Flow by and flow through copper electrodes for the electrochemical conversion of CO₂ into CO

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At the University of Twente, methods are developed to electrochemically convert carbon dioxide (CO₂) into chemicals, such as carbon monoxide (CO). This process requires a selective catalyst to enhance CO production, and inhibit formation of by-products (H₂ evolution). The best known electrocatalyst for CO production is silver (Ag), in the form of nanoparticles coated onto gas diffusion electrodes (GDE). Although Ag-GDE based cells show excellent performance (> 95% faradaic efficiency) for CO production [1], the reaction still requires a high over-potential, inducing energy losses.

Copper (Cu), is a metal that is well known for its conductivity and capability to produce hydrocarbons in the reduction of CO₂. Copper-based GDEs (Cu-GDEs) show high selectivity to hydrocarbons [2], while in 3D-hollow fiber morphology CO production has been shown, with a faradaic efficiency of 70% at low cathodic potential (-0.4 V vs RHE) [3]. This can be mainly explained by the excellent transport phenomena induced by the hollow-fiber morphology. While in the case of Cu-GDE the CO₂ molecules “flow by” the diffusion layer (carbon substrate) before being converted into CO on copper sites, for copper hollow fibers the bottom of the fiber is closed, so CO₂ molecules are forced to “flow through” the porous wall of the fiber, likely inducing a higher contact area with copper sites, as shown in Figure 1.

The main goal of this work is to compare the performance of copper hollow fibers with the more conventional copper-based gas diffusion electrodes (GDE). We are looking for similarities (and differences) in their preparation methods, dominant physico-chemical properties, structural and morphological characteristics and electrochemical activity, aiming at improving the activity, selectivity to CO, and stability of both type of electrodes.

On the GDE evaluation side, the focus is on the effect of ink composition on catalyst activity. The ink is made by dispersing a catalyst (Cu particles) and a binder polymer in a solvent. Variable solvents, polymers and catalyst loading have been tested, aiming to elucidate the optimal polymer/solvent composition. On the improvement of hollow fibers, thermal treatments to provide higher mechanical strength, and the influence of feed composition (CO₂, CO and their mixtures) have been evaluated.

Flow by and flow through transport mechanism for the electrochemical reduction of carbon dioxide


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