature defined by thermogravimetry analysis interpretation. The resulting biochars were characterized by elemental and proximate analysis, total organic carbon, Hg porosimetry, specific surface area (BET), FTIR, NMR, and SEM (Figure 1). Then, MS-222 adsorption kinetic and equilibrium experiments were performed using the different biochars produced and the results were compared to those obtained with one commercial activated carbon. Even when biochars display lower MS- 222 adsorption capacities than activated carbon, lower costs involved in their production combined with the valorisation of useless industrial and agricultural wastes justify the effort of further investigation in this area.

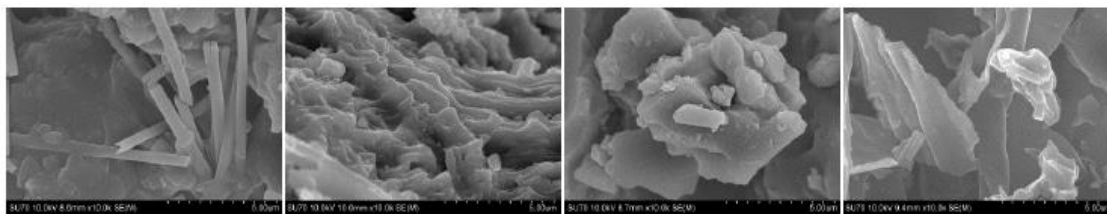


Figure 1 – SEM micrographs of pyrolysed grape seeds; peach stones; olive waste, and peanut shells (from left to right) at 10 000×.

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## **Food Chemistry**

## P88 - Wild and commercial samples of *Achillea millefolium* L.: proximate composition and individual compounds obtained by chromatography

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Medicinal plants have been used since ancient times and emerge nowadays as alternative to synthetic products, due to their richness in bioactive compounds. In a society that requires new and safer products, due to the growing concern with health and nutrition, medicinal plants are now being used not only in traditional medicine but also in a number of food and pharmaceutical products [1]. *Achillea millefolium* L., belongs to Asteraceae family and it is commonly known as yarrow, very common in mountain meadows, pathways, crop fields and homegardens. Widespread across Europe, its infusion, decoction and alcoholic extract are widely used as an herbal remedy to treat digestive problems, diabetes, hepatobiliary diseases and amenorrhea, showing also antitumor, antimicrobial, anti-inflammatory and antioxidant properties [2,3]. In the present work, commercial and wild samples of *A. millefolium* were characterized regarding the proximate composition and individual compounds namely, free sugars, organic acids, fatty acids and tocopherols, determined by chromatographic techniques coupled to different detectors (HPLC-RI, HPLC-DAD, GC-FID e HPLC-fluorescence, respectively). Carbohydrates, followed by proteins, were the major macronutrients in both samples. Commercial yarrow gave higher content of fat (and saturated fatty acids, mainly palmitic acid C16:0), proteins, ash, energetic value and total sugars (including fructose, glucose, sucrose and trehalose). Wild sample revealed higher levels of carbohydrates; it also showed raffinose (not detected in the commercial sample), polysaturated fatty acids (mainly linoleic acid, C18:2n-6) and organic acids (including malic, oxalic and quinic acids). Regarding tocopherols, both samples showed similar profile, although the wild sample gave higher levels of total tocopherols;  $\gamma$ -Tocopherol was the most abundant isoform;  $\delta$ -Tocopherol was not found in the samples. Data obtained are clear evidence that traditional medicinal plants can be used not only in household products but also in pharmaceutical and food industry as a source of new and safer bioactive compounds.

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- [1] Phillipson, J.D. Review. *Phytochemistry* **2007**, 68, 2960-2972.
- [2] Carvalho, A.M. Plantas y sabiduría popular del Parque Natural de Montesinho. Un estudio etnobotánico en Portugal. Biblioteca de Ciencias CSIC, vol. 35.; Madrid, 2010.
- [3] Candan, F., Unlu, M., Tepe, B., Daferera, D., Polissiou, M., Sökmenc, A., Akpulat, H. A. *Journal of Ethnopharmacology* **2010**, 87, 215-220.

