Electro-catalyst systems for energy storage through coupled water oxidation and CO₂ reduction

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Project Publications


Project Summary

The steadily rising atmospheric content of CO₂ due to burning of fossil fuels generates much concern with respect to changing global climate. Considering the ambient operating conditions and the possibility of direct integration with renewable resources, electrochemical conversion of CO₂ to fuels and useful chemicals opens door to a sustainable carbon neutral fuel cycle. However, the main challenge is to find a suitable catalyst to overcome the high activation barrier for the reduction of thermodynamically stable CO₂. In addition, when operated in an aqueous medium (pH ~ 7), the selected
catalyst material has to impede the hydrogen evolution reaction (HER) initiated already at much lower overpotentials.

Cu is in the focus of electrochemical reduction of CO$_2$ owing to its ability to catalyze CO$_2$ reduction towards energy-dense hydrocarbon products. However, the electrochemical reduction of CO$_2$ on Cu is challenged by insufficient selectivity and a wide spectrum of products formed. The surface of the catalyst plays a key role in affecting the intermediate adsorption and by controlling the number of active sites for the reactants. The performance of Cu-based catalysts can be improved by tuning the structure, morphology and composition of the catalyst.

**Evaluation of Cu-based nanostructured materials with controlled morphology for CO$_2$ reduction**

By utilizing the **hydrogen bubble templated electrodeposition method**, the morphology and the pore size can be easily controlled by changing the deposition current and time. During the electrodeposition of Cu at high current densities, the hydrogen bubbles originating from the cathodic reaction create a continuous path from the electrode surface to the electrolyte air interphase, and these bubbles act as a dynamic negative template for the Cu deposition (Fig. 1).

![Figure 1. Hydrogen bubble templated electrodeposition of Cu](image)

Apart from the Cu only structures, we also develop bimetallic electrocatalysts for CO$_2$ reduction, namely **AgCu** and **CuZn** by electrochemical synthesis. Fig. 2 shows the porous Cu and bimetallic AgCu synthesized by hydrogen bubble templated electrodeposition method.
Figure 2. SEM images of Cu and Ag-Cu structures electrodeposited using the hydrogen bubble templated electrodeposition method.

The synthesized materials are initially characterized for the electrochemical CO$_2$ reduction by means of linear sweep and cyclic voltammetry and chronoamperometry. Determination of the product distribution of the electrochemical CO$_2$ reduction is carried out by an online gas analysis using a gas chromatograph.