

Catalytic vs electrocatalytic CO₂ reduction to added-value products

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Catalytic vs electrocatalytic CO₂ reduction to added-value products / Hernández, Simelys; Guzmán, Hilmar; Salomone, Fabio; Batuecas, Esperanza; Bensaid, Samir; Tommasi, Tonia; Russo, Nunzio. - STAMPA. - (2019). (Giornate dell'Elettrochimica Italiana GEI 2019 Padova (Italia) 8-12 September 2019).

Availability:

This version is available at: 11583/2966202 since: 2022-06-08T16:01:44Z

Publisher:

Società Chimica Italiana

Published

DOI:

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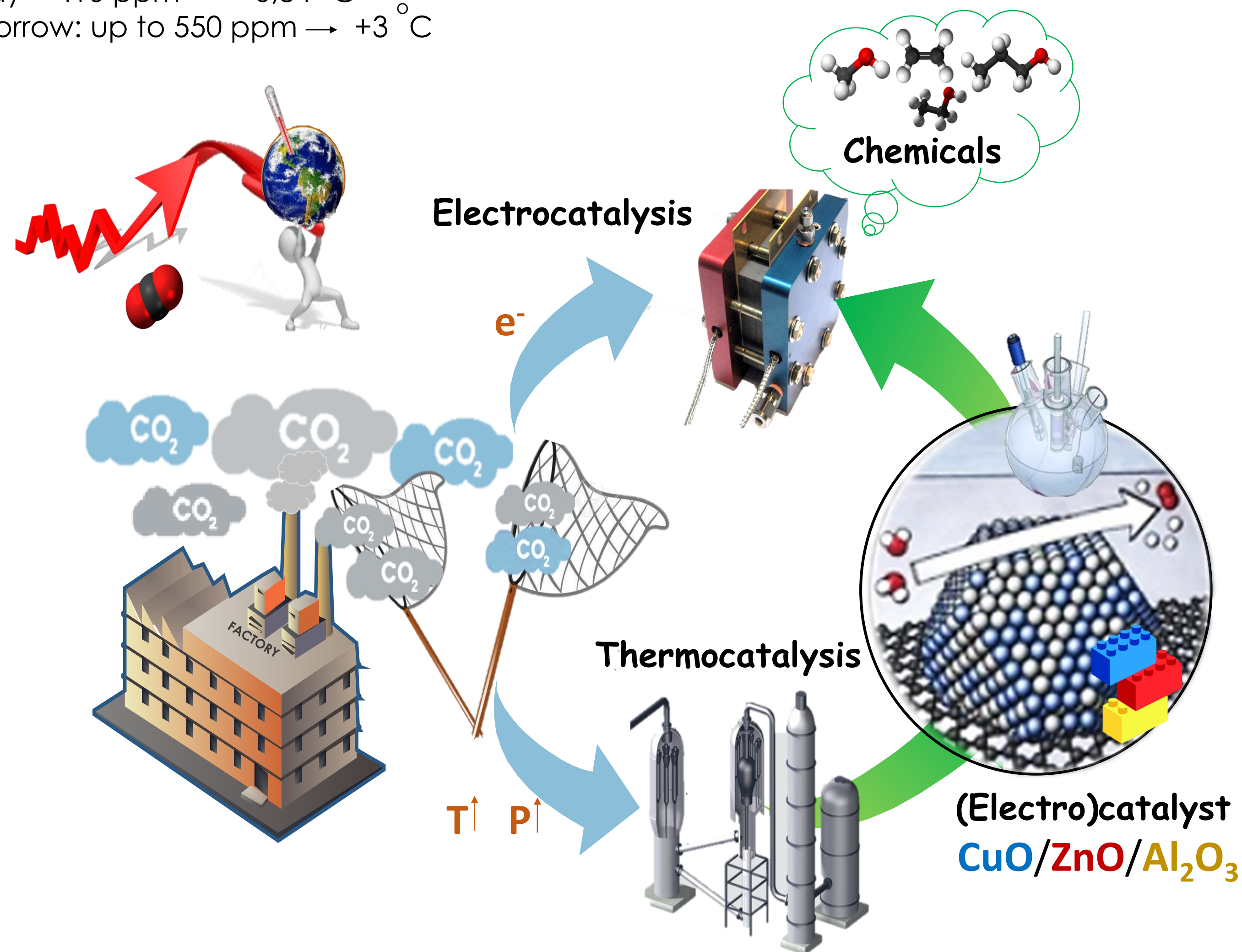
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Overview

CO₂ concentration before industrial revolution = 270 ppm
Today > 410 ppm → +0,84 °C
Tomorrow: up to 550 ppm → +3 °C



The industrialization has not only brought technology and convenience to human life but also the increase in the concentration of CO₂ in the atmosphere over 400 ppm causing the raising of global temperature [1].

