Electrocatalytic CO_2 Reduction with Copper/Carbon Catalysts to C_2 and C_{2+} Value-added Products supported over Gas Diffusion Layers

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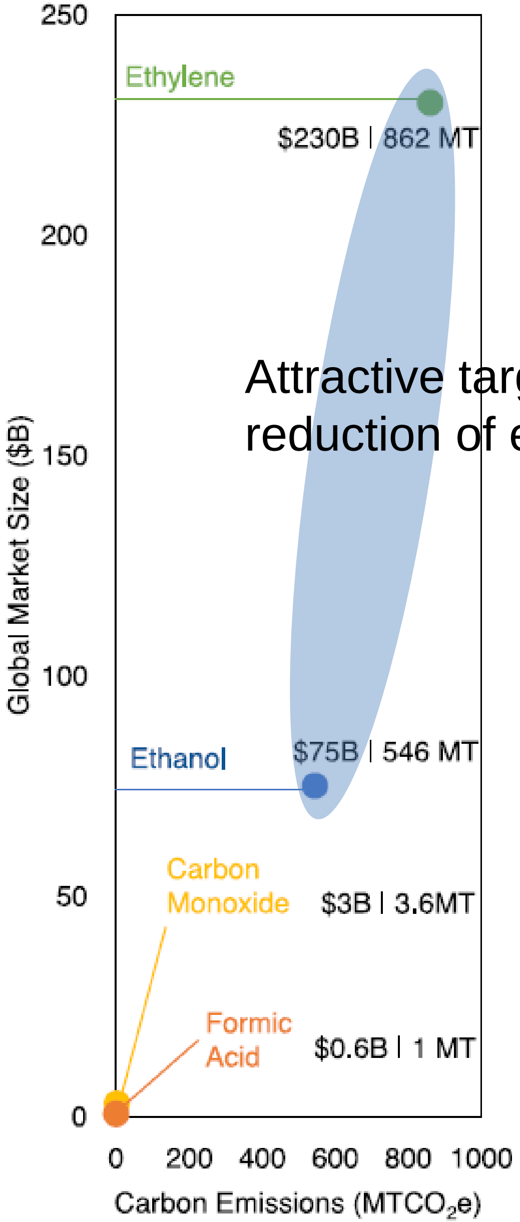
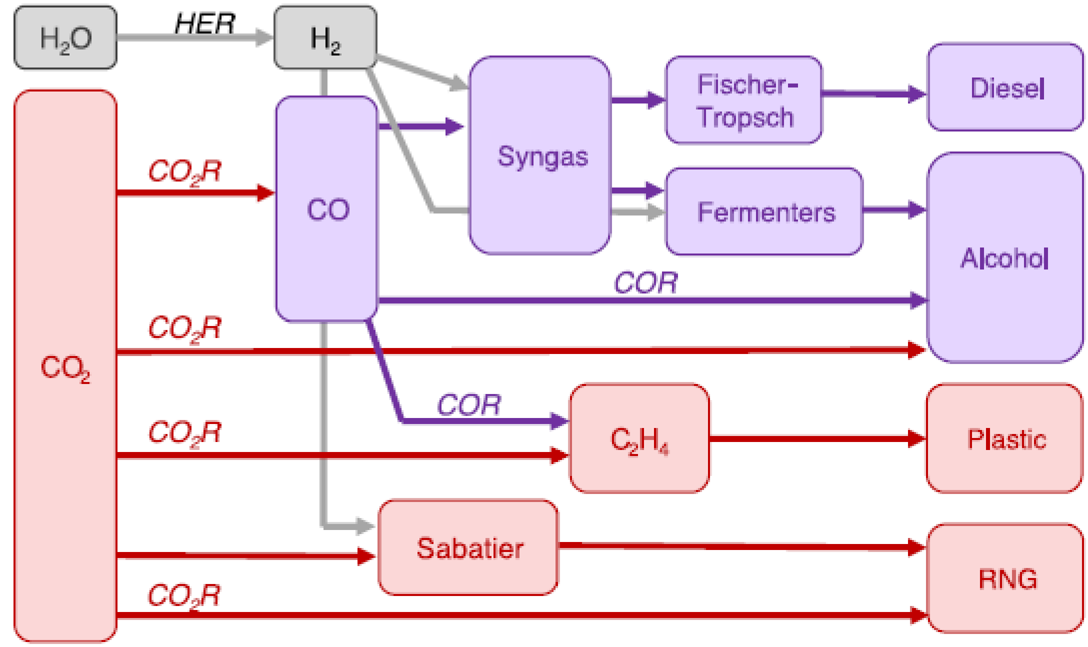
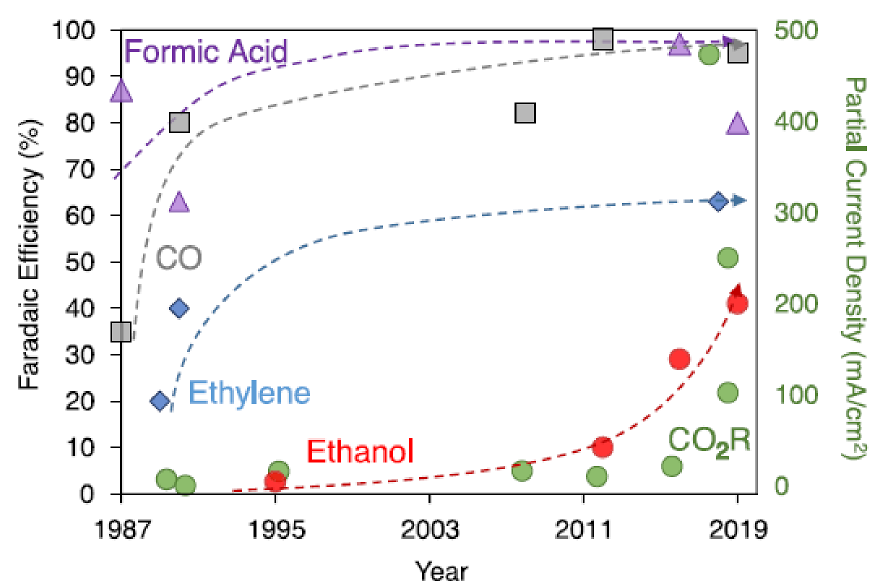
JP AMPEA - Workshop on Carbon Capture, Utilisation and Storage (CCUS)

