Strategies for improving GDE performance by a uniform dispersion of catalyst nanoparticles and an optimal Nafion content

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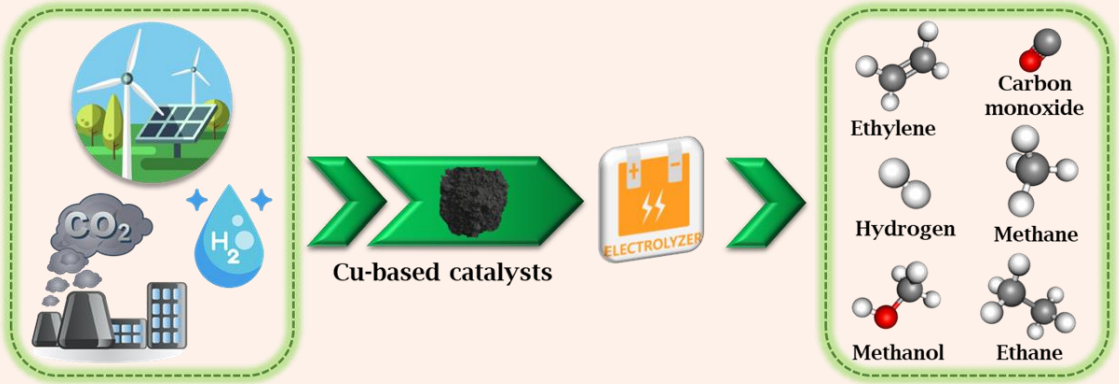
OVERVIEW

The electrochemical CO_2 reduction represents a promising alternative to mitigate **CO_2 emissions** and combat **climate change**[1].

In this work, the catalytic ink deposition on a carbon paper support has been carried out both by **airbrushing** (manual) and by **spray-coating** (automated).

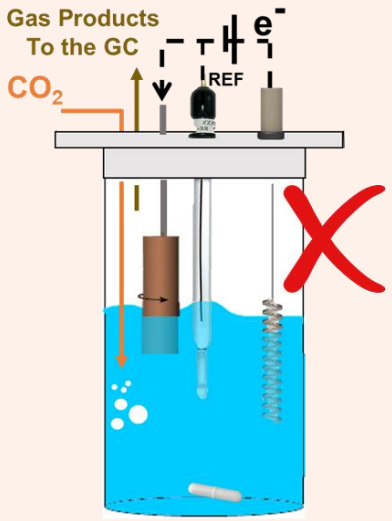


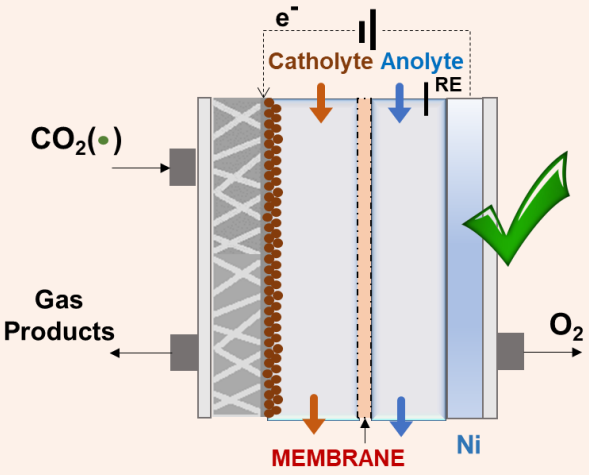
Cu-based catalysts[2] have been used to perform the EC-CO_2RR in a GDE-based setup.

The physical-chemical properties of the catalytic materials employed have been investigated through different characterization techniques.

AIMS

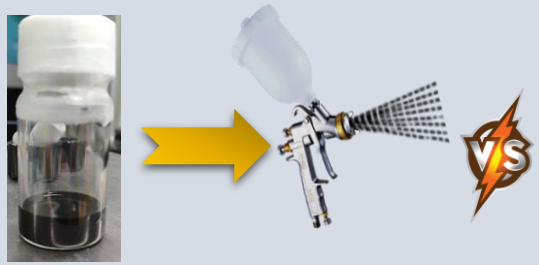
- To overcome the **limitations** shown by configurations with **CO_2 dissolved** in the electrolyte.
- To **exploit** the potential of **Copper-based** catalysts in **prompting the C-C coupling** and **enhancing alcohols production.**
- To achieve a **more uniform deposition**[3] of the catalyst particles by means of an **automated and scalable technique.**