Nowadays, exploiting CO₂ as a raw material to synthesize high added-value products via electrochemical reduction reaction is a sustainable interesting process to capture and store energy renewable and CO₂ in the form of chemicals or fuels [2]. In such context, we are exploiting the basic knowledge of thermochemical catalysis to understand the synergies between these two processes and make faster progress in the development of an optimal electrocatalyst [3].

Investigation Highlights

Fig. 3 TEM images: CZA morphology

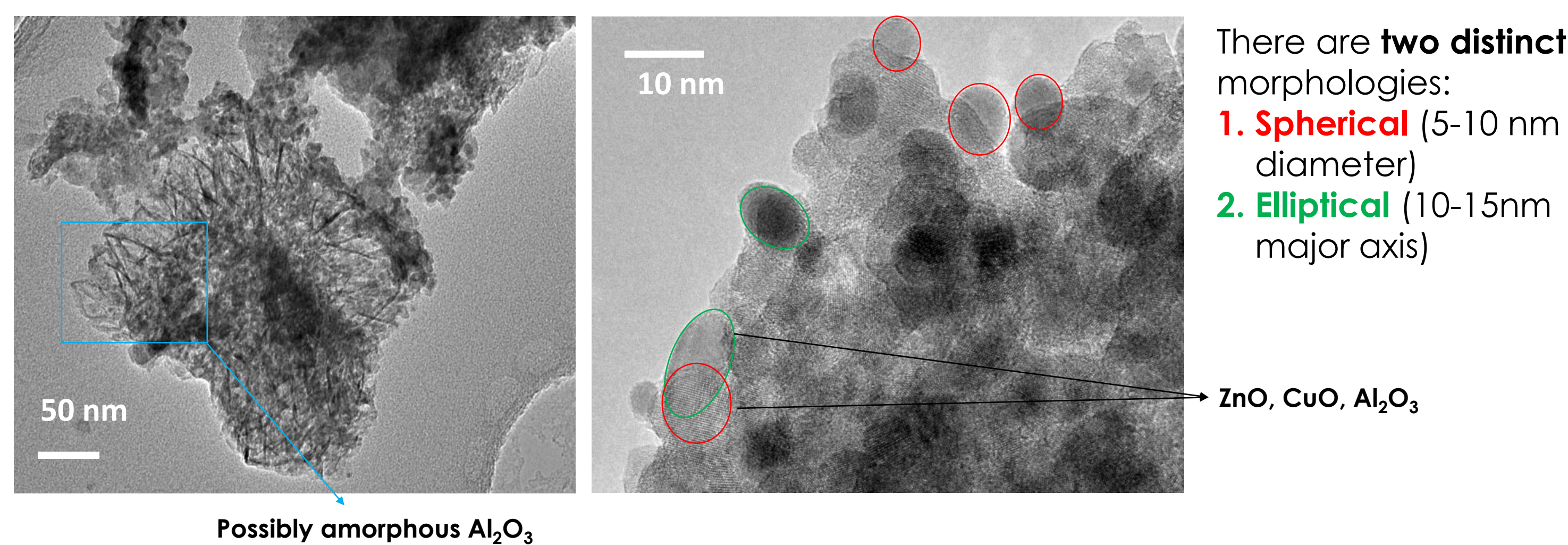


Table 1 Physicochemical properties

Catalyst	Mass percentage, wt%	BET surface area, m ² g ⁻¹	Total pore Volume, cm ³ g ⁻¹	Mesopore volume, cm ³ g ⁻¹
CZA CC	CuO 63,5 % ZnO 25 % Al ₂ O ₃ 10 % MgO 1,5 %	92	0,182	0,164

