



Bimetallic Covalent Organic Framework For Electrochemical CO₂ Reduction



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Background

What is CO₂ Reduction?

Instead of letting CO₂ pollute the atmosphere, we capture it and use electricity to "reduce" it by breaking its chemical bonds to build valuable products.



- The Process:** We take CO₂ emissions from factories or the air and add electricity (ideally from wind or solar).
- The Transformation:** Using our catalyst (COF-SH22), the CO₂ is transformed into clean fuels or raw materials for industry.
- The Goal:** Moving from a linear economy to a Circular Carbon Economy where emissions become the fuel of tomorrow.

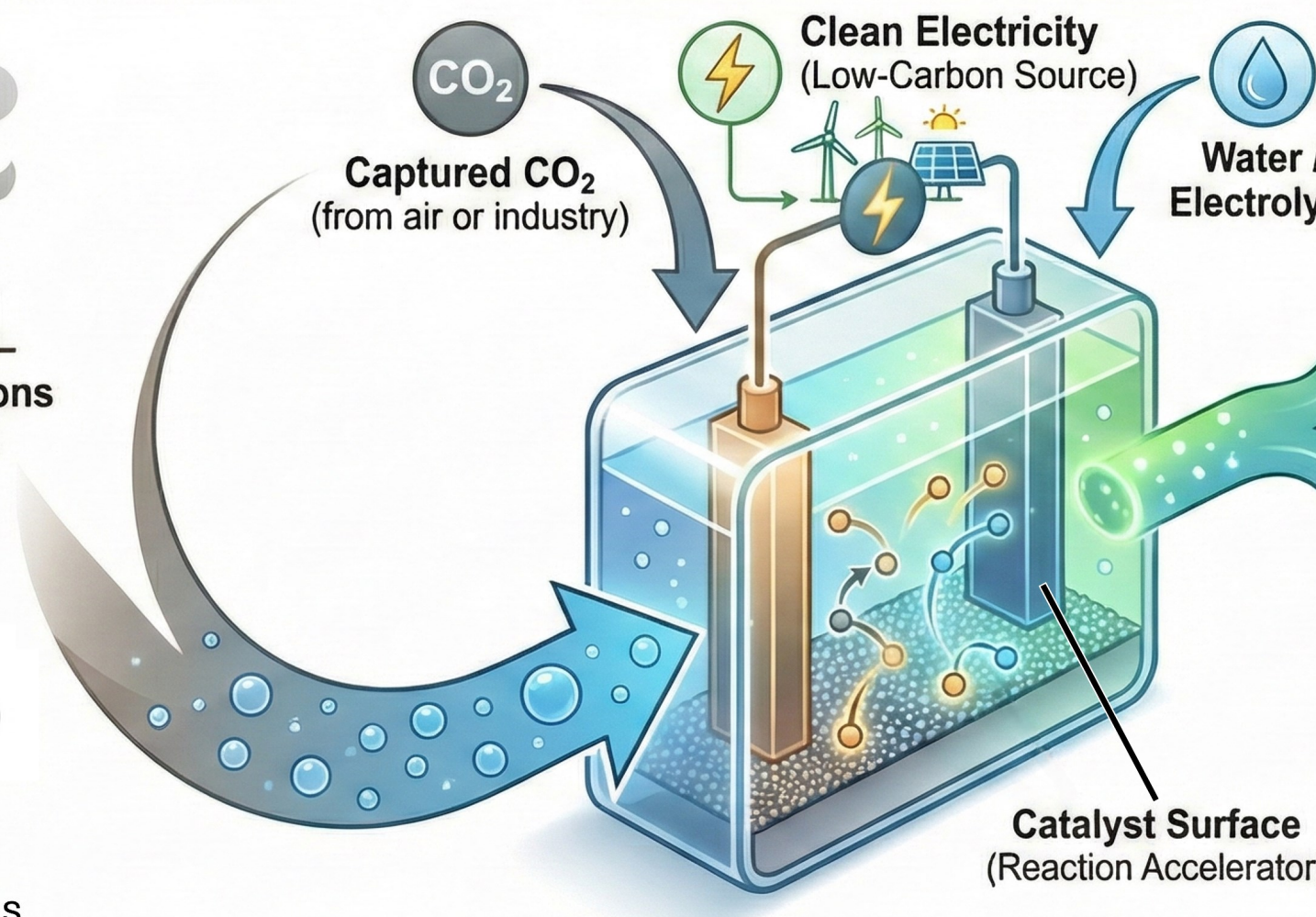
CO₂RR : Transforming Waste CO₂ Into Economic Value