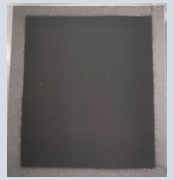


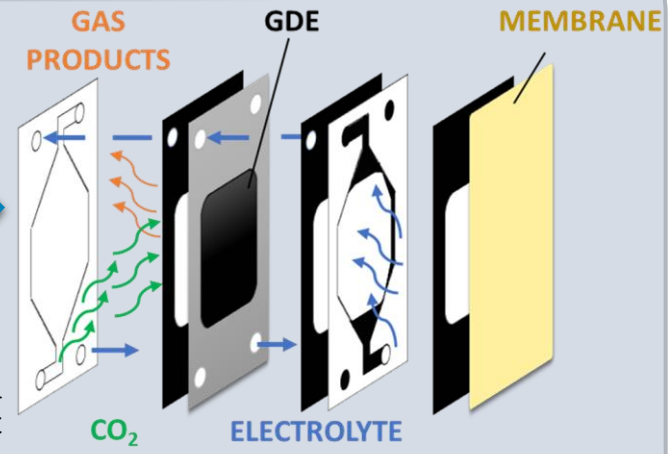
MATERIALS AND METHODS

Cu-based catalysts have been prepared by **co-precipitation method**.



GDE active area:
10 cm²





- The catalytic ink consists of: **Cu-based catalyst** nanoparticles, carbon support (**Vulcan XC 72R**), **Nafion dispersion** and **isopropyl alcohol**.
- The catalytic ink has been deposited onto a porous and conductive support by **airbrusher/ spray coater**.
- Electrochemical measurements in a **continuous flow cell** at ambient conditions.

3-electrode systems
- Working Electrode: Cu-based GDE
- Reference Electrode: Ag/AgCl
- Counter Electrode: Ir-MMO plate

OUTCOME OF THE WORK

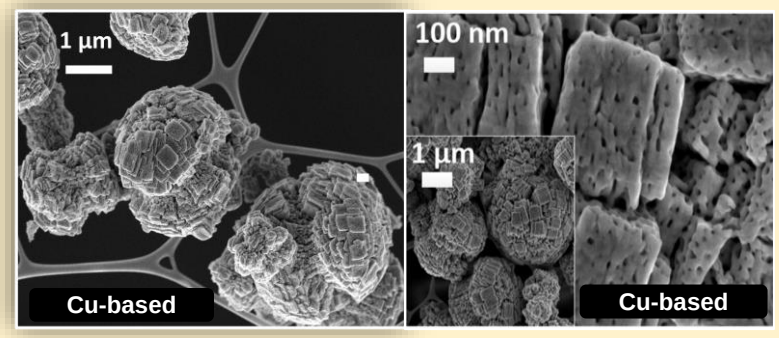


Fig. 1 FESEM micrographs of the synthesized materials.

Microspherical particles made up of rectangular section-structures can be observed.

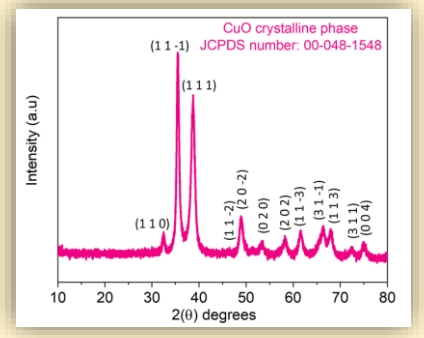


Fig. 2 XRD pattern of the synthesized materials.

The XRD analysis has detected the presence of only CuO in the **crystalline structure**.

Table 1. Physical-chemical properties of the synthesized material.

Catalyst	BET surface area, $m^2 g^{-1}$	Total pore volume, $cm^3 g^{-1}$	Crystallite size, nm
			(11-1) facet of CuO
Cu-based	**23.65**	0.131	**14**

The **Cu-based** catalyst is constituted by **nanocrystals**.