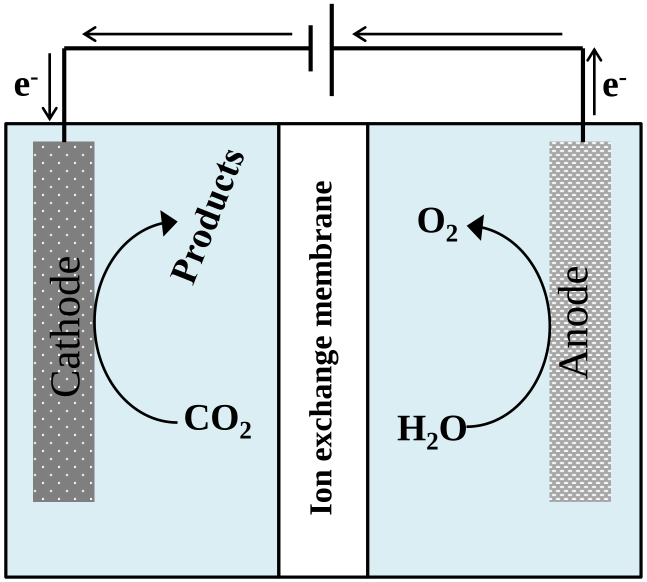


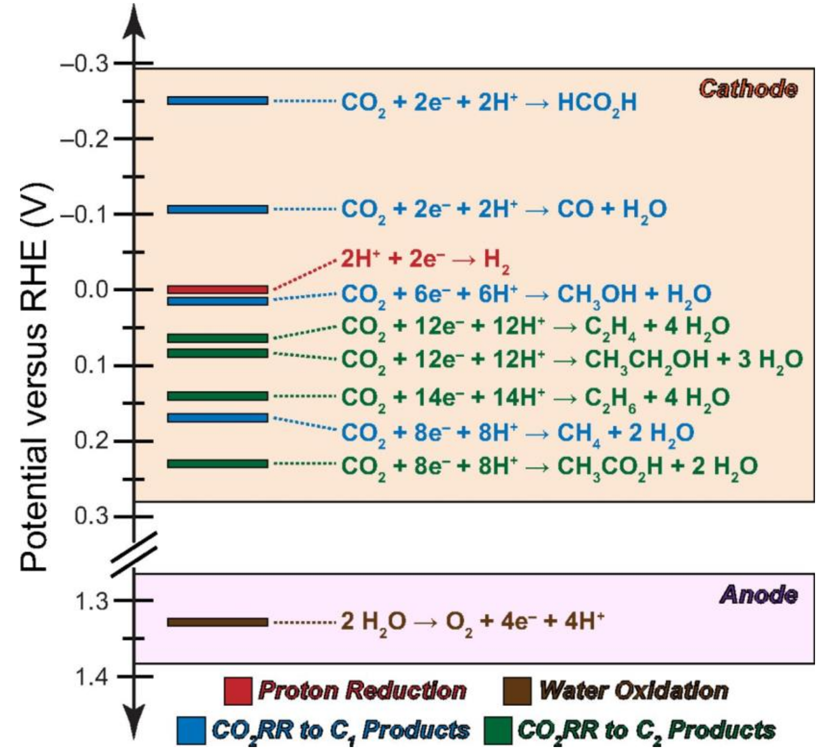
Attractive targets for reduction of emissions



De Luna *et al.*, *Science* **364**, eaav3506 (2019)



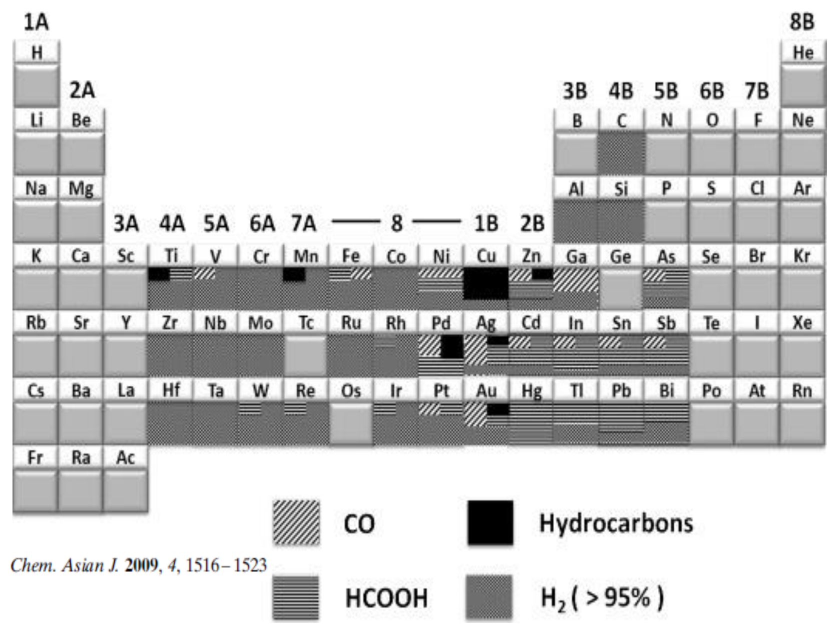




PNAS *2019* 116 (20) 9693-9695

Challenges:

1) HER competitive reaction
2) Selectivity
3) Other issues

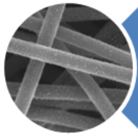


Chem. Asian J. **2009**, *4*, 1516 – 1523

Electrochemical, Chemical Energy Storage & Harvesting

Redox Flow batteries
- Vanadium
- Organic, semi-solid
- Battery components

Post-lithium batteries
- Li-S
- Sodium batteries
- Ionic liquid electrolytes

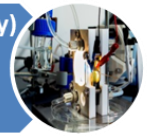


Supercaps
- Porous electrodes
- Flow supercaps
- Lithium capacitors

Electrode fabrication
- Electrospun carbon nanofibers
- Hydrothermal , electrodeposition
- Simulation modeling

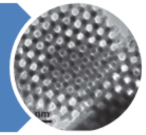
Battery & system testing
- Aging measurements, degradation
- Climatic tests
- Diagnosis and prognosis

