Electrochemical conversion of CO_2 using different cathodes: role of current density and pressure

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The electrochemical reduction of CO_2 (CO_2ER) has been widely investigated as a promising strategy to convert waste-CO_2 into value-added chemicals [1-2]. According to the literature, to be suitable for the commercialisation, the CO_2ER should reach simultaneously high current density ($|j| > 100$ mA cm^{-2}), faradaic efficiency (FE > 95 %), high product concentration as well as limited costs and long-term stability of cathodes [3]. One of the main handles of the CO_2ER is the low CO_2 solubility in aqueous electrolyte [4]. To overcome this issue, increasing attention was focused on the CO_2ER under relatively high pressure of CO_2 (PrCO_2ER) [4,5].

In this study, the PrCO_2CR process into formic acid/formate (FA) and CO was investigated in aqueous electrolytes using various cathodes, including Sn, Bi, Ag and Ni, to evaluate the role of both the CO_2 pressure (P) (ranged from 1 to 56 bar) and j (ranged from –50 to –230 mA cm^{-2}) on the FE and total productivity (r_{TOT}). It was observed that the selection of proper operative conditions (such as 40 bar and –150 mA cm^{-2}) allows to achieve both high FE and CO (close to 80-90 %) and total productivity (close to 7 mmol s^{-1} m^{-2}) for all adopted electrodes, except for Ni.

Eventually, the effect of P and j on the economic figures of the process using Sn, Ag and Bi will be discussed highlighting the main factors that affect the scalability of the process on an industrial scale. Overall, the most appealing economic figures were obtained under very similar operative conditions for Sn, Bi and Ag, such as relatively high P of 30 - 56 bar and high j ranged from –150 to –190 mA cm^{-2}.

Keywords: *CO_2 reduction, Pressure, Current density, Cathodes' nature, Formic Acid, Carbon monoxide*

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