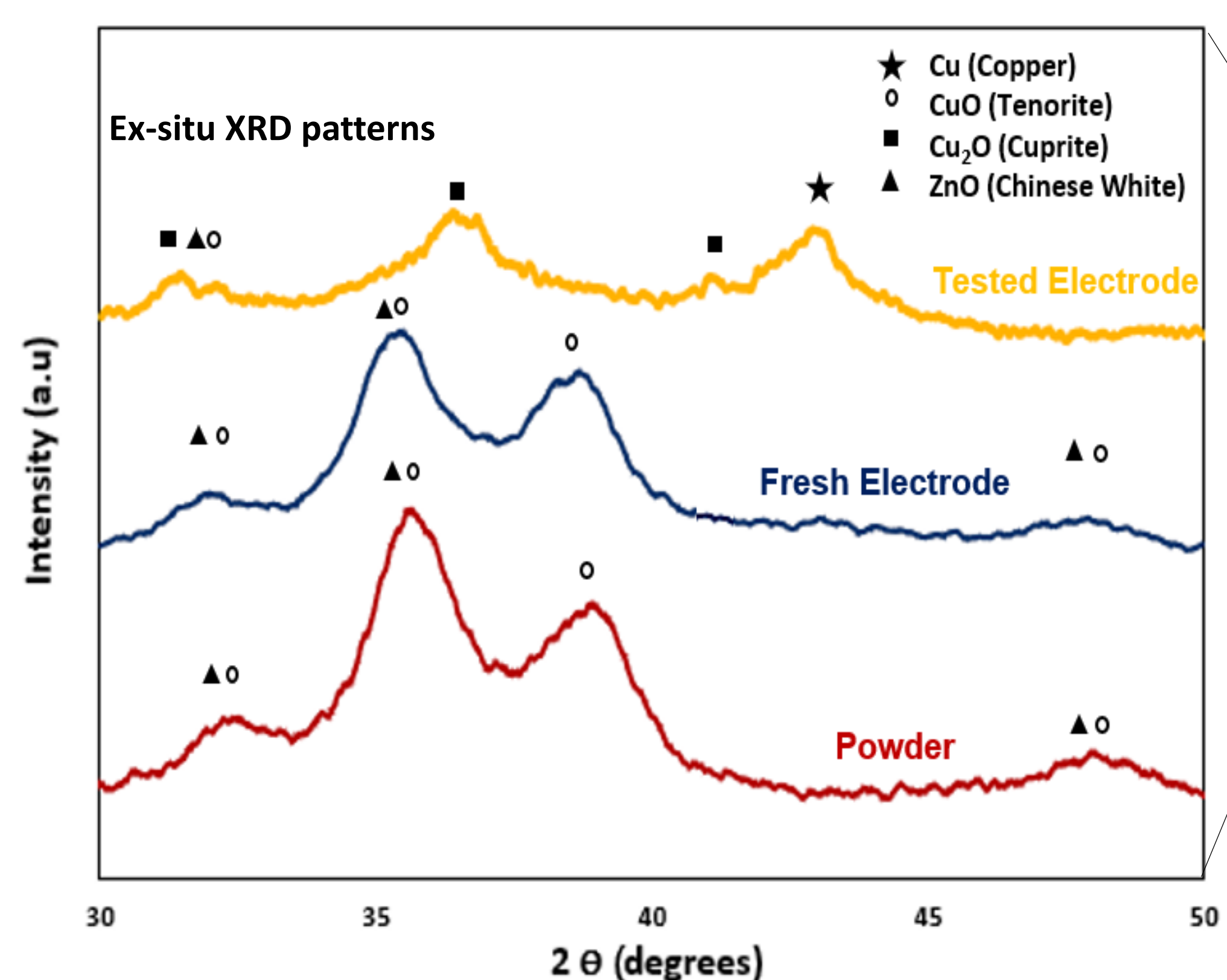


Fig. 5 EX situ XRD patterns of powder catalyst, fresh and tested electrode.

- The powder catalyst and fresh electrode are quite similar.
- The fresh and Tested electrodes evidenced the reduction from Cu⁺² to Cu⁺¹ and Cu⁰ during the **Electrochemical reaction**.
- Exhausted catalyst (**not shown**) from **Thermocatalytic reaction** evidenced a complete reduction from Cu⁺² to Cu⁰.