Solar fuels (solar refinery)
- Photoelectrochemical process
- Photocatalytic conversion
- Hydrogen – CO_2 reduction

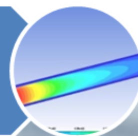


Power-to-X (synthetic fuels)
- CO_2 electrochemical reduction
- CO_2 hydrogenation, plasma & FT
- Biomethane, biorefinery

Catalyst fabrication
- Mesoporous catalysts
- Thin film electrodes
- Electrode passivation

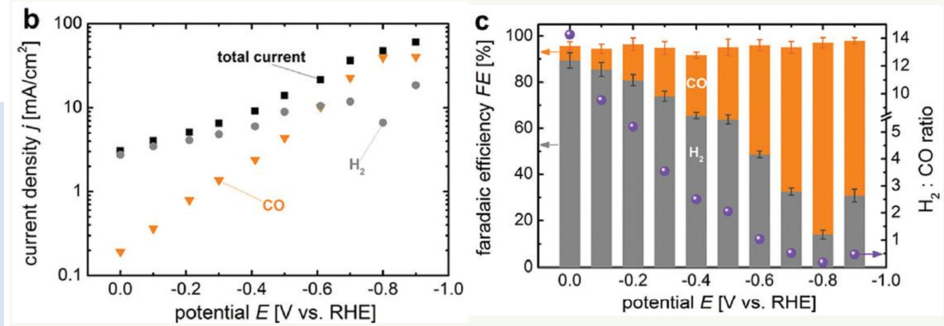


Reactor modeling
- Microfluidic modeling
- Process simulation
- Reactor engineering



Energy Harvesting
- Sensors
- Smart metering
- Fully autonomous systems

EC and PEC-CO_2RR to **syngas**



Energy Environ. Sci., 2017, 10, 2256-2266

EC and PEC-CO_2RR to **$HCOO^-$**

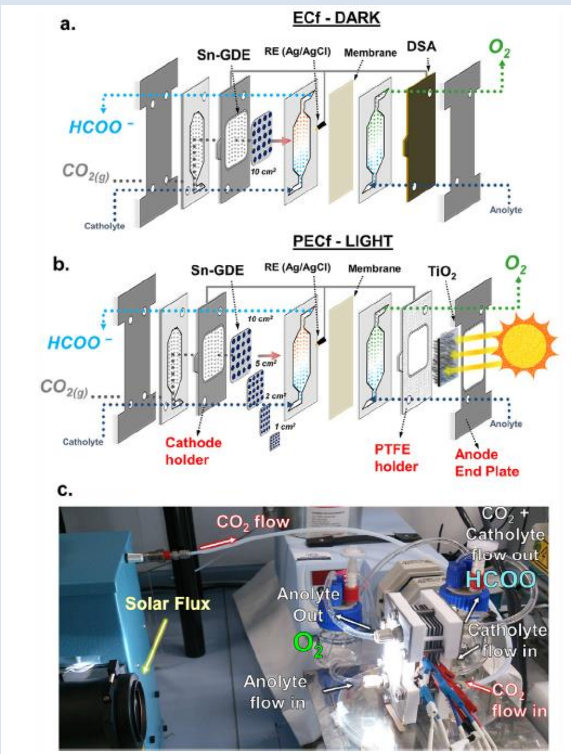
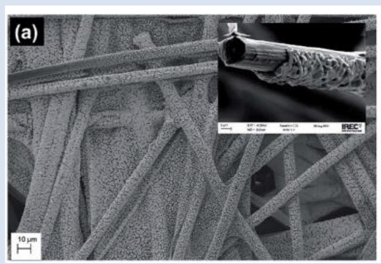
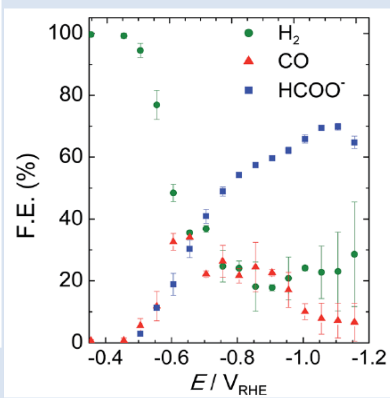