CURRENT LINEAR ECONOMY
(The Problem)



Waste CO₂ Release
(greenhouse gas in the atmosphere)

ELECTROCHEMICAL CELL
(The Technology)



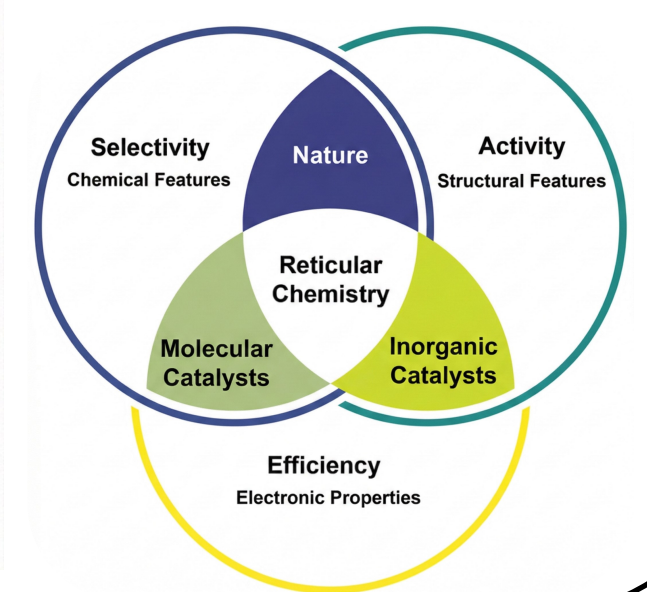
COF-based catalyst

CIRCULAR CARBON ECONOMY
(The Solution)

- Synthetic Fuels** (Transport, Aviation, Shipping) - Energy Storage
- Chemical Building Blocks** (Plastics, Pharma, Fertilizers) - Domestic Supply
- 1. Deep Decarbonisation
- 2. Energy Security & Storage
- 3. Sustainable Growth & Jobs

Why Covalent Organic Frameworks (COFs)?