Recent studies have shown that the interface between Cu⁺¹ and Cu⁰ contributes to the dimerization of CO adsorbed on the electrode surface to generate products ≥ C₂.

Methods and Materials

A **commercial** material composed of CuO, ZnO, Al₂O₃ and a small amount of magnesium oxide (CZA CC) was studied as catalyst in Thermocatalytic and Electrocatalytic tests (See Fig. 1 and 2)

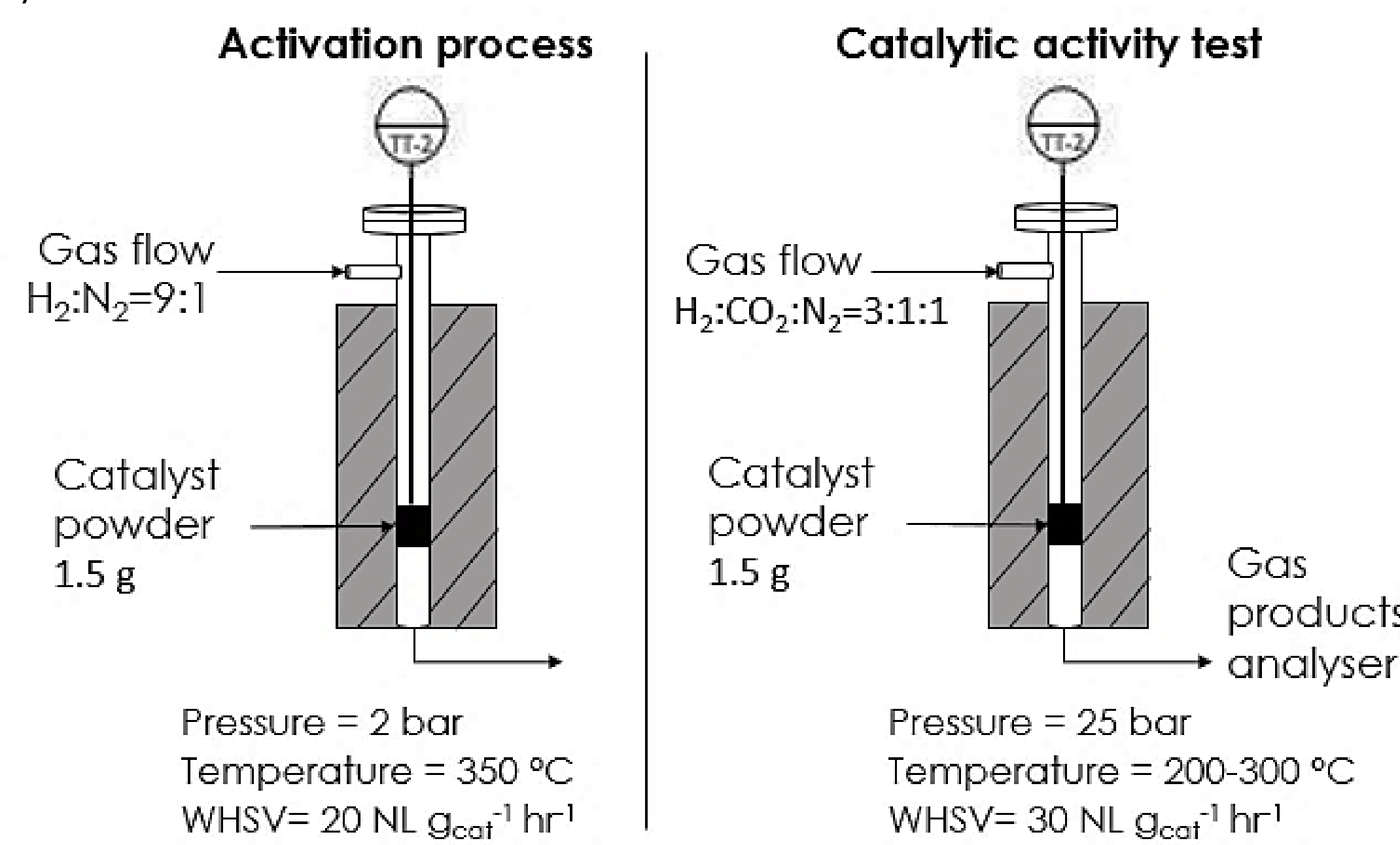


Fig. 1 Thermocatalytic Experimental Setup

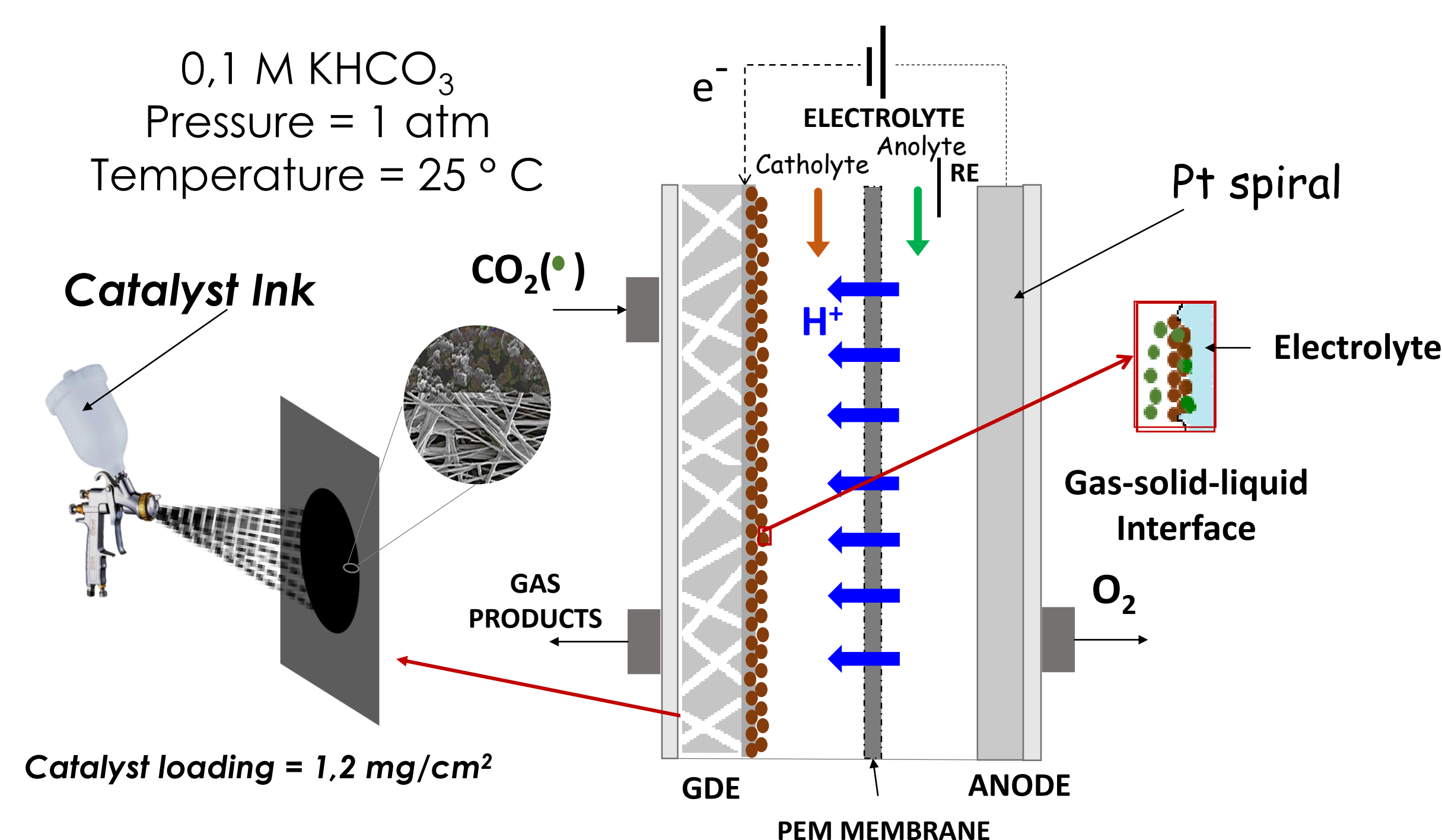


Fig. 2 Electrocatalytic Experimental Setup

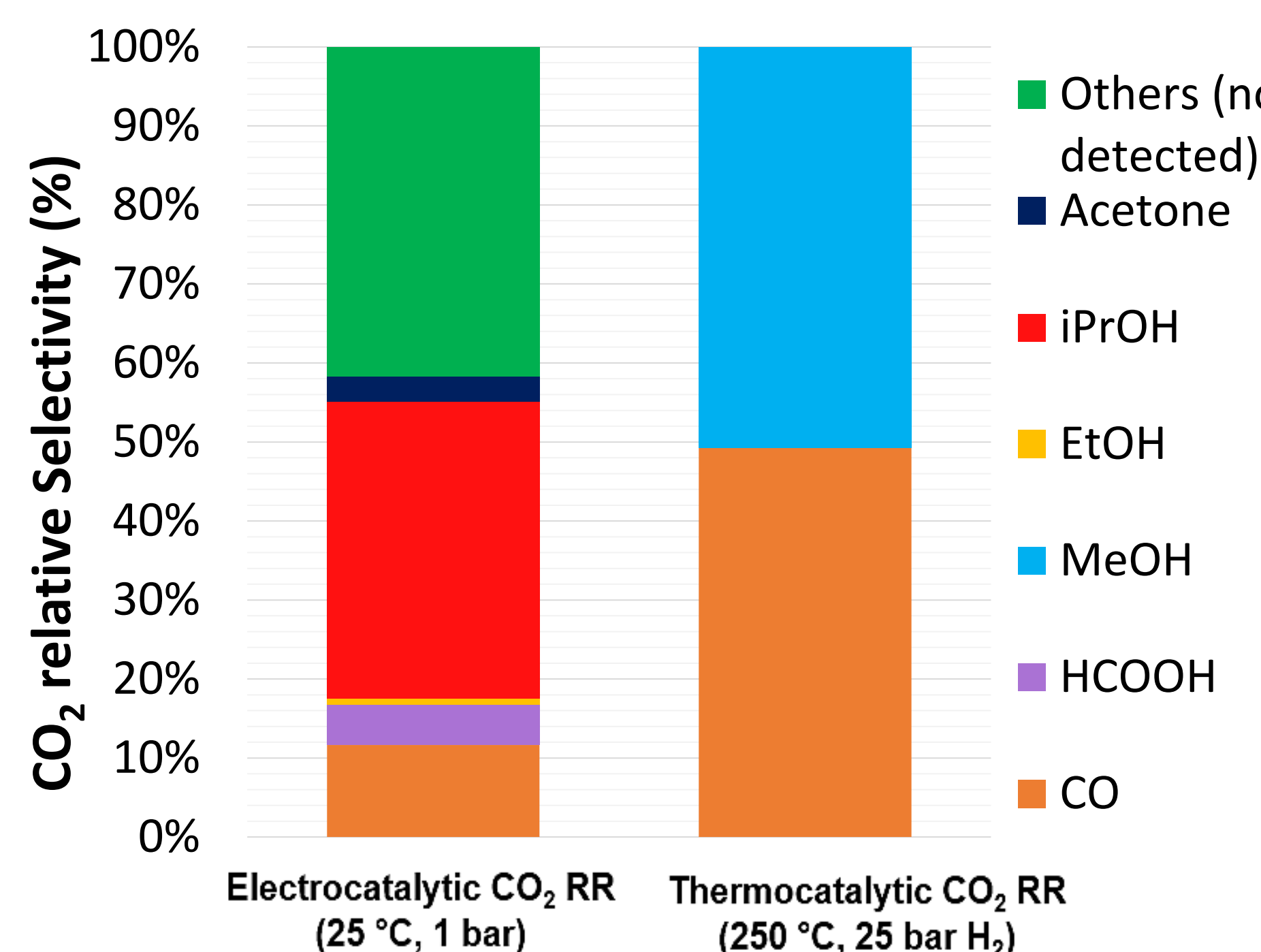


Fig. 4 CO₂ relative selectivity for different products in Thermocatalytic and Electrocatalytic process.

- CZA CC can produce ≥C₂ products at ambient T, via CO₂ electroreduction.
- CZA can also produce methanol at higher T and P, via CO₂ hydrogenation.
- The selectivity ratio of oxygenates/CO is about 8 times higher in the Electrochemical test than in the Thermocatalytic one.