## P89 - Salting-out assisted liquid-liquid extraction as a tool for the recovery of value added compounds from fennel (*Foeniculum vulgare*)

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The salting-out effect has been widely used in analytical chemistry with many different purposes, e.g. to increase the volatility of the analytes in headspace extractions, to precipitate proteins in biological samples or to improve the recoveries in liquid-liquid extractions. An interesting application of this effect is the separation of water-miscible organic solvents (such as propanol, acetone, and acetonitrile) from water. The addition of electrolyte(s) to the solution allows the weakening and/or the disruption of the solvation forces between the water-miscible organic solvent and water. As a result, two distinguishable liquid phases are formed in which the upper phase is mainly composed by the organic solvent. Simultaneously, it occurs the extraction of solutes to the organic layer, consisting in a salting-out assisted liquid-liquid extraction (SALLE). The interest in this type of extraction procedure has been increasing and it is nowadays the basis of a widespread sample preparation technique, the QuEChERS methodology [1,2]. The application of SALLE in plants is well documented but mainly aims the analysis of contaminant compounds (e.g. pesticides, toxins). However, the potentialities of SALLE are vast and should be further explored. In this work, the use of SALLE for the chemical profiling of fennel (*Foeniculum vulgare*) extracts is presented. Fennel seeds and plant were firstly extracted by decoction with different solvent compositions. Then, the decoction extracts were subjected to SALLE using ammonium sulphate. Finally, the organic layer was directly analyzed by HPLC-UV-MS/MS. For GC-MS analysis, a dispersive solid-phase extraction clean-up of the extracts was needed to remove residual water and other interferences. HPLC-UV-MS/MS results showed that the more polar compounds extracted by water were not detected in SALLE extracts, and phenolic compounds such as quercetin and caffeic acid derivatives were identified. GC-MS analysis indicated that estragole was the major volatile detected in fennel seeds extracts, followed by fenchone and anisaldehyde. In addition, fennel seeds also contained minor amounts of various constituents such as anetole, benzaldehyde, camphor, and apiol. Different extraction conditions are currently under investigation in order to enhance the recovery of value added compounds from fennel.

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- [1] Anastassiades, M.; Lehotay, S.J.; Štajnbaher, D.; Schenck, F.J., *Journal of AOAC International* **2003**, 86, 412-431.
- [2] Valente, I.M.; Santos, C.M.; Moreira, M.M.; Rodrigues, J.A., *Journal of Chromatography A* **2013**, 1271, 27–32.

## **P90 - High pressure processing applied on strawberry pulp: effect on microbiological and physicochemical parameters during refrigerated storage**

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Strawberries are known for their particular flavour and are used in a variety of products, as pulp to be used in several products. To extend the shelf-life of this product, thermal processing is applied, which permits the inactivation of microorganisms and enzymes, therefore avoiding the product spoilage. However, important losses in terms of flavour, colour, sensory and nutritional qualities occur when this product is heat treated. Non-thermal processing methods, such as high pressure processing (HPP), could potentially be used for pasteurisation, being one of the main advantages the improvement of nutritional and sensorial quality [1]. The main objective of this study was to extend the shelf-life of strawberry pulp by HPP treatment (550 MPa for 2.5 and 10 min) and comparing the quality with the thermal processed (TP) product. Thus, the microbiological quality (total aerobic mesophiles - TAM, total coliforms - TC, and yeast and moulds - YM) and physicochemical parameters (pH, titratable acidity - TA, colour, total soluble solids - TSS, total phenolic content - TPC, and antioxidant capacity - AC) were evaluated during 60 days of storage at 4 °C. A control sample without any treatment (HPP or TP) was also analysed. Before processing, the strawberry pulp showed a good microbiological quality, since it presented counts below the detection limit (<1 Log CFU/g) for all the microorganisms analysed. After HPP and TP treatments and during the 60 days of storage, TAM was not significantly affected, with an average of 1.25 Log CFU/g. TC counts were always below the detection limit. HPP permitted to maintain the YM counts below the detection limit, but the same was not observed in TP treatment, since an increase of YM counts to an average value of 1.94 Log CFU/g occurred after 40 days of storage. The physicochemical parameters, pH and TA values were not significantly affected by HPP and TP treatments, with pH values ranging between 3.71-4.06 and TA between 5.98-6.87 mg tartaric acid/g. In HPP-samples, TSS tended to increase with storage time from ≈13 to ≈15 °Brix, while in TP-samples a more pronounced increase from ≈13 to ≈18 °Brix was observed. HPP caused an increase of colour lightness and redness compared to TP samples, while these samples showed a higher yellowness compared to HPP samples. TPC value decreased from the control sample (≈1.03 mg gallic acid/g) to the HPP and TP-samples (≈0.75 and ≈0.69 mg gallic acid/g, respectively); a slight increase to values similar in both treated-samples (≈1.10 mg gallic acid/g) and similar to the one obtained in control sample occurred during storage. After HPP, the AC values decreased from ~30% (in control sample) to ~22%, maintaining similar values during all storage. On the other hand, significant differences between control and TP-samples were not observed.

