CAPTUS LIQUID RENEWABLE ENERGY CARRIERS FROM CAPTURED CARBON EMISSIONS

First CAPTUS project's scientific publications

The CAPTUS consortium is pleased to announce the publication of its first scientific papers.

The 4-year project coordinated by Fundación CIRCE Centro de Investigación de Recursos y Consumos Energéticos (CIRCE) aims to demonstrate the sustainable and cost-effective production of high-added value renewable energy carriers (RECs) in energy intensive industries (EIIs) by valorising industrial carbon emissions with the integration of renewable electricity surplus. Therefore, three complete REC value chains will be demonstrated at three different demonstration cites.

1. A bioprocess based on a two-stage fermentation to produce triglycerides in a steel plant.
2. Lipids-rich microalgae cultivation followed by hydrothermal liquefaction to produce bio-oils in a chemical plant.
3. Electrochemical reduction of CO_2 to produce formic acid in a cement plant.

In the context of the CAPTUS project, four scientific papers written by the partner Universidad de Cantabria (UNICAN) have been released recently. The four articles are available on the project website (Scientific Publications section) as well as in the dedicated CAPTUS community on Zenodo.

Photoelectrochemical CO_2 electrolyzers: From photoelectrode fabrication to reactor configuration: The conversion of CO_2 into valuable products through (photo)electrochemical methods offers a promising solution for combating climate change. Key challenges lie in optimizing electrodes and electrolyzers. This review delves into fabrication techniques, structures, and characterization of electrodes, from basic to advanced methods. Emphasis is placed on measuring and enhancing electrode features. Additionally, it explores integrating electrodes into various electrolyzer setups, including photocathode, photoanode, and tandem configurations, for efficient CO_2 conversion. The aim is to provide guidance for developing sunlight-driven CO_2 conversion systems for real-world applications.

Coupling glycerol oxidation reaction using Ni-Co foam anodes to CO_2 electroreduction in gas-phase for continuous co-valorization: Electrocatalytic CO_2 reduction offers a promising method for energy storage and valuable product generation, such as formic acid/formate. This study demonstrates the successful coupling of glycerol oxidation with continuous CO_2 electroreduction to formate, using Ni-Co foam-based anodes. The developed MEA-electrolyzer achieves high formate concentrations (up to 359 g L^{-1}) with Faradaic efficiencies reaching 95%. Additionally, it produces dihydroxyacetone at a rate of 0.434 mmol m^{-2} s^{-1} in the anodic compartment. This approach presents a notable balance between key metrics, promising future scalability of the system.

Fabrication and optimization of perovskite-based photoanodes for solar-driven CO_2 photoelectroreduction to formate: Photoelectrochemical CO_2 reduction shows promise in reducing emissions, but scaling up requires efficient photoelectrode design. This study proposes a photoanode combining $CaTiO_3$ and $BiVO_4$ layers on an FTO substrate via automated spray pyrolysis. Optimal configuration and catalytic loading yield impressive current densities (–71 mA cm^{-2} at –1.8 V vs. Ag/AgCl). Integrated into an electrolyzer, this photoanode achieves visible light-driven CO_2 reduction

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to formate, reaching a concentration of 63.8 g L^{-1}, with a Faradaic Efficiency of 79.1% and solar-to-fuel conversion efficiency of 7.6%. These findings mark a significant step forward in scalable photoelectrochemical CO_2 reduction toward formate as a value-added product.

Exploring the impact of partial pressure and typical compounds on the continuous electroconversion of CO_2 into formate: Previous research on CO_2 electroreduction often neglected the influence of residence time and N_2/O_2 compounds, which are crucial for industrial implementation. This study investigates these factors using Bi carbon-supported nanoparticles in Gas Diffusion Electrodes within an electrochemical flow reactor. Results underscore the importance of residence time and the role of N_2/O_2 compounds in CO_2 electroconversion. Optimal residence times of 1.8 to 2.9 seconds yield promising Faradaic Efficiency for formate (75.0%). Notably, achieving 100% CO_2 capture efficiency is not essential, thereby reducing associated costs in CO_2 recycling plants.

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