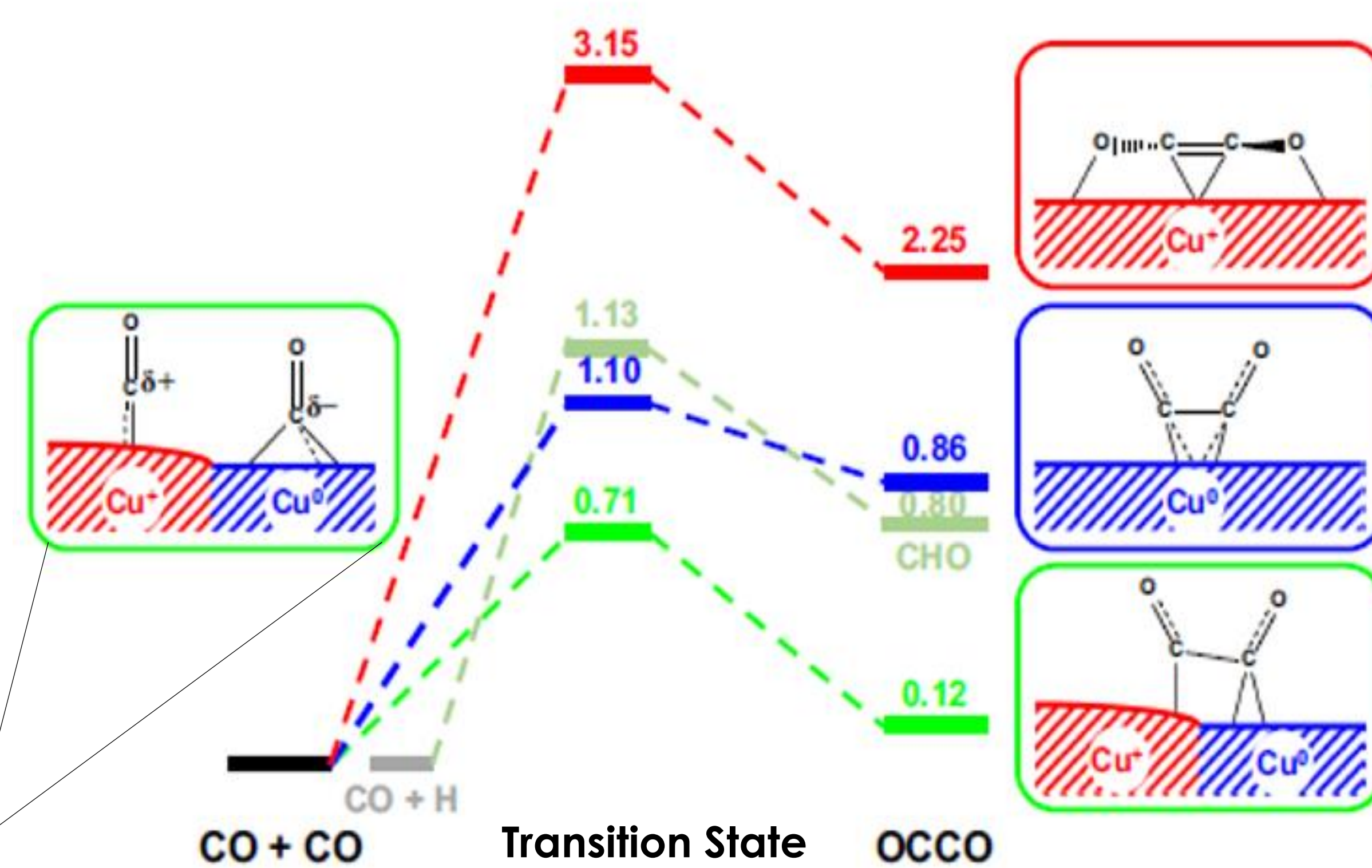


Fig. 6 Free energy profiles of CO dimerization for CO hydrogenation to form surface CHO species taken from reference [4].

Ongoing Work

We are developing a benchmarking protocol to study the activity, stability and Faradaic efficiency of synthesized materials with the same components. The activity of these material will be tested in a home-made prototype of electrochemical reactor created by using 3D printing process and technology.

References

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Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement 768583- RECODE (Recycling carbon dioxide in the cement industry to produce added-value additives: a step towards a CO₂ circular economy) project. (<https://www.recodeh2020.eu/>).
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