OUTCOME OF THE WORK

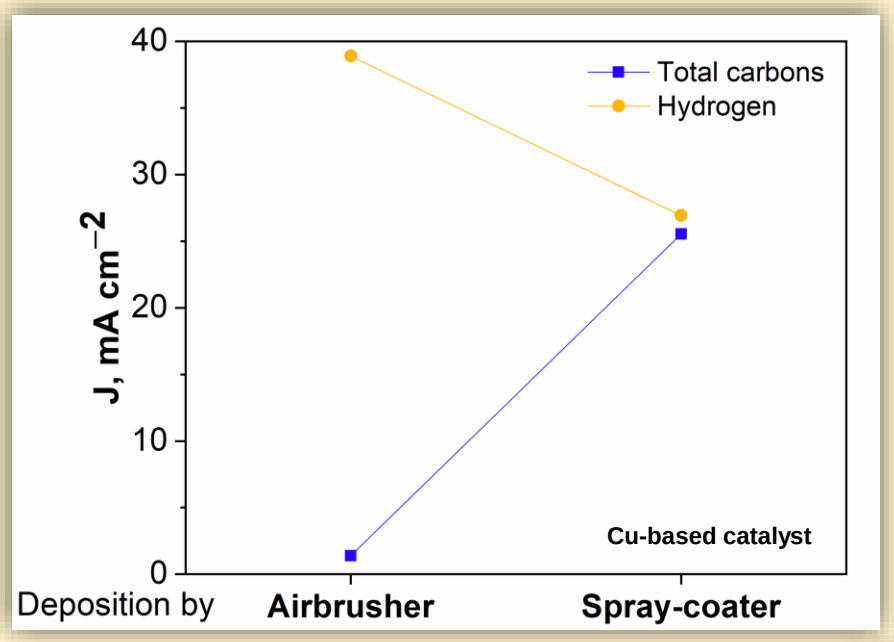


Fig. 3 Effect of the deposition technique on partial current densities (applied current density: 50 mA cm^{-2}).

A higher activity (>~**10 mA cm^{-2}**) has been evidenced by the **spray coated-electrode** during linear sweep voltammetry under CO_2 flow.

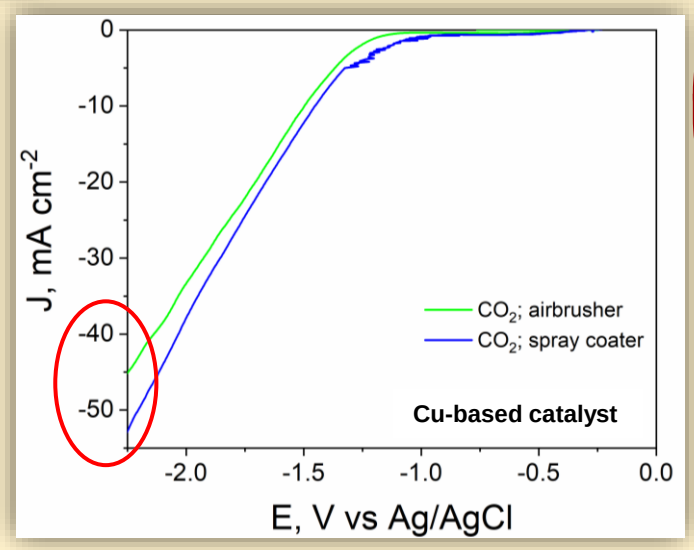


Fig. 4 Linear sweep voltammetry

The ***spray-coated*** electrode far exceeded the performance of the hand-made electrode.

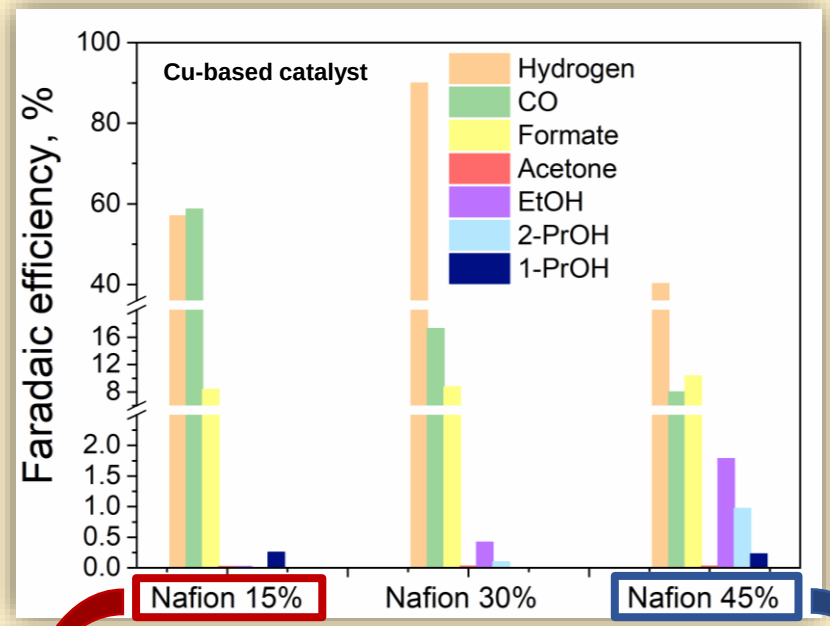


Fig. 5 Faradaic efficiencies of liquid and gas products: Nafion content effect.

A **lower** Nafion content has led to increase CO selectivity; whereas, a **higher** Nafion content has promoted C_{1+} production.[4]

RESEARCH HIGHLIGHTS

- The Cu-based catalysts here synthesised by co-precipitation method promoted C_{2+} products formation and hampered the hydrogen evolution reaction.
- A more uniform and controlled catalyst layer deposition enhanced the electrocatalytic activity.
- The spray-coated electrode outperformed the hand-made one, with FE of ~30% towards added-value products.
- The Nafion content has a relevant effect in the selectivity of the process.

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