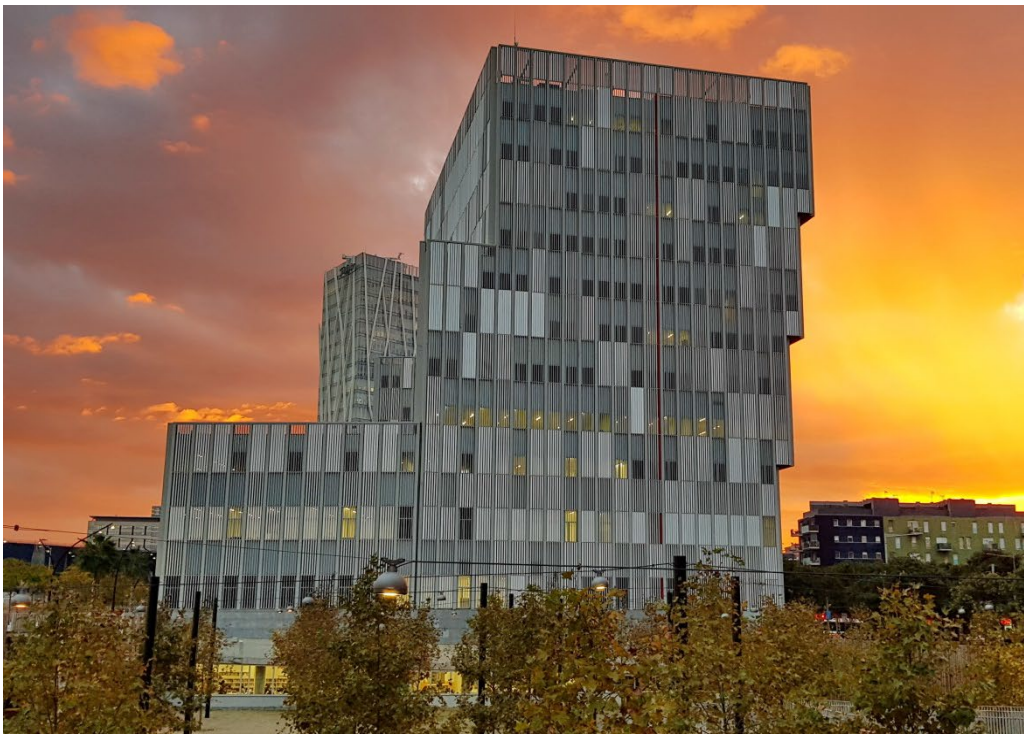


CAMPUS DIAGONAL -BESÒS

Research Newsletter

Summer 2021

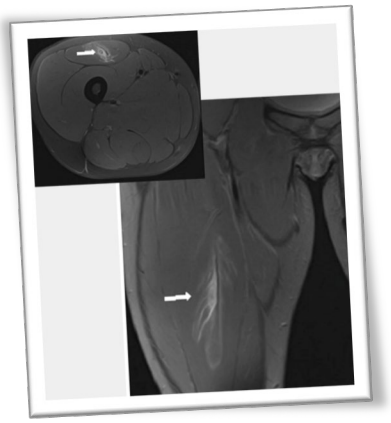
FOREWORD

Campus Diagonal-Besòs

Muscle Injuries in Professional Football Players – When CDB meets FC Barcelona

What is the connection between sports and engineering? In 1997, Prof. Steve Haake created the *International Sports Engineering Association* (ISEA), establishing **Sports Engineering** as a new, recognized academic discipline.

Sports engineering relies on the application of maths, physics, and engineering to solve sporting problems, such as designing equipment, building facilities, or analyzing athlete performance.



In this framework, a pioneering study has been recently conducted by researchers of the **Electronic and Biomedical Instrumentation group (IEB)**, based at the Campus Diagonal-Besòs (CDB), in collaboration with the **FC Barcelona Medical Department**[1].

The study analyzed the importance of performing localized bioimpedance measurements after a muscle injury in the assessment of the recovery period or "return to play" time.

