Barcelona Institute of Science and Technology

PRESS RELEASE

Second edition of Ignite programme

Researchers at two BIST centres join forces to change the power paradigm of the future

- **The SOLHYCAT project uses innovative carbon nanostructures to make it more efficient and affordable to produce clean energy from water and sunlight (artificial photosynthesis)**
- **It is one of the five projects funded through the seed phase of the 2018 edition of the BIST Ignite programme to accelerate multidisciplinary research**

Barcelona, 5 April 2018. Hydrogen has the potential to be used as a clean energy source and, if it's produced from water and sunlight, it is endless. However, obtaining it from water hydrolysis is quite expensive because the process uses a lot of power and the catalysts require precious metals, like platinum. Following the model of natural photosynthesis, researchers have developed a synthesis of nanoparticles that can absorb sunlight and transform it into separate charges (the research group led by **Dr Víctor F. Puntes** of the **ICN2** - Catalan Institute of Nanoscience and Nanotechnology specialises in this area). At the same time, at the other end, researchers have also developed molecular catalysts based on derivatives of more affordable metals like cobalt and nickel (the specialisation of the group led by **Dr Antoni Llobet** of the Institute of Chemical Research of Catalonia - **ICIQ**).

The challenge today is to **effectively and efficiently connect the semiconductor nanoparticles with the molecular catalysts** to obtain an economically feasible and industrially scalable process that makes it possible to use hydrogen as an alternative to fossil fuels.

The solution proposed by the **SOLHYCAT** project is to use carbon nanostructures as the charge transfer platform between the semiconductor nanoparticles and the catalysts. *"What we need is a material that gives us a quick enough charge transfer so power isn't lost in the process. Materials like graphene and carbon nanotubes are great candidates, with the right conductivity and at an affordable price, too. So, if the project is proven effective, we'll be blazing the trail for a radical change in the production of hydrogen as an energy source,"* explains Dr Carolina Gimbert, scientific coordinator of Dr Llobet's group.

Both SOLHYCAT and the other four projects selected for this year's Ignite programme, explained below, were highlighted for their high potential for success and impact by international experts.

Quantum physics and proteins

Observing photosynthesis is also at the heart of the **Q-SPET** project led by **Dr Pau Gorostiza** of the Institute for Bioengineering of Catalonia (**IBEC**) and **Dr Niek van Hulst** of the Institute of Photonic Sciences (**ICFO**), which aims to measure quantum effects in photosynthetic protein complexes. *"In photosynthetic bacteria and plants, we find these groups of proteins that work together to transform light into electric current with nearly perfect efficiency. Niek was a pioneer in the discovery of these complex's large-scale quantum effects in light absorption, which is their physiological function,"* explains Dr Gorostiza. The IBEC group, which specialises in ultrasensitive electrochemical measurements in proteins, and the ICFO group, a leader in studying quantum effects in photosynthetic complexes, have joined forces to measure a scientific phenomenon with huge potential.

"Observing quantum effects requires extreme experimental conditions, so being able to discover and measure quantum effects in proteins at room temperature is an exceptional advance that opens up many doors. To start with, it will allow us to study the physiological significance of these quantum phenomena, which hasn't yet been proven, but expectations are much broader: we could come to have quantum technology, like computers, based on quantum bits of proteins working at room temperature, or develop extremely efficient systems to collect solar energy," explains Dr Gorostiza.

Culturing tissues for personalised medicine

Also at **IBEC**, but in a totally different area of science, is the research group led by **Dr Elena Martínez**, who heads up the **ENGUT** project with **Dr Emilio Gualda** of **ICFO**. The project aims to come up with a new cell culture method that allows for in vitro production of epithelial tissue like that covering the inside walls of the intestine for use in basic research, diagnostics, drug assessment and for transplants and personalised regenerative medicine.

"The stem cells in intestinal tissue are renewed every 4 days. This process is regulated by a specific biochemical signalling, which reaches each cell in a different manner depending on its position in the cavities inside the intestines. We want to reproduce these vertical structures in a microfluidic device and, using a chip, control how much of the proteins reach each cell depending on its position. We hope this will help us speed up production of intestinal tissue," explains Dr Martínez.