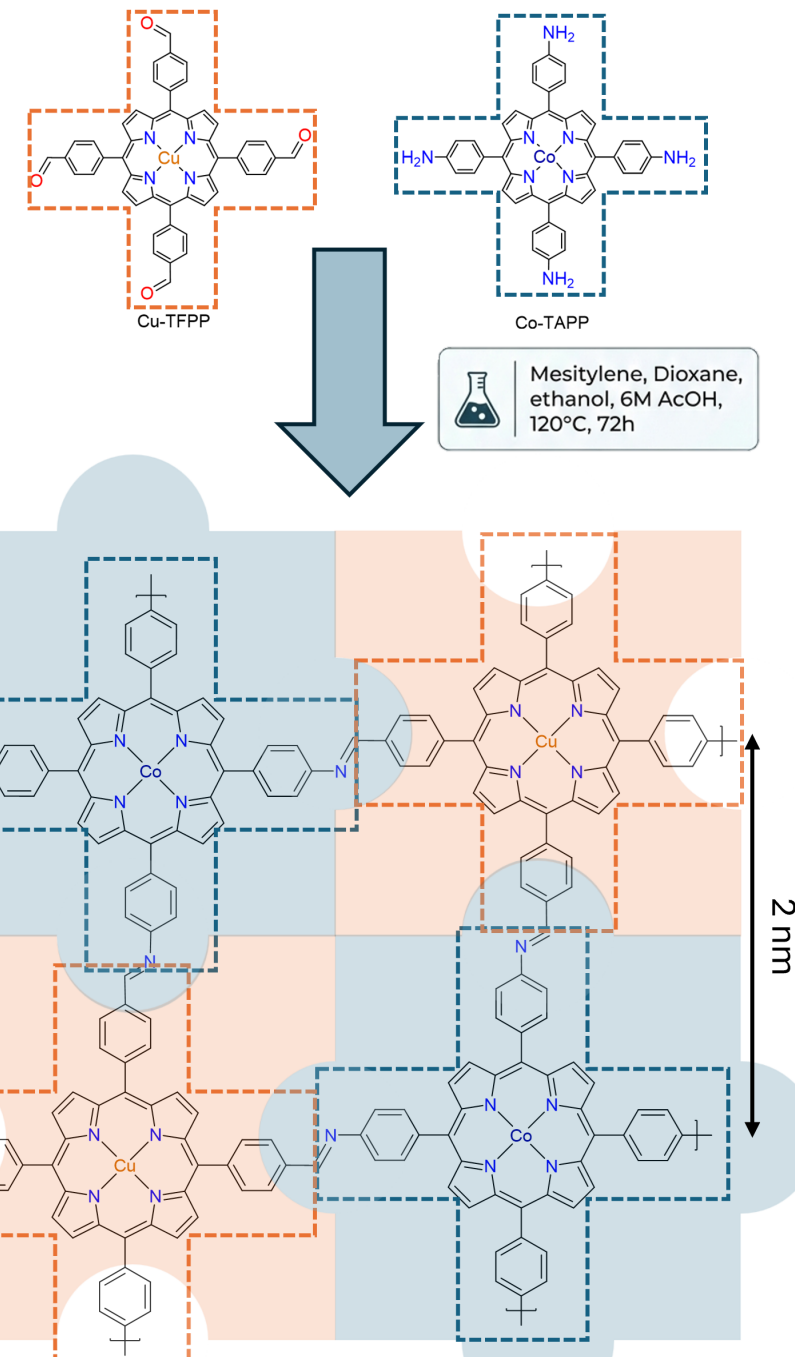
- Atomic Precision:** We place copper and cobalt atoms 2 nm apart to create **synergy** that outperforms traditional, single-metal catalysts.¹
- Maximum Efficiency:** The ordered crystalline structure ensures **no material is wasted**, every atom counts.
- Built to Last:** COFs are **chemically stable** and designed for **long-term industrial use**.²