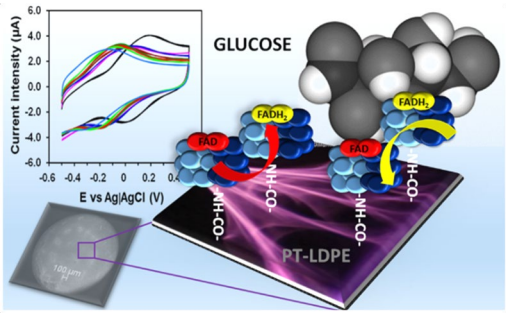
To this end, 37 muscle injuries in 32 professional football players[2] (seasons 2016-17 and 2017-18) were analyzed. The study revealed that these measurements could complement other imaging techniques (e.g., magnetic resonance imaging, or ultrasounds) and be useful in making day-to-day decisions after an injury.

Welcome to the Campus Diagonal-Besòs, where future's science and technology is being forged.

[1] https://www.frontiersin.org/articles/10.3389/fphys.2020.574124/full

[2] https://barcainnovationhub.com/es/bioimpedancia-localizada-l-bia-para-diferenciar-y-cuantificar-la-gravedad-de-lesiones-musculares/

IN THIS ISSUE

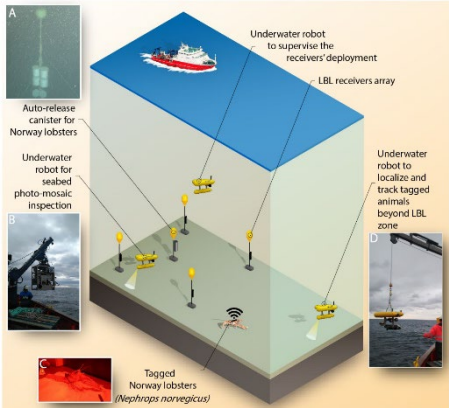


Research Highlights

AUTONOMOUS UNDERWATER VEHICLES FOR TRACKING DEEP-SEA FISH RESOURCES

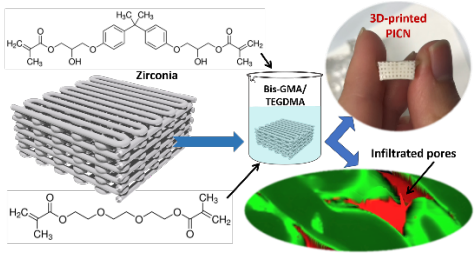
I. Masmitja, J. Navarro, **S. Gomariz**, J. Aguzzi, B. Kieft, T. O'Reilly, K. Katija, P. J. Bouvet, C. Fannjiang, M. Vigo, P. Puig, A. Alcocer, G. Vallicrosa, N. Palomeras, M. Carreras, **J. del Rio**, & J. B. Company, "Mobile robotic platforms for the acoustic tracking of deep-sea demersal fishery resources", ***Science Robotics*** 5, eabc1705 (2020) [*Q1, 4/6462 in Computer Science; IF=18.68*]

Knowing the displacement capacity and mobility patterns of industrially exploited marine resources is key to establishing effective conservation management strategies in human-impacted marine ecosystems. However, such information is usually scarce, and high-frequency and prolonged data collection is rarely available. In this study, researchers from the **Technological Development Center for Remote Acquisition and Data Processing System (SARTI)** report the implementation of autonomous underwater vehicles and remotely operated vehicles as an aid for acoustic long-baseline localization systems for autonomous tracking of Norway lobster, one of the key living resources exploited in European waters. In combination with seafloor moored acoustic receivers, they detected and tracked the movements of 33 tagged lobsters at 400-m depth for more than 3 months. They also identified the best procedures to localize both the acoustic receivers and the tagged lobsters, based on algorithms designed for off-the-shelf acoustic tags identification.



3-D PRINTING OF CERAMICS FOR DENTISTRY

L. Hodasova, J. Sans, B. G. Molina, C. Alemán, L. Llanes, G. Fargas, & E. Armelin, "Polymer infiltrated ceramic networks with biocompatible adhesive and 3D-printed highly porous scaffolds", ***Additive Manufacturing*** 39, 101850 (2021) [*Q1, 4/593 in Industrial and Manufacturing Engineering; IF=11*]



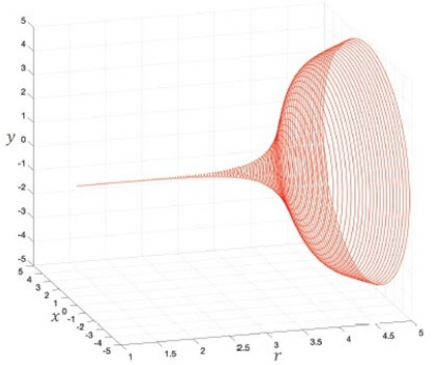
Ceramics are widely used in dentistry due to their excellent aesthetical and mechanical properties. In this research, we combine know-how and expertise of **CIEFMA (Center for Structural Integrity, Reliability and Micromechanics of Materials**) and **IMEM (Innovation in Materials and Molecular Engineering)** groups in 3D-printing of ceramics and polymer technology respectively, to create an organic/inorganic composite. Combination of zirconia and biocompatible methacrylates create a polymer infiltrated ceramic network (PICN), a material similar to natural teeth. Zirconia scaffolds were 3D-printed with 50% of solid infill and the designed pores were later filled with polymeric material.

