

Study of a coupled electrochemical process involving of CO₂ reduction and methanol oxidation into formic acid/formate

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In response to the growing concerns over environmental pollution and the energy crisis, the development of advanced technologies for the storage and conversion of CO₂ has become increasingly urgent. Among the various strategies explored, electrochemical CO₂ reduction (CO₂RR) was considered one of the most promising ones, particularly due to the high selectivity achieved with some adopted electrocatalysts, the potential use of renewable energy sources and the production of various value-added products [1]. Among them, formic acid/formate (FA) was identified as one of the most attractive targets. FA can be potentially used not only as a valuable chemical but also as an ideal hydrogen carrier. However, the CO₂RR process still suffers from various drawbacks and up to now is not still sustainable from an economic point of view [2]. To improve the economic perspectives of this route, recent studies proposed to couple the CO₂ reduction at the cathode with the electrooxidation of small organic molecules, such as urea or methanol, at the anode to higher value products like FA.

This study investigated a coupled process that involves the CO₂RR to FA in the cathodic compartment and the anodic oxidation of methanol into FA in the anodic one. Electrolyses were performed using a divided conventional glass cell equipped with a Sn cathode, a cation exchange membrane (Nafion 117) and various anodes at a constant current density of 11 mA/cm².

The results provided insights on the role of electrode materials and electrolyte composition in enhancing FA production efficiency. Among the tested conditions, the combination of specific anode materials and optimized pH in the two compartments showed promising performance in terms of both selectivity and energy efficiency.

Keywords: CO₂, sustainability, electrochemical reaction, coupled process

[1] Sabatino, Simona, et al. *ChemElectroChem* 2017, 4, 150 – 159.

[2] Lou, Hang, et al. *Materials Today Energy* 2025, 48 101779.