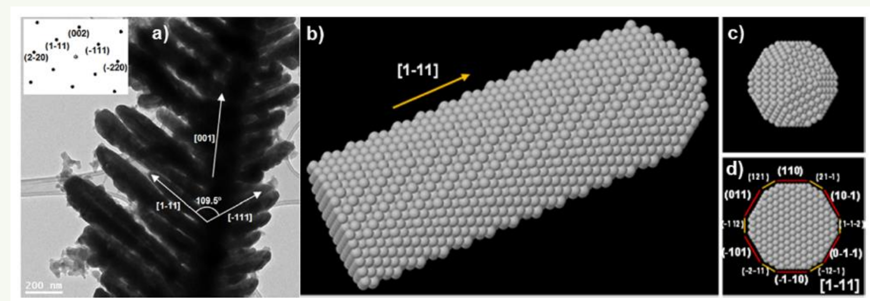
Fig. 1. (a) EC_f-Dark: Electrochemical flow cell scheme using DSA anode, (b)PEC_f-Light: Photoelectrochemical flow cell scheme using TiO_2 photoanode and (c) photograph of the PEC_f cell setup.

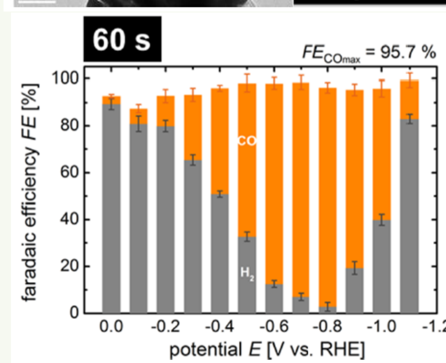
Electrochimica Acta 240 (2017) 225–230

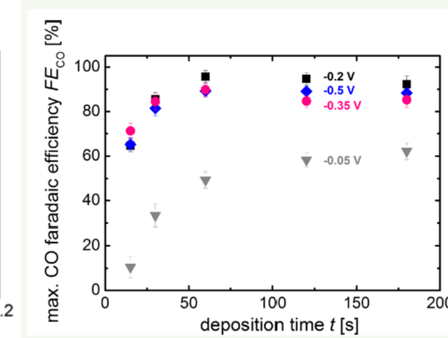




J. Mater. Chem. A, 2016, 4, 13582–13588







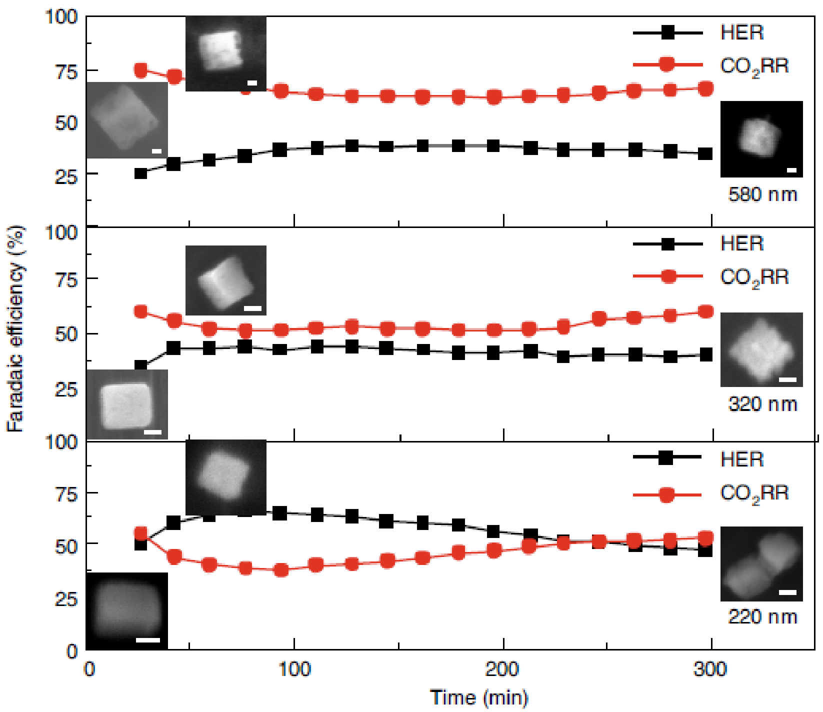