In this paper, the authors propose, develop and successfully validate a manufacturing route for PICN, including printing of porous scaffold with robocasting technique, the infiltration of designed pores with outstanding adhesion of polymer to the inert zirconia surface, and PICN's anti-bacterial response, the latter through assays proving that the material does not support any bacterial growth on the surface.

USING HOPF OSCILLATORS TO CONTROL SINGLE-PHASE INVERTERS

M. Li, Y. Gui, Y. Guan, **J. Matas**, J. M. Guerrero, & J. C. Vasquez, "Inverter Parallelization for an Islanded Microgrid Using the Hopf Oscillator Controller Approach with Self-synchronization Capabilities", ***IEEE Transactions on Industrial Electronics*** (in press, 2021) [*Q1, 59/6462 in Computer Science; IF=7.52*]

Nonlinear dynamical systems, such as weakly coupled oscillators, can be adopted for the regulation and synchronization of power inverters inside microgrids when operating in islanded mode. This work, with participation of researchers of the **Energy Processing & Integrated Circuits group (EPIC)**, proposes the use of a Hopf oscillator to control single-phase inverters. The Hopf oscillator dynamic equations are used for providing the inverter's frequency and amplitude voltage references which lead to a robust nonlinear droop behavior for driving the system without using communications.



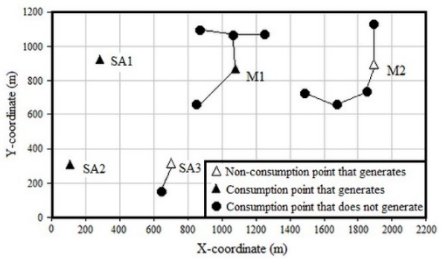
It provides better sharing of the load between inverters with higher robustness, less harmonic distortion, and faster time response of the associated limit cycle than

the achieved by a Van der Pol oscillator. Also, global asymptotic synchronization of system is proven by Lyapunov approach. Simulation results of a system composed by paralleled inverters are provided and compared with a Van der Pol oscillator approach. Experimental results are also provided under different circumstances.

NEW ADVANCES IN ISOLATED ELECTRIFICATION SYSTEMS

A. García-Villoria, **B. Domenech**, L. Ferrer-Martí, M. Juanpera, & **R. Pastor**, "Ad-hoc heuristic for design of wind-photovoltaic electrification systems, including management constraints", ***Energy*** 212, 118755 (2020) [*Q1, 11/905 in Energy Engineering and Power Technology; IF=7.15*]

Isolated electrification systems are suitable to provide electricity to rural communities in developing countries. In particular, the design of wind-photovoltaic systems combining individual supplies and microgrids is a challenging optimization problem. Most literature works focus on techno-economic aspects; and only one procedure, based on mixed integer linear programming, includes the management of the systems to enhance users' satisfaction and projects' sustainability. However, excessive computing time is required. A fast, new procedure has been proposed by researchers of the **Supply Chain and Operations Management Group (SCOM)**, and validated with 640 random instances. This procedure finds feasible and cheap solutions in less than 7 seconds, on average; and even for large instances, solutions are found in less than a minute. Thus, the procedure is efficient to optimize the design of electrification projects considering techno-economic and management aspects.



