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Congratulations to New ICFO PhD Graduate

Dr. Blanca Belsa graduated with a thesis entitled ï¿½Engineeri g Catalyst-Ionomer Interfaces for Carbon-Efficient CO2 Electrolys s and Technology Prospectsï¿½

February 20, 2026

We congratulate Dr. Blanca Belsa who defended her thesis this morning in ICFO's Auditorium. Dr. Belsa obtained her MSc in Multidisciplinary Research in Experimental Sciences at Universitat Pompeu Fabra. She joined the CO2 Mitigation Accelerated by Photons team led by Prof. Dr. F. Pelayo Garcia de Arquer. Her thesis titled ï¿½Engineering Catalyst-Iono er Interfaces for Carbon-Efficient CO2 Electrolysis and Technology Prospectsï¿½ was super ised by Prof. Dr. F. Pelayo Garcia de Ar

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ABSTRACT:

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The electrochemical reduction of CO2 (CO2E) offers a promising route to convert greenhouse gas emissions into value-added chemicals and fuels. However, achieving performance metrics that enable the technoeconomic and sustainable viability of CO2E remains challenging. This is especially acute in the case of multicarbon products (C2+), important precursors for energy fuels and manufacturing, where achieving combined selectivity and carbon utilisation under industrially relevant conditions is challenged by undesired competing reactions. This thesis explores the design and implementation of new strategies to modulate electrochemical interfaces in CO2E to overcome this barrier. These are based on the implementation of ionomer coatings that specifically address key reactants and intermediates in CO2E.

A key contribution is the development and mechanistic elucidation of ion management channels (IMCs), formed by co-distributing cation and anion exchange ionomers (CEIs and AEIs) within the catalyst layer. This architecture enables local regulation of hydroxide and cation populations, mitigating *OH poisoning and enhancing *CO adsorption, critical steps for promoting C-C coupling and C2+ product formation.

The ionomer-catalyst interface is comprehensively characterised using SEM-EDS, FTIR, XPS, KPFM, contact angle measurements, cyclic voltammetry, and EIS. In situ Raman spectroscopy reveals the dynamic evolution of surface species, confirming that excessive

*OH accumulation suppresses C2+ selectivity, while IMCs restore favourable interfacial conditions. These insights are correlated with improved electrochemical performance, carbon efficiency, and stability across a wide range of operating conditions, including highly acidic environments.

The IMC concept is further implemented in membrane electrode assembly (MEA) devices operating under neutral pH. Preliminary results demonstrate improved performance and reduced cell voltages for IMC-based electrodes, indicating compatibility with scalable reactor platforms and commercially viable components.

The thesis concludes with a broader analysis of the challenges facing CO2E at scale. Key bottlenecks, such as the reliance on iridium anodes and fluorinated membranes, are critically assessed, and material and performance targets for gigaton-scale deployment are proposed. A techno-economic and life-cycle analysis outlines trade-off between performance, cost, and sustainability, while global scaling efforts are reviewed. Benchmarking protocols are proposed to bridge the gap between laboratory research and industrial implementation. Together, this work advances a cohesive framework for interfacial engineering in CO2E, linking molecular-level understanding to device-scale integration, and providing pathways toward industrial deployment.

Thesis Committee:

Prof. Dr. Teresa Andreu Arbella, Universitat de Barcelona

Prof. Dr. Nicoletta Liguori, ICFO

Prof. Dr. Jose Solla Gullon, Universitat d'Alacant

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