Dr Teresa Andreu

Researcher at Catalonia Institute for Energy Research (IREC)
Lecturer at the Dept. of Materials Science
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Nanocatalysts to turn carbon dioxide and water to carbon-neutral synthetic fuels

An important approach towards an efficient and sustainable economy is storing the surplus of renewal energy into chemicals through water splitting and CO2 reduction, to convert them in carbon-neutral synthetic fuels. To this end, several technologies can be pursued, from photocatalysis, electrolysis or thermochemical conversion, and thus, catalysis is playing a major role in the activation of the stable water and carbon dioxide molecules. To find the suitable processes, together with new cheap and earth abundant nanocatalysts adaptability is mandatory for large scale industrialization and deployment of the novel technologies.

In this talk, the recent advances will be presented in the production in our laboratory of solar fuels by photoelectrocatalysis and low temperature CO2 electrolysis as well as CO2 conversion from biogas by conventional thermocatalytic hydrogenation and plasma-catalysis. For upscaling the technology, a mandatory focus on the selectivity, productivity, costs and energy efficiency should be taken into account as well as a discussion on the intrinsic limitations of some of the processes, to look at the future challenges for its practical implementation to replace fossil fuels.

Dr Christophe Aucher

Energy Storage Team Leader, LEITAT R&D Department

Critical raw material free battery technology for automotive and stationary applications

The growth of energy needs and the depletion of the fossil resources demand the development of sustainable energy alternatives including both energy harvesting and storage. For the latter, new battery technologies are emerging to respond to this challenge, to reach higher performances, with respect to products already on the market and reaching their limit, and to decrease our dependency on suppliers out of Europe. Thus, CRM-free batteries such as lithium-air (Li-air), lithium-sulfur (Li-S) and aluminum-ion (Al-ion) batteries are receiving great attention.

Three European projects, namely ALION ("High specific energy aluminum-ion rechargeable decentralized electricity generation sources"), POROUS4APP ("Pilot plant production of controlled doped nanoporous carbonaceous materials for energy and catalysis applications") and ALISE ("Advanced Lithium Sulfur battery for xEV") aim for the development of new active materials, adapted to the issues proper to each battery technology.

The projects include also component manufacturers, battery assemblers and final users for the technology validation. Al-ion technology has been assessed for isolated microgrid application whereas Li-S technology has been assessed for PHEV and BEV.

Dr Mariano Campoy-Quiles

Tenured scientist at Institute of Material Science of Barcelona (ICMAB-CSIC)

From colour-on-demand organic solar cells to solar thermoelectrics

Earth receives from the Sun electromagnetic radiation with wavelengths ranging from the UV (< 250 nm) to the mid IR (> 2500 nm). Typical solar cells having a single photoactive layer can harvest a fraction of the energy above their band gap (around 1000 nm). How can this range be extended to capture more efficiently the solar energy? Making solar cell stacks with active layers exhibiting different band gaps, aka tandem solar cells, has been the most widely used approach. Despite the academic success of this approach, commercial implementation has thus far being limited to niche applications due to the extraordinary fabrication complexity of tandem cells.

In this talk, I will present a series of new opportunities that emerge when using molecular based technologies, which are characterized by a low carbon footprint and amenability for chemically tuning their optoelectronic properties. First, I will demonstrate that multicomponent systems are the most efficient strategy to obtain a colour-on-demand solar cell technology [1]. As an example, I will show a greenhouse design that simultaneously optimizes photovoltaic performance and crop growth [2]. Then, I will introduce a high throughput screening method that enables the fast experimental evaluation of the complex parameter space of multicomponent systems aimed at obtaining panchromatic absorption [3-4]. Finally, I will discuss two methods of extending the harvesting capabilities into the infrared by two very different approaches. In the first, we use photonic structures to strongly enhance the charge transfer absorption [5]. In the second, we apply the Seebeck effect to directly convert heat into electricity through solar organic thermoelectric generators [6, 7].

Prof. Anders Hagfeldt

Laboratory of Photomolecular Science,
Swiss Federal Institute of Technology Lausanne (EPFL)

The Versatility of Mesoscopic Solar Cells

This talk will focus on recent development in our research on solid-state dye-sensitized solar cells (ssDSSC) and perovskite solar cells (PSC).

ssDSSC: We have recently shown that copper phenanthroline complexes can act as an efficient hole transporting material. We prepared ssDSCs with a novel organic dye WS-72 and $[Cu(tmby)_2]^{2+/+}$ as redox system and achieved record power conversion efficiencies for ssDSCs of 11.7%. Our best DSC efficiency of 13.1% (32% for indoor light illumination) for a liquid Cu-complex electrolyte is achieved by the discovery that the PEDOT based counter electrode can be directly contacted with the dye/TiO_2 photoelectrode. Thus, there is no space between the two electrodes minimizing diffusion limitations and fill factors up to 0.8 is achieved.