RISK ASSESSMENT IN ACCIDENTS INVOLVING FLAMMABLE GASES

A. Àgueda, J. Subirana, E. Pastor, A. Miralles, & E. Planas, "Revisiting the dispersion safety factor (DSF) for vapor clouds of liquefied flammable gases (LNG and propane)", ***Safety Science*** 128, 104748 (2020) [*Q1, 15/108o in Safety, Risk, Reliability and Quality; IF=4.88*]

The use of liquefied natural gas (LNG) -mainly methane- and liquefied petroleum gas (LPG) -basically propane- as energy sources has increased over the last years. In emergency situations involving leaks of LNG or refrigerated propane a flammable cold cloud is usually originated by the evaporation and dispersion of the fuel initially forming a pool. The cold cloud condenses the water vapor in the atmosphere making it visible. A useful indicator is the Dispersion Safety Factor (DSF), defined as the ratio between the flammable region of the vapor cloud (set at a concentration equal to the low flammability level) and the corresponding visible boundary of the cloud. DSF values higher than 1 indicate that the flammable region is located outside the visible boundary of the vapor cloud. From an operational point of view, this situation would not be desirable since it would mean that the hazard is not limited to the opaque condensed vapor cloud but it does extend longer invisibly. In this work, conducted by researchers of **CERTEC (Centre for Technological Risk Studies)**, a computational fluid dynamics model was used to simulate the dispersion of these two fuels and to determine the DSF factor considering different variables (i.e. pool leakage rate, ambient temperature, wind velocity and relative humidity). An interaction between relative humidity (RH) and wind velocity for DSF in the low-to-medium range of the RH and the wind velocity values considered was observed. This proved useful in ensuring the safety of firefighters during emergency operation in this type of accidents.

USE OF CYANOBACTERIA IN WASTEWATER TREATMENT

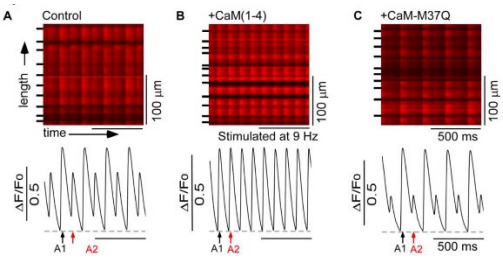
E. Rueda, M. J. García-Galán, A. Ortiz, E. Uggetti, J. Carretero, J. García, & R. Díez-Montero, "Bioremediation of agricultural runoff and biopolymers production from cyanobacteria cultured in demonstrative full-scale photobioreactors", ***Process Safety and Environmental Protection*** 139, 241 (2020) [*Q1, 16/108o in Safety, Risk, Reliability and Quality; IF=6.16*]

70% of the freshwater withdrawals are used in agriculture. Large quantities of chemicals (e.g., pesticides and fertilizers) are regularly applied in land and received by drainage channels and rivers, without any treatment. Microalgae-based systems are very efficient treating these waters. Moreover, these contaminants can be used by microalgae to produce added-value products, such as nutraceuticals, pigments, biopolymers, biofertilizers, energy... In this study, performed by researchers of the **Environmental Engineering and Microbiology Group (GEMMA)**, three full-scale photobioreactors were used with the objective to produce biopolymers and sugars and to treat agricultural runoff. Maximum concentrations of 4.5% and 69% were obtained for polyhydroxybutyrate (PHB) and carbohydrates, respectively. The present study demonstrates at full-scale the potential of cyanobacteria to produce PHB within a wastewater biorefinery concept.

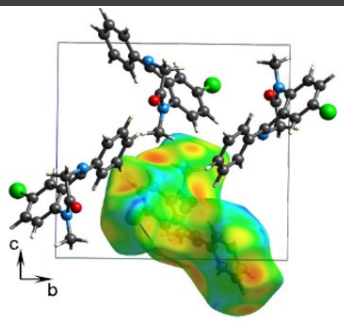
UNDERSTANDING THE EMERGENCE OF CARDIAC PATHOLOGIES

J. Wei, J. Yao, D. Belke, W. Guo, X. Zhong, B. Sun, R. Wang, J. P. Estillore, A. Vallmitjana, **R. Benitez**, L. Hove-Madsen, E. Alvarez-Lacalle, B. Echebarria, & S. R. W. Chen, "Ca^{2+}-CaM Dependent Inactivation of RyR2 Underlies Ca^{2+} Alternans in Intact Heart", ***Circulation Research*** 128, e63 (2020) [*Q1, 108/7126 in Medicine; IF=15.86*]

This study, with participation of researchers of **ANCORA (Analysis and Control of the Cardiac Rhythm),** is a multidisciplinary collaboration between biologists, biophysicists and engineers aimed at understanding the emergence of cardiac alternans (CA), a pathological response observed in cardiac cells. It is known that CA can yield to life-threatening conditions such as ventricular fibrillation or sudden cardiac death. However, the molecular and cellular mechanisms underlying CA are still unclear and have been the focus of a long controversy in cardiac physiology. The main hypothesis of the study is that CA result from the inactivation of the ryanodine receptor by a messenger protein called calmodulin. Fluorescence microscopy is used to characterize the alternating patterns in ventricular cells with mutations that either preserve or inhibit calmodulin function. Our results demonstrate that inactivation of calmodulin is a major determinant of CA, identifying an important therapeutic target.