Our Approach

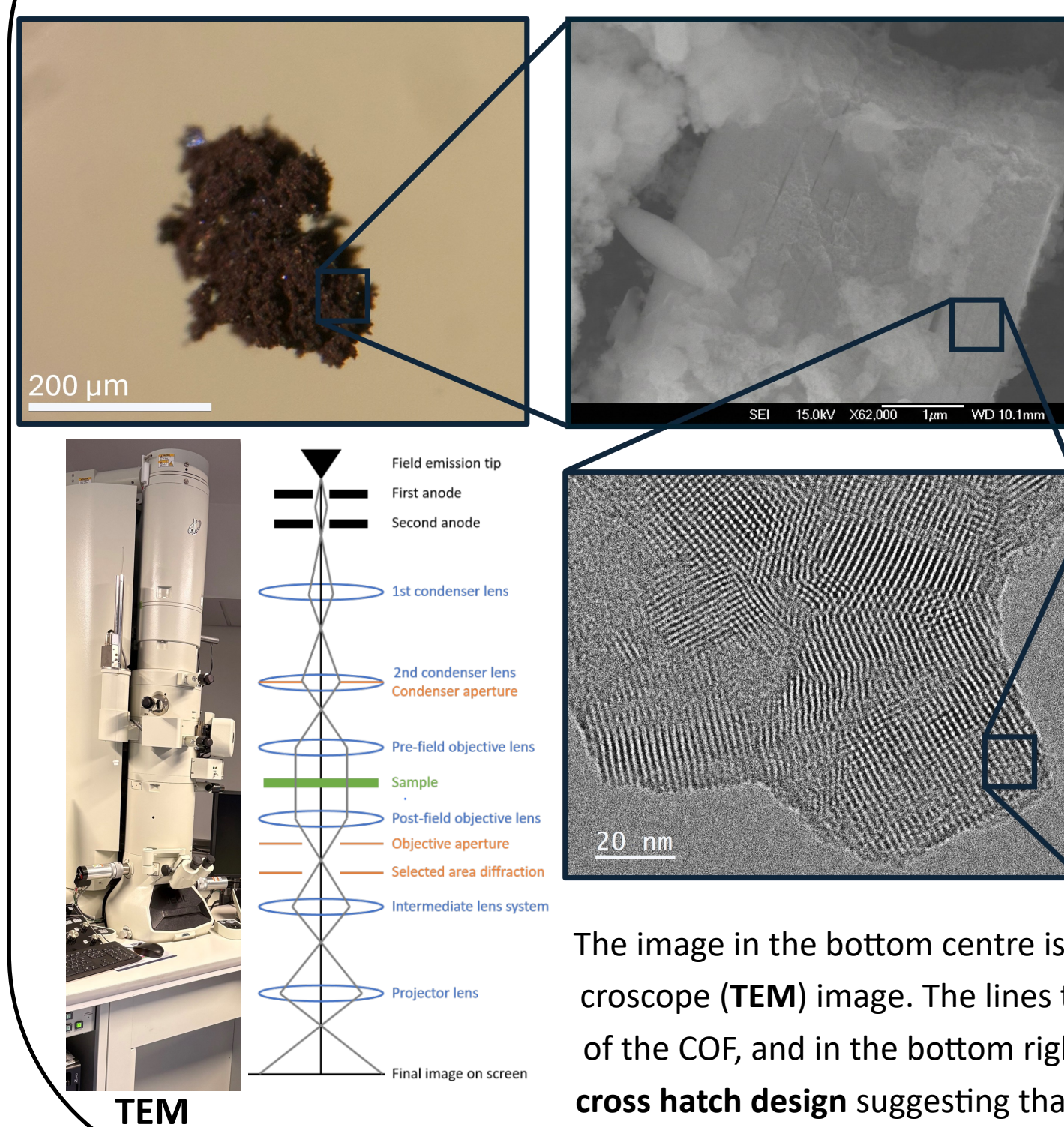
Synthesis

- Modular Assembly:** We use individual "building blocks" that are designed to fit together in a repeating pattern.
- Atomic "Error-Correction":** The