ELECTROCHEMICAL REDUCTION OF CO₂ TO FORMIC ACID USING GAS DIFFUSION ELECTRODES

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One of the major challenges of this century is undoubtedly reducing the atmospheric emissions of carbon dioxide. Therefore, over the past decades, CO₂ capture and storage (CCS) technologies have received increasing attention. Nowadays, the conversion and utilization of CO₂ is being considered as an attractive solution to solve CO₂ issues. An effective utilization of CO₂ as a storage medium for renewable energy could be achieved by an electrochemical approach. Many valuable chemicals and fuels could be obtained by reducing the CO₂. For instance, metals as Au, Ag, Pd and Zn show a high selectivity for reducing CO₂ to CO which can be used in a Fischer-Tropsch process to produce liquid hydrocarbons. Alcohols and hydrocarbons can be directly produced by reducing the CO₂ on a Cu electrode, although the selectivity of the reaction is poor and requires a lot of energy [1]. At relatively high overpotential, several metal electrodes have proven their efficiency to selectively reduce CO₂ into formic acid. On indium electrode, the potential required to reduce CO₂ to HCOO⁻ is much less negative than other metals (Pb, Cd, Bi and Tl) [1]. Formic acid could be either selectively dissociated into hydrogen and CO₂ with the appropriate catalyst or used in a Direct Formic Acid Fuel Cell (DFAFC) to recover energy in an electrical form [2,3].

However, the electrocatalytic reduction of CO₂ in aqueous media at bulk metal electrodes suffers from several hindrances. An essential problem is the hydrogen evolution reaction which prevails over the CO₂ reduction especially in acidic solutions. Owing to the low solubility of CO₂ in aqueous media under ambient conditions, the reaction rates and current densities are limited by mass transfer on solid electrodes [4]. In addition, the low specific surface area of these electrodes and their deactivation due to surface poisoning, are the major factors limiting their utilization in an electrochemical process. Several studies have been published showing that gas diffusion electrodes (GDE) could be a solution to increase the current density [5,6].

In this communication, we will focus on indium-loaded GDE, their preparation and physical characterization, as well as their redox properties. The electrocatalytic performance of these GDE were tested in a designed electrolysis cell (Figure1) allowing a controlled flow of CO₂ through the GDE. In addition, we will show that GDE loaded with molecular metal carbonyl complexes [7] are also excellent catalysts that allow performing electrocatalysis with a high current density and good selectivity for the formation of formic acid at a low over-potential in aqueous medium.

Figure 1: Schematic representation of the self-made electrolytic H type cell.

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