RESEARCH GROUPS



GCM in a nutshell

The **GCM** group (Group of Characterization of Materials) of the Universitat Politècnica de Catalunya (UPC) is a Consolidated Research Group of the Generalitat de Catalunya (2017 SGR 0042), and it is part of the Barcelona Research Center in Multiscale Science and Engineering at UPC. GCM currently consists of 22 researchers: Prof. Josep Lluís Tamarit, Prof. Daniel Crespo, Prof. Trinitat Pradell, Dr. María del Barrio, Dr. Pere Bruna, Dr. Carlos Escorihuela, Jonathan Gebbia, Dr. Pol Lloveras, Dr. Roberto Macovez, Mehran Nabahat, Leila Panahi, Dr. Luis Carlos Pardo, Dr. Eloi Pineda, Dr. Jose Ignacio Rojas, Dr. Michela Romanini, Yajuan Duan, Alejandro Salvatori, Maahin Shaahim, Neda Shojaei, Sofia Valenti, Mingyue Yuan, and Ming Zeng.

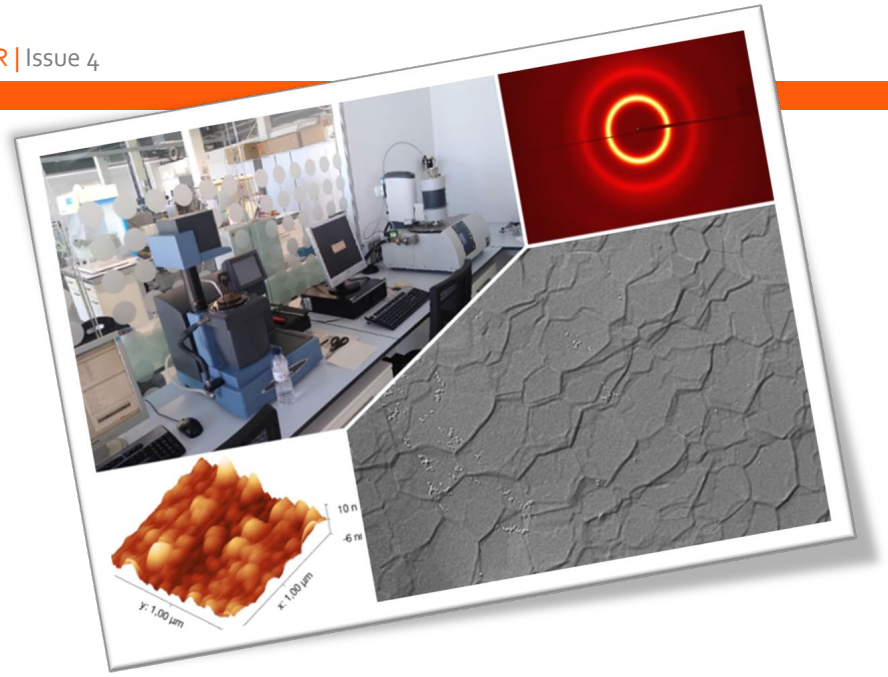
GCM's expertise ranges from the experimental characterization of matter to its description using simulation techniques. Their research focuses on the temperature- and field-dependent response of partially and fully disordered systems, including glass-forming molecular liquids and polymers, drugs in amorphous formulations, molecular mesophases, multiferroic systems, ancient materials and metallic glasses. Understanding materials is an important milestone to design the future, contribute to the present, and also to explore the past. With this aim, we apply our expertise to the development of solid materials for future refrigeration technology; the study of drug polymorphism and amorphous drug formulations for pharmaceutical companies; the characterization of commercial products for the food and polymer industries; and the study of ancient materials to understand the material fabrication technology of the past. The research developed by GCM is carried out using several experimental techniques ranging from dielectric spectroscopy to X-ray diffraction, dilatometry and calorimetry, to home-developed high-pressure devices. We have been also using large facilities such as synchrotron light or neutron sources to complement the experimental devices at our laboratories