Dr Gualda's group specialises in a novel technique known as light-sheet fluorescence microscopy (LSFM), which is essential for both manufacturing the device and monitoring and assessing cell growth. *"Our devices are between 500 and 800 microns, a scale that makes it impossible to see them entirely with more common high-resolution microscopy. LSFM, instead of emitting a beam of light at a specific point, distributes it in a wider, ultra-thin layer that makes it possible to see relatively large structures and dynamic processes,"* explains Dr Martínez.

During the seed phase (8 months), the ENGUT team will manufacture the device and test the structure for cultivating intestinal stem cells from animal models, monitoring the process with LSFM. If the results are good, there will be a second phase in collaboration with the group led by Prof. Eduard Batlle of the Institute for Research in Biomedicine (IRB Barcelona), which is also a BIST centre. This study will use the device as the basis for a 3D model of cancerous intestinal epithelial tissue, which would be a very important advance in in vitro models for oncology research. The final goal, after successful proof-of-concept with animal stem cells, is to produce intestinal tissue from patients' own stem cells to be used in personalised medicine (implants or cell regeneration).

"Cell cultures are three-dimensional structures that are still in a very early stage, and a lot of research is still needed to address all the challenges this poses," says Dr Martínez, *"but we are convinced this project will be a great step forward."*

Discovering previously unknown aspects of cell structure

The **PHASE-CHROM** project, led by **Dr Juan Andrés Torreno** of **ICFO** and **Dr Catalina Romero** of the Centre for Genomic Regulation (**CRG**), brings together the disciplines of molecular and cellular biology and theoretical biophysics to research the existence and functions of organelles that form inside cells and are believed to regulate many of their functions. These organelles are concentrations of molecules without a membrane around them and they behave like drops of liquid. They are so ephemeral (lasting only the milliseconds necessary to perform their function) that observing and studying them is a great scientific challenge.

The PHASE-CHROM project will focus on analysing the formation of these organelles induced by poly-ADP-ribose (PAR) in the nucleus of breast cancer cells and the role they play in regulating ATP synthesis (adenosine triphosphate, a precursor to DNA), the organisation of chromatin and gene expression in cancer cells. The research will use advanced spectroscopy and nanoscopy techniques, as well as analysis with cryogenic fluorescence tomography (CFT) and cryogenic x-ray tomography, which will be done at the Alba-CELLS Synchrotron.

More electric transfer with less heat

Finally, the **2DNANOHEAT** project, led by **Dr Klaas-Jan Tielrooij** of **ICFO** and **Dr Marianna Sledzinska** of **ICN2**, is pooling the knowledge of four BIST research groups (those at ICFO led by professors Niek van Hulst and Frank Koppens and those at ICN2 led by Clivia M. Sotomayor and Sergio O. Valenzuela) to develop a new type of thermoelectric and photodetection devices based on what is known as two-dimensional materials (like graphene, in a film only one atom thick). The challenge is to boost their capacity to transport an electric charge while reducing the heat generated as much as possible in order to develop technology that can be used to produce energy and photosensors for medical diagnostics or to design computer components.

BIST has earmarked €500,000 for the various stages of the Ignite programme since 2017. The five projects selected in the first phase of the 2018 edition will have eight months to conduct the proposed research. After this period, the two with the most promising results will be chosen to receive funding for a second stage of development, lasting 12 months.

About BIST

The Barcelona Institute of Science and Technology (BIST) is an initiative of seven research centres of excellence in Catalonia that aim to boost collaboration to build a joint scientific project. Its strength lies in the research capacities of these seven centres and their potential to promote cutting-edge multidisciplinary projects.

The BIST member centres are the Centre for Genomic Regulation (CRG), Institute for Bioengineering of Catalonia (IBEC), Institute of Photonic Sciences (ICFO), Institute of Chemical Research of Catalonia (ICIQ), Catalan Institute for Nanoscience and Nanotechnology (ICN2), High

Energy Physics Institute (IFAE) and Institute for Research in Biomedicine Barcelona (IRB Barcelona).

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NOTE:

Images of the SOLHYCAT project can be downloaded here:

- Figure SOLHYCAT
- Carbon nanotubes - SOLHYCAT
- Graphene - SOLHYCAT

Figures show the different carbon nanostructures proposed by the SOLHYCAT project as the charge transfer platform between the semiconductor nanoparticles and the molecular catalysts.