HPP showed advantages for the strawberry pulp preservation, with an acceptable shelf-life of up to 60 days, which permits its longer preservation than thermal treatments.

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[1] Yordanov, D.G.; Angelova, G.V., *Biotechnology & Biotechnological Equipment*. **2010**, 24 (3), 1940-1945.

## P91 - Shelf-life extension of *Caldo Verde* soup at 4 °C by high pressure processing

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High pressure processing (HPP) is being applied with increasing success in food industries as a non-thermal processing technique, extending food products shelf-life, while better maintaining organoleptic and nutritional properties in comparison with thermal processing [1, 2]. A large number of HPP products, namely seafood, sausages, fruit juices, ready-to-eat meals and sliced ham, are currently available in the market.

The aim of this work was to evaluate the HPP effect (400 MPa/10 min and 625 MPa/10 min) on *Caldo Verde* soup shelf-life period, since this product is one of the most traditional Portuguese dishes and very appreciated by consumers. The quality of *Caldo Verde* soup was evaluated during 28 days of storage at 4 °C, by microbiological and physicochemical analyses.

At day 0, all samples presented undetectable levels ( $\leq 1.00$  log UFC/g) of all microorganisms analysed. However, in the 7<sup>th</sup> day of storage, control sample revealed  $2.54 \pm 0.22$  log UFC/g for aerobic colony counts (TAM), which is similar to samples treated at 400 MPa ( $2.15 \pm 0.17$  log UFC/g) and higher than samples treated at 625 MPa ( $\leq 1.00$  log UFC/g). The concentrations of *Enterobacteriaceae* (ENT), total coliforms (TC) and yeasts and moulds (YM) were below the detection limit ( $\leq 1.00$  log UFC/g) in the 7<sup>th</sup> day. At day 14, TAM counts were  $\geq 6.00$  log UFC/g for control sample, whereas at 400 and 625 MPa presented  $4.35 \pm 0.04$  and  $\leq 1.00$  log UFC/g, respectively. At day 21, 400 and 625 MPa samples showed  $4.69 \pm 0.03$  and  $\leq 1.00$  log UFC/g for TAM, values still below the maximum limit for consumption. From 21<sup>st</sup> to 28<sup>th</sup> day, ENT and TC for control sample were  $\geq 3.00$  log UFC/g, while the pressurised samples always presented values  $\leq 1.00$  log UFC/g. YM presented  $\leq 1.00$  log UFC/g counts up to 28 days of storage, for all samples.

Total lipid content throughout storage showed an increasing trend in all samples, starting from day 0, with  $\approx 2.4$  to 6.4% in control sample and reaching  $\approx 9.3\%$  in pressure treated samples, at day 28, being the highest increase verified between the 21<sup>st</sup> and 28<sup>th</sup> day of storage. Lipid oxidation, as described by the peroxide index (PI), increased similarly during storage in all samples ( $\approx 13$  to  $\approx 44$  mEq peroxide/Kg lipid). TBARS, showed a trend to increase up to the 14<sup>th</sup> day (from  $\approx 0.26$  to  $\approx 0.35$  mg MDA/Kg sample), but the values decreased in all samples at day 28 (from  $\approx 0.35$  to  $\approx 0.12$  mg MDA/Kg sample). The optimum HPP condition was 625 MPa/10 min, to obtain an acceptable product with extended shelf-life, with at least 21 days of storage at 4 °C, compared to only 7 days of the non-processed *Caldo Verde*.