GCM's RECENT RESEARCH HIGHLIGHT

M. Romanini, Y. Wang, K. Gurpinar, G. Ornelas, **P. Lloveras**, Y. Zhang, W. Zheng, **M. Barrio, A. Aznar,** A. Gràcia-Condal, B. Emre, O. Atakol, C. Popescu, H. Zhang, Y. Long, L. Balicas, **J. Ll. Tamarit**, A. Planes, M. Shatruk, and L. Manosa, *Giant and Reversible Barocaloric Effect in Trinuclear Spin-Crossover Complex $Fe_3(bntrz)_6(tcnset)_6$*, **Advanced Materials** 33, 2008076 (2021)

GCM's RESEARCH FAST FACTS

Source: https://futur.upc.edu/GCM



RESEARCH GROUPS @ CDB

Group of Characterization of Materials (GCM)

RESEARCH OUTPUTS

- 648 research papers in indexed journals
- 767 contributions to Conference Proceedings
- 42 research and text books
- 34 PhD theses
- 3 patents

FUNDING & AWARDS

- 120 R+D+I international & national competitive projects
- 13 awards and special grants

At present time, the main GCM research lines are the following:

- Barocaloric effect: how to use solid phases for refrigeration technologies avoiding pollutant gases
- Physical stability of drugs: investigating the phase behavior of drugs to understand their polymorphism and their kinetic stability in amorphous polymer formulations
- Molecular glasses: combining experiments and simulations to understand how glasses are formed and how they behave at a microscopic level
- Metallic glasses: improving the mechanical properties of metallic glasses through a better comprehension of their microscopic properties
- Ancient materials: studying ancient materials to gain information about how and where were they crafted

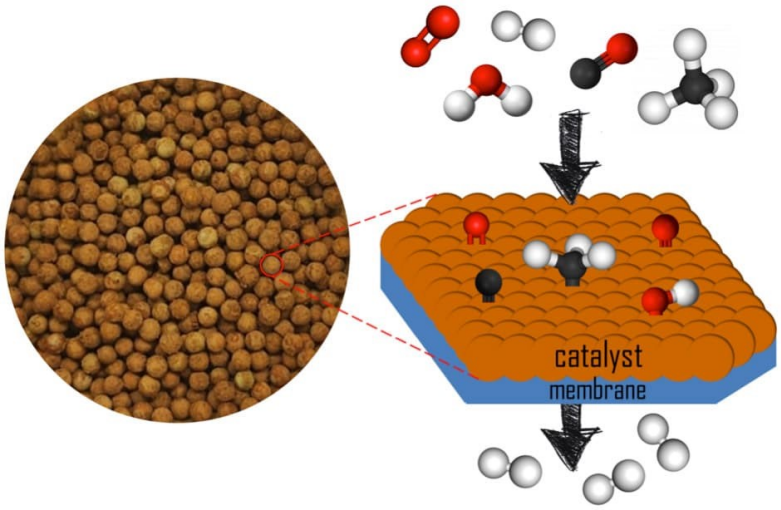
FOR MORE INFORMATION

Prof. Josep Lluís Tamarit,
josep.lluis.tamarit@upc.edu

WHAT/WHICH/HOW

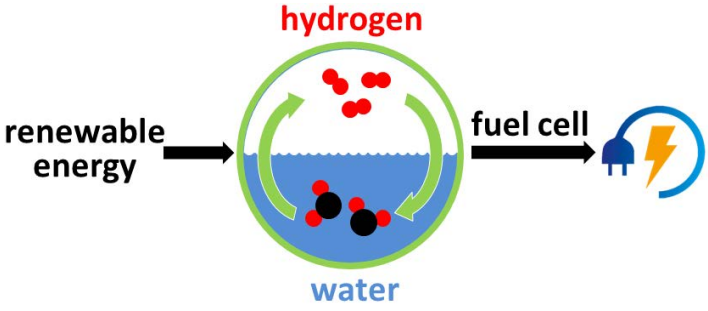
WHY Are Hydrogen Fuel Cells Important?

