Development and Optimization of Gas Diffusion Electrodes for Electrochemical CO_2 Reduction at High Current Density

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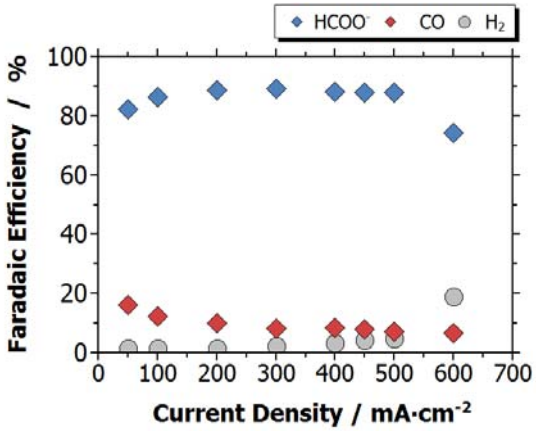
Motivation

The electrochemical reduction of CO_2 to valuable compounds is a promising approach for its substantial utilization and the storage of electricity in chemical form. At present, the main challenges impeding technical realization are i) low production rates due to mass transport limitations deriving from the low solubility of CO_2 in the electrolyte, ii) high overpotentials and poor energetic efficiency, necessitating development of more active catalysts, as well as iii) the demonstration of its continuous production which combines the above with low ohmic losses and long-term stability. Furthermore, hydrogen evolution occurs in the same potential range, and becomes dominating at current densities above 10 $mA \cdot cm^{-2}$ on conventional metallic electrodes when diffusion of CO_2 to the electrode surface becomes rate-determining.

Approach and results

The approach that has been shown to efficiently facilitate the transport of CO_2 to the cathode is the use of gas diffusion electrodes (GDE), in which the three-phase boundary for reaction forms inside of the porous carbon network into which the catalyst is dispersed. Although optimization potential is very high, studies on their preparation and elucidation on the governing parameters are very scarce. In the study presented, the relation between the GDE properties, given by the pore structure of carbon type, content of the binding agent, hydrophobicity and catalyst dispersion, and performance (activity, mass transport) has been evaluated. Employing GDEs with optimized pore structure prepared by a newly developed preparation method [1] allows to massively enhance performance (500 mA/cm², 80% selectivity). Importantly, the governing physical-chemical characteristics of the GDE have been assessed to understand their importance and to allow for a more sophisticated electrode design.



References:

[1] Kopljar D, Inan A, Vindayer P, Wagner N, Klemm E (2014) *J. Appl. Electrochemistry 44*:1107-1116