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[1] Yordanov, D.G., Angelova, G.V., *Biotechnol Biotech Eq*, **2010**, 24 (3), 1940-1945.

[2] Bermúdez-Aguirre, D., Barbosa-Cánovas, G.V., *Food Eng Rev*. **2010**, 3 (1), 44-61.

## **P92 - Food storage under pressure, hyperbaric storage, at and above room temperature, as an alternative to refrigeration using whey cheese, *Requeijão* as a case study**

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High pressure (HP) is a non-thermal processing technology that can inactivate microorganisms and enzymes extending food shelf life, while causing negligible impairment in foods sensory properties and nutritional quality [1].

Nowadays HP technology is being studied for a novel application, as a new preservation method, called hyperbaric storage, in which foods or other biomaterials are subjected to low pressures at room temperature, with no need for refrigeration [2, 3]. Some authors studied this method in several food products using different temperatures and storage time combinations. The results obtained showed an extension food products shelf under pressure at variable room temperature, comparatively to refrigeration [2]. This is a remarkable achievement that would potentially allow significant energy savings during storage, since energy is only required to reach the desired pressure.

The aim of this work was to evaluate the effect of hyperbaric storage on *Requeijão*, the Portuguese whey cheese that has a high nutritional value and is considered a highly perishable food due to high water activity and almost neutral pH. Microbial quality was analysed at room temperature (25 °C) and above it (30 °C and 37 °C), using different pressures (100 and 150 MPa) and storage periods (4 and 8 h). For total aerobic mesophiles (TAM), *Enterobacteriaceae* (ENT), lactic acid bacteria (LAB) and yeasts and moulds (YM), initial loads were 3.26, 2.99, 2.27 and 2.95 log CFU/g, respectively. For all microorganism, hyperbaric storage at 100 MPa and 25 °C was able to maintain initial loads, but when compared to refrigeration, about one logarithmic reduction was observed, during 4 and 8 h respectively, for TAM (2.93 and 3.46 log CFU/g), ENT (2.79 and 2.75 log CFU/g) and LAB (2.74 and 1.59 log CFU/g). At the same temperature and 150 MPa for 8h, ENT, LAB and YM were reduced to undetectable levels ( $\leq 1.00$  log CFU/g). Compared to refrigeration, ENT (2.84 log CFU/g) and YM (2.06 log CFU/g) showed one logarithmic reduction when stored at 30 °C, for 4h at 100 MPa, both reaching undetectable levels at 150 MPa for 8h. LAB were highly susceptible to hyperbaric storage conditions, being reduced to undetectable levels at 30 and 37 °C for all tested pressures and storage periods. TAM were the most resistant microorganism to hyperbaric storage conditions, however, even above room temperature, overall, microbial reduction superior to one logarithm occurred for all pressures, comparatively to refrigeration. At 37 °C and 100 MPa, ENT load remained low (2.29 log CFU/g) and YM reached undetectable levels. These results indicate the feasibility of this promising food preservation methodology in maintaining food microbiological safety at variable room temperatures, with the associated energy savings as a promising better alternative to refrigeration.

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[1] Norton, T.; Sun, D-W., *Food and Bioprocess Technology*, 2008. **1**: 2-34.

[2] Queirós, R. P.; Santos, M. D.; Fidalgo, L. G.; Mota, M. J.; Lopes, R. P.; Inácio, R. S.; Delgadillo, I.; Saraiva, J. A., *Food Chemistry*, 2014. **147**: 209-214.

[3] Fidalgo, L. G.; Queirós, R. P.; Santos, M. D.; Inácio, R. S.; Mota, M. J.; Lopes, R. P.; Gonçalves, M. S.; Neto, R. F.; Saraiva, J. A., *Food and Bioprocess Technology*, 2013: 1-10.

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