PSC: We have achieved efficiencies above 22% with a mixed composition of iodide/bromide and organic and inorganic cations. With the use of SnO_2 compact underlayers as electron acceptor contacts we have constructed planar perovskite solar cells with a hysteresis free efficiency above 21%. Through compositional, engieneering larger preovskite grains grown in a monolithic manner are observed and reproducibility and device stability are improved. With regards to lifetime testing, we have shown a promising stability at 85 oC for 500 h under full solar illumination and maximum power point tracking (95% of the initial performance was retained). Recently, we have also commented on the standardization of PSC aging tests.

Dr Sohini Kar-Narayan

Associate Professor of Device & Energy Materials in the Department of Materials Science, University of Cambridge

Nanostructured polymer-based piezoelectric and triboelectric materials and devices for energy harvesting

Harvesting energy from ambient mechanical sources in our environment has attracted considerable interest due to its potential to power applications such as ubiquitous wireless sensors and Internet of Things devices. In this context, piezoelectric and/or triboelectric materials offer a relatively simple means of directly converting mechanical energy from ubiquitous ambient vibrating sources into electrical power for microscale/ nanoscale device applications. In particular, nanoscale energy harvesters, or nanogenerators, are capable of converting low-level ambient vibrations into electrical energy, thus are vital to the realization of the next generation of self-powered devices. Polymer-based nanogenerators are attractive as they are inherently flexible and robust, making them less prone to mechanical failure which is a key requirement for vibrational energy harvesters. They are also lightweight, easy and cheap to fabricate, lead-free and biocompatible, but in many cases their energy harvesting performance is found lacking in comparison to more commonly studied inorganic materials. Recent advances have been made in developing scalable nanofabrication techniques for flexible and low-cost polymer-based nanogenerators with improved energy conversion efficiency, including the incorporation of high-quality polymer nanowires with enhanced crystallinity, piezoelectric and/or surface charge properties. In this talk, I will discuss aspects of nanomaterials growth and energy harvester device design, including those involving nanowires of polymers of polyvinylidene fluoride and its co-polymers, nylon-11, and poly-lactic acid for scalable piezoelectric and triboelectric nanogenerator applications, as well as the design and performance of polymer-ceramic nanocomposite nanogenerators. In particular, I will highlight the effects of growth parameters, nanoconfinement effects, self-poling, surface polarization, crystalline phases, and device assembly on the energy harvesting performance of a range of nanostructured polymer-based materials and devices.

Joan Ventura

Senior Researcher at the Institute of Physics of Materials of the University of Porto (IFIMUP)

Triboelectric nanogenerators: from fundamental concepts to applications in harsh environments

Micro and nano-generators, able to harvest energy from the environment, have been attracting large interest because they are green, sustainable and cost-efficient energy sources that can be easily integrated in common electronic gadgets. A major breakthrough in the field of mechanical energy harvesting occurred in 2012 when the first triboelectric nanogenerator (TENG) was invented. TENGs are based on the coupling between triboelectric and electrostatic processes that generate a charge distribution at the interface of materials that come into contact. They show very high efficiency (up to 75%), power densities above 500 W/m2, record voltage outputs above 1200 V, wide material choice, simple design, easy manufacturing and integration. Their applications are almost infinite because of the possibility to use all flexible and dynamic surfaces like cloth or shoes, touchable electronics or even the human body, to produce electricity. Here, we will discuss the basic phenomena behind triboelectric nanogenerators and their applications as novel energy harvesters for extreme conditions (high temperatures up to 150ºC and pressures up to 830 bar) for the oil & gas industry and as blue energy devices able to transform wave and currents energies into useful electrical power.

María Escudero Escribano

Assistant Professor at the Department of Chemistry and the Nano-Science Centre, University of Copenhagen

Electrocatalysis for renewable energy conversion and production of sustainable fuels and chemicals

There is an urgent need to develop a sustainable economy based on renewable energy and green synthesis processes. Electrocatalysis may play an essential role in this transition towards a sustainable future. Electrochemical energy conversion devices, such as fuel cells and electrolysers, coupled to renewable sources, allow producing renewable fuels and chemicals as well as clean electricity. On the other hand, electrocatalytic methods are very appealing to achieve a sustainable valorisation of simple chemical building blocks. Switching from traditional fossil-fuel dependent methods to electrosynthesis processes may be key to transition towards a green chemical industry.

This talk will focus on our research on tailored electrocatalysts for electrochemical energy conversion and electrosynthesis of renewable fuels and chemicals. We have tailored the electrochemical interface at the atomic and molecular level in order to understand the structure-reactivity relations and tune the electrocatalytic properties. This approach has been very relevant to rationally design highly active platinum-based electrocatalysts for the oxygen reduction reaction (ORR) in fuel cells. This talk will first present some strategies aiming to understand and tailor the ORR activity, stability and selectivity by means of atomic ensemble control and electronic effects. In particular, our work on Pt-lanthanide alloys show that the trends in electrocatalytic activity and stability can be controlled by fine tuning the alloy structure. Finally, we will summarise our recent work on the electrocatalytic synthesis of value-added chemicals, with a special focus on the production of dimethyl carbonate, an industrially relevant and green chemical.