chemical bonds used are reversible, allowing the material to "fix" itself during growth.



Structure

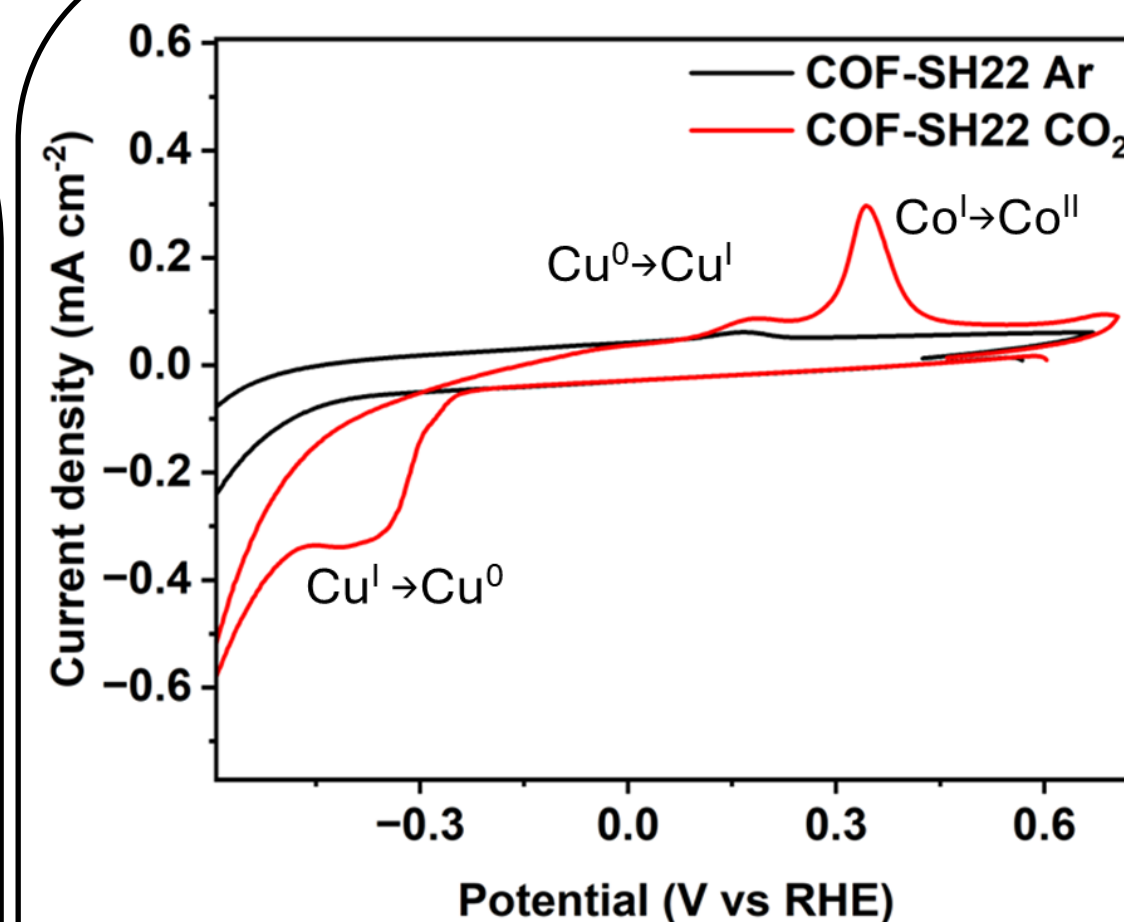
How Do We Know We Have Made A COF With A Checkerboard Atomic Pattern ?



