Artificial Photosynthesis by Design: Industrial Relevant Oxygen Evolution Catalysts, Low-Valent Catalysis, and Closed-Loop Electrochemistry

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ABSTRACT

Inspired by natural photosynthesis, there is a vision to synthesize fuels and chemicals using Earth's abundant molecules (such as H_2O, CO_2, N_2) and renewable energy.[1] Understanding these processes is crucial for developing efficient small molecule transformations.[2] In this context, we will discuss our efforts to develop well-defined coordination complexes that act as efficient homogeneous catalysts for CO_2 reduction, activation of alkyl chlorides and other transformations identified during the process.[3] These transformations share that are mediated by low valent metal complexes.[4]

For CO_2 reduction, I will present highly active manganese-based catalysts that operate effectively at very low CO_2 concentrations and demonstrate how the selectivity of CO_2 reduction can be tuned using covalent organic frameworks from CO to HCO_2H. The development of stable and selective catalysts for CO_2 reduction has needed a deep insight of the CO_2 reduction mechanisms by metal complexes, which has been instrumental in designing more efficient catalysts and find reaction conditions to shift the selectivity to yield formate. We will discuss how CO_2 can act as a surrogate for carbon monoxide in electrocatalytic carbonylation reactions, mediated by a dual catalytic system.[5]

Finally, I will present our efforts to automatize the advance of electrocatalysts by the development of an **A**utonomous **M**odular **P**latform for **E**lectrochemistry **R**esearch **(*A*MPER).**

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Short BIO.

Prof. Julio Lloret-Fillol began his academic career at the University of Valencia, completing his PhD in 2006 under Profs. P. Lahuerta and J. Pérez-Prieto in organometallic chemistry. He then joined Prof. L. H. Gade's group at the University of Heidelberg as a Marie Curie postdoctoral fellow. In 2010, he started independent research under the Ramón y Cajal program at the University of Girona, mentored by Prof. M. Costas. In 2014, he joined ICIQ as Group Leader, and in 2015, he became an ICREA Research Professor, also receiving an ERC Consolidator Grant (GREENLIGHT-REDCAT) to harness light for catalytic reductions in water oxidation and solar fuel production.

His research focuses on catalysts design, with a long-term vision of using renewable energy to drive chemical reactions that can mitigate environmental issues and contribute to the global transition towards sustainable fuels and chemical production. His group works at the interphase of homogeneous catalysis, material science and automatization, developing photo- and electrocatalysis, leading to advances in energy conversion, hydrogen generation, CO_2 reduction and synthetic methodology. He recently received the Ramon Areces Grant 2022 and GEQO Research Excellence Award 2023.

Beyond his academic accomplishments, Prof. Lloret-Fillol has actively worked towards transforming scientific discoveries into real-world applications. He co-founded two spin-offs, Treellum Technologies and JOLT Solutions, focused on developing technological solutions derived from his research to advance in the manufacturing of scientific instrumentation and electrodes for green hydrogen production.