Innovative materials for CO_2 capture and conversion to e-fuels

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Significance and Relevance

The general objective of this research is the development of innovative photoelectrochemical devices that incorporate CO_2 capturing from dilute sources and selectively transporting it to electrodes for CO_2 conversion. Specifically, this project aims to realize appropriate electrochemical systems that facilitate the capture of CO_2 and its simultaneous reduction to base products such as methanol (CH_3OH) and ethylene (C_2H_4) for the production of e-fuels, such as dimethyl ether and linear hydrocarbons.

The component capable of selectively capturing and transporting CO_2 consists of metal organic frameworks (MOF) based compounds, and works synergistically with Cu-based materials capable of catalyzing the reduction of CO_2. These materials can be integrated into photoelectrocatalytic devices (PEC), allowing the development of zero-gap flow electrochemical cells, which represent the current development frontier of these devices towards industrial applications.

Preferred and 2nd choice for the topic: **CO_2 utilization and recycling**; **Sustainable and clean energy production and transport**

Preferred presentation: **Short Oral / Poster**

Introduction and Motivations

Carbon Capture and Utilization (CCU) is one of the technologies adopted to simultaneously reduce CO_2 emissions and obtain chemical products or fuels (e-fuels)[1]. Current processes involve the CO_2 capture and purification stages, the "green" H_2 production and the catalytic conversion in one or more stages to e-fuels, making the overall process expensive and inefficient in terms of effective reduction of the carbon footprint[2]. Therefore, the innovative solution that this research aims to develop is based on integrated electrochemical devices, that directly incorporate CO_2 capture and conversion. The goal is directly use the captured CO_2 and sunlight to produce e-fuels through photoelectrocatalytic devices (PEC). In this way devices could operate independently from the availability of electricity from renewable sources, as well as the process costs would be strongly reduced to develop a competitive Solar-to-X (StX) technology that opens new market prospects compared to current e-fuels production technologies.

Results and Discussion

A promising Zr-based MOF system has been selected to be incorporated into a polymeric membrane (Nafion) to obtain a MOF-based mixed matrix membrane (MMM) to be inserted on the gas diffusion side of a porous GDL electrode and a preliminary characterization has been performed. In parallel, proper Cu metal particles and Cu coordination compounds have been prepared to be applied as catalytic components for CO_2 reduction. In particular, complex $[Cu(Neocuproine)_2]^+(PF_6)^-$ has been successfully deposited onto the disk surface (dia=0.5cm) of a GC-RDE (Rotating Disk Electrode) in order to characterize the powder and to study the CO_2 reduction on that material through cyclic voltammetry measurements ranging the potential between -1.5 to 1.6 V vs Reversible Hydrogen Electrode (Fig. 1).

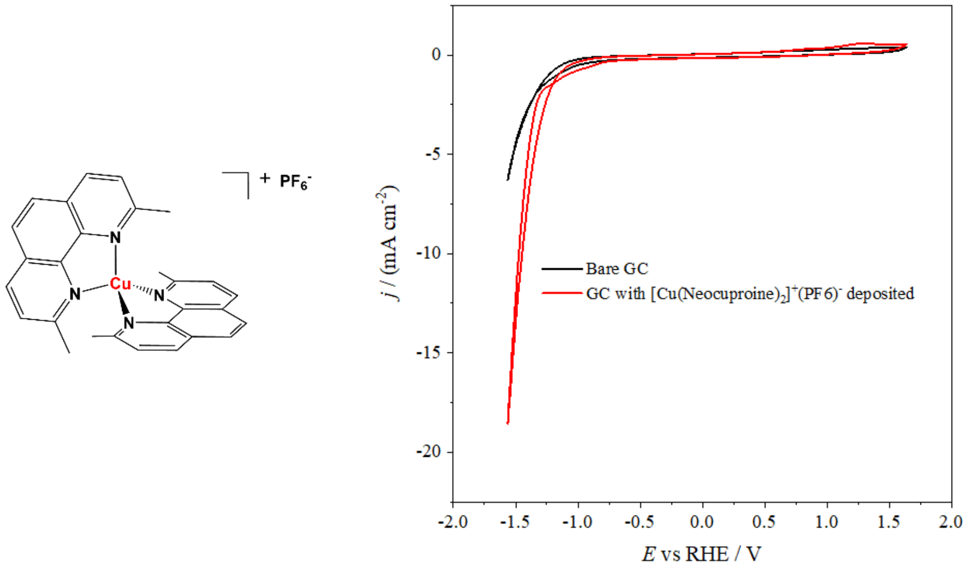

Figure 1 Cyclic voltammetry performed on glassy carbon (black) and on glassy carbon with the copper complex deposited (red) in $NaHCO_3$ 0.1M solution saturated with CO_2

This cyclic voltammetry clearly shows that, by depositing the metal complex, the cathodic current deeply increases, which means an augmented activity toward the reduction of the CO_2 saturated solution. The comparison between activity of the Cu complex with CuO_X nanoparticles showed interesting effects. Then, the GDL electrodes have been evaluated in the electroreduction of CO_2 to methanol, showing preliminary promising results.

References

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