With the use of Microscopy we can see the **individual atoms** within the COF Crystal. By shooting X-rays at the COF we then get back data that tells us that there is Copper and Cobalt in the crystal.

The image in the bottom centre is a transmission electron microscope (TEM) image. The lines that are seen are the atoms of the COF, and in the bottom right of the image they form a **cross hatch design** suggesting that the atoms are arranged as shown in the final image.

Electrochemistry

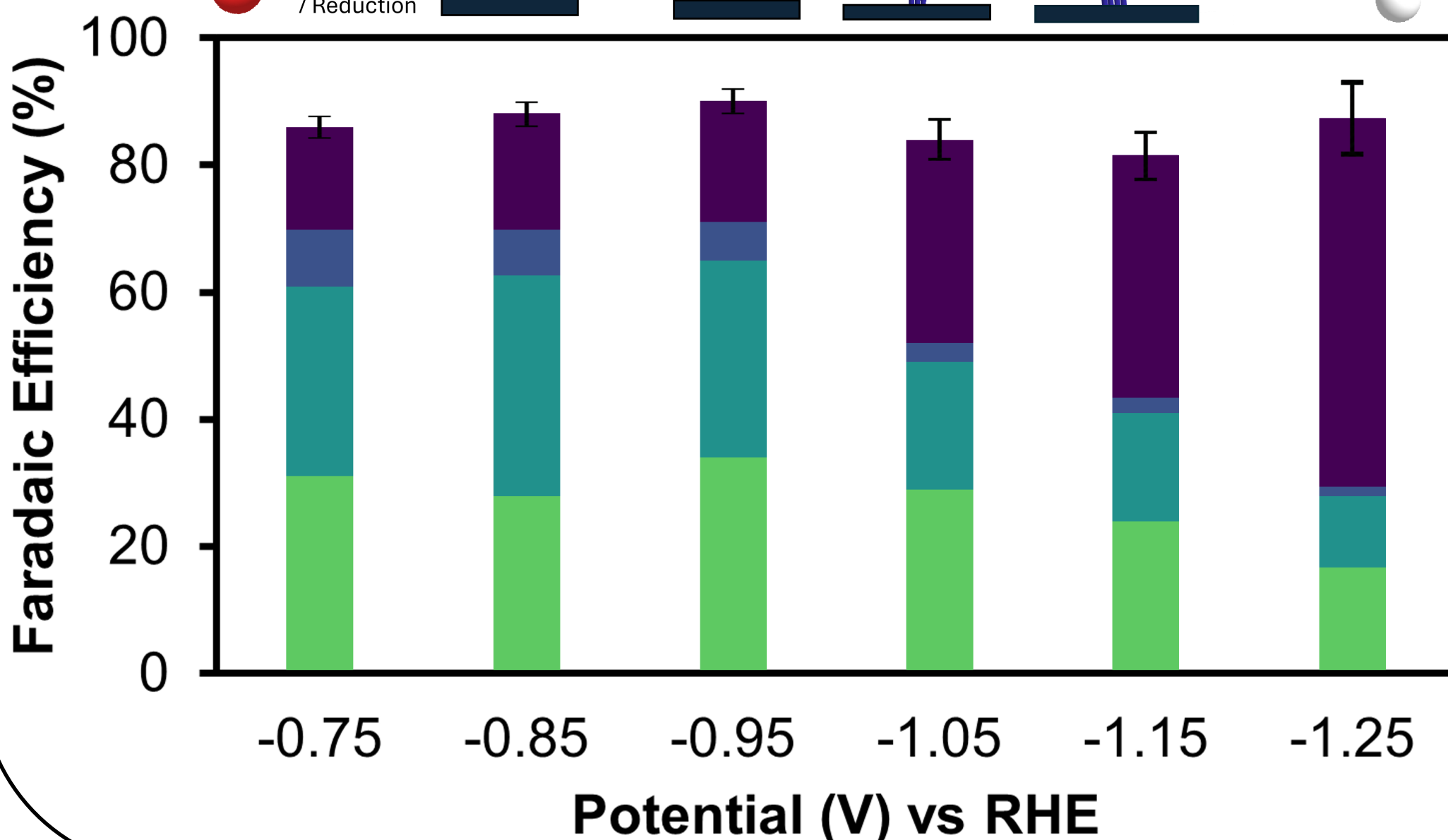
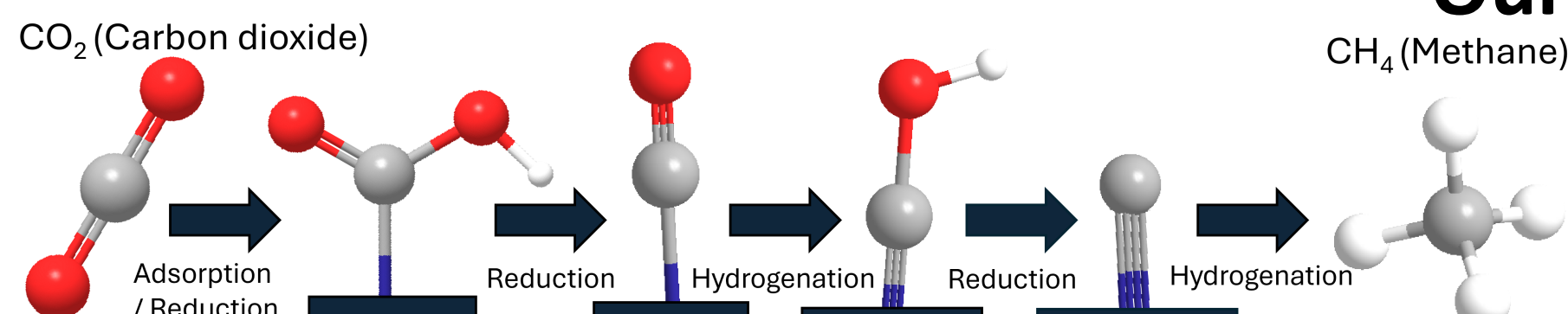


The **Cyclic Voltammetry (CV)** graph acts like a "heartbeat" proving the material is active and moving energy.

Active Centres: The peaks confirm both Copper and Cobalt atoms are functional and ready to convert CO₂.

High-Speed Transfer: The data suggests an "electron highway" where energy jumps between the two metals instantly.

Our Findings



Our COF based catalyst is capable of archiving a faradaic efficiency of **90%** and is able to produce a mix of **valuable products from CO₂**.

- Hydrogen (H₂)** → Fertilisers, Hydrogen power plants, Hydrogen energy storage systems
- Ethane (H₃C-CH₃)** → Clean plastics production, Chemical feedstocks
- Methane** → Transportation fuel, Heating and cooking gas, Power plant fuel
- Formate** → Hydrogen storage material, Chemical feedstocks

References

- S. Lin, C. S. Diercks, Y.-B. Zhang, N. Kornienko, E. M. Nichols, Y. Zhao, A. R. Paris, D. Kim, P. Yang, O. M. Yaghi and C. J. Chang, *Science* (1979), 2015, 349, 1208–1213.
- Z. Chen, N. Li and Q. Zhang, *Small Struct.*, 2024, 5, 2300495–2300528.

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