By Prof. Jordi Llorca (NEMEN, Dept. Chemical Engineering and Institute of Energy Technologies EEBE-CDB; UPC's Research Vice-Rector)



Hydrogen economy, fuel cells, energy transition, sustainability, decarbonisation... we hear these words every day and, yes, they are important. Why? Because hydrogen is a clean fuel (carbon-free) that can be used to store energy very efficiently. Unlike electricity, which is hard to store (we know our smartphone battery drains even if we don't use it, right?), hydrogen is a chemical compound and can be stored forever. Hydrogen can be burned to obtain heat (the use of hydrogen in internal combustion engines dates back to 1806!), but now we can do something much cleaner and more efficient: use fuel cells. In certain types of fuel cells, hydrogen combines with oxygen (air) to produce electricity and heat.

The efficiency of fuel cells can reach fabulous values of up to 90% (compare with the efficiency of combustion engines, typically 20 to 40%). Furthermore, the only by-product in a fuel cell is water; there are no harmful emissions. And the energy transition? Most renewable energies (wind farms, solar plants...) suffer from transient generation and excess energy can be conveniently stored as hydrogen through electrolysis of water and later hydrogen can be converted into electricity in a fuel cell. In addition to this, the size and weight of a fuel cell is not related to its capacity -as in a battery- and fuel cells can be manufactured in any size. But fuel cells and hydrogen production from renewables remain expensive.



At EEBE, the **NEMEN** research group (Nanoengineering of Materials Applied to Energy) is actively working on the design of new, robust and more efficient catalysts for the energy transition. This year, researchers from NEMEN have reported an outstanding catalyst based on nickel and ruthenium supported on cerium oxide for the production of hydrogen.

FURTHER READING ON HYDROGEN FUEL CELLS

I. Lucentini, G. García Colli, C. D. Luzi, **I. Serrano**, O. M. Martínez & **J. Llorca**, *Catalytic ammonia decomposition over Ni-Ru supported on CeO_2 for hydrogen production: Effect of metal loading and kinetic analysis*, **Applied Catalysis B: Environmental** 286, 119896 (2021)

THE EEBE @ THE UPC RESEARCH RANKINGS

The last research report (2019) endorsed by the Vice-Rectorate for Science Policy of the Universitat Politècnica de Catalunya (UPC),

https://drac.upc.edu/info%26gt%3B/ca/lavaluaciodel-curriculum-vitae/upc-punts-par/informe/informe-any-2019

has once more positioned the Barcelona East School of Engineering (**EEBE**) at the forefront of the 16 UPC Schools and Faculties in overall research outputs, with 9035 PAR. This represents an increase in research productivity of 3% with respect to 2018. In terms of normalized ratios, the EEBE ranks second (as in 2018), with a noticeable average of 63.6 research points per researcher (PAR/EDP).

With regard to the pool of EEBE-based Research Groups, the ranking is led once again by **NEMEN** (Nanoengineering of Materials Applied to Energy), with 269.2 PAR/EDP (and 120468 PATT/EDP, which measures the normalized funding per researcher, in terms of research grants, contracts, patents...).

Six additional research groups based at EEBE (i.e., **e-PLASCOM**, **PSEP**, **PROCOMAME**, **CERTEC**, **CIEFMA**, and **BIOSPIN**) have exceeded 100 PAR/EDP during 2019.

AWARDS, GRANTS, & EVENTS

PhD Theses Defended

David Agis (Advisor: Francesc Pozo, CoDAlab), "Desarrollo de un sistema de monitorización de la integridad estructural para aplicaciones en ingeniería mediante técnicas de reducción de la dimensionalidad" (Dec/2020)

Ines Hamouda (Advisors: Cristina Canal/Cédric P. Labay, BBT), "Synthesis and characterization of plasma-treated liquid and hydrogels for bone cancer therapy" (Dec/2020)

Yafeng Zheng (Advisors: Gemma Fargas/Luis M. Llanes, CIEFMA), "Assessment of corrosion-induced damage in the mechanical contact response of cemented carbides at different length scales" (Dec/2020)

Bahareh Rasaeifar (Advisor: Juan J. Perez, GBMI), "Structure-Function Studies of Bombesin and Bradykinin Receptors and their Ligands for new Therapeutic Opportunities" (Dec/2020)

Joaquim Terricabras (Advisors: Lexa Nescolarde/Javier Yanguas, IEB), "Canvis musculars detectats per bioimpedància localitzada i ressonància magnètica, després d'una lesió muscular i fins a la tornada al joc, en equips professionals de l'esport" (Dec/2020)

Javier Rodriguez (Advisor: Beatriz Giraldo, BIOSPIN-IBEC), "Characterization and interpretation of cardiovascular and cardio-respiratory dynamics in cardiomyopathy patients" (Dec/2020)

Daniel Llinás (Advisors: Josep Coll/Jesus Abad, GRO), "La consolidación de las prácticas de alto rendimiento de gestión de personas, una tarea prioritaria para el éxito de los sistemas de producción cíber-físicos en medianas empresas españolas" (Dec/2020)

Jesus Ordoño (Advisors: Soledad Perez/Elisabet Engel, IMEM-BRT), "Lactate: unraveling the regenerative potential for cardiac tissue engineering" (Nov/2020)

Dolores Blanco (Advisor: Raimon Jané, BIOSPIN-IBEC), "Noninvasive multimodal analysis of thoracic bioimpedance and myographic signals for the assessment of chronic obstructive pulmonary disease" (Nov/2020)

Kwon Bok Rodríguez (Advisor: Ignasi Casanova, NEMEN), "Formation and Evolution of Carbonate Phases upon Accelerated Carbonation of Mg-Oxides and Silicates" (Nov/2020)

Jorge Toro (Advisors: Montserrat Perez/T. Hirth, CEPIMA), "UV-Advanced Oxidation Process without additives in liquid phase - Process characterization and validation" (Oct/2020)

Shikha Singh (Advisors: Maria Lluïsa Maspoch/Kristiina Oksman, e-PLASCOM), "Properties of poly(lactic acid) in presence of cellulose and chitin nanocrystals" (Oct/2020)

Miquel Canudas (Advisors: Joan de Pablo/Josep M. Morera, R2EM), "Resines acríliques modificades com a nous productes de readobament i/o adobament sense formol ni fenol" (Jul/2020)

Idriss El Azhari (Advisors: Frank Mücklich/Luis M. Llanes, CIEFMA), "Multiscale mechanical and microstrutural characterization of titanium and zirconium carbonitride hard coatings" (Jul/2020)

Mohammad Zandi (Advisors: José A. Travieso/Ramon Jerez, TECNOFAB), "Study and characterization of mechanical properties of wood-PLA composite (Timberfill) material parts built through fused filament fabrication" (Jul/2020)

Brenda Molina (Advisors: Elaine Armelin/Carlos Aleman, IMEM-BRT), "Modified polymers as electroactive biomaterials" (Jul/2020)

New Research Grants

3D Fire LABoratory, UE, H2020-892463-3DFIRELAB (2020), PI: E. Pastor (CERTEC)

MACROSENSE. Sensor espectroscópico de metano basado en silicio macroporoso para la monitorización de gasoductos de gas natural, AGAUR 2019 LLAV 00037/IU68-017004 (2020-2021), PI: J. Llorca (NEMEN)

Implementació industrial del brunyit per a l'acabament de superfícies de motlles d'injecció, AGAUR 2019 PROD 00036 / IU68-016743 (2020-2022), PI: J.A. Travieso (TECNOFAB)

Formación Doctoral en Mecanobiología y Bioingeniería, MICIU, EIN2020-112287 (2020-2022), PIs: José J. Muñoz/Pablo Sáez (LaCàN)

Atacando el cáncer con especies reactivas (RONS) de plasmas fríos: Desarrollo de una plataforma basada en biopolímeros, MICIU, EIN2020-112386 (2020-2021), PI: C. Canal (BBT)

Automatic data processing and interpretation system in monitoring the state of structures, Nat. Centre for Research and Development, Poland, LIDER/3/0005/L-9/17/NCBR/2018 (2019-2021), PIs: Z. Dworakowski/ L. E. Mujica (CoDAlab)

New Postdoctoral Fellows

Barbara de Marco (GAA, Ramon y Cajal fellow)

Ronan Paugam (CERTEC, Marie Curie fellow)

Awards

Prof. Cristina Canal (BBT) has been awarded with an *ICREA Academia 2020* distinction

Other Research News

BBT (Biomaterials, Biomechanics and Tissue Engineering group) is associated to the **Research Institute St. Joan de Deu**, which has been recognized as a **CERCA** center

A new research unit, formed by the merging of **IMEM-BRT** (Innovation in Materials and Molecular Engineering – Biomaterials for Regenerative Therapies) and **CIEFMA** (Center for Research in Structural Integrity, Reliability and Micromechanics of Materials), has been recognized as a **TECNIO** center

CAMPUS DIAGONAL-BESOS

Research Newsletter

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Campus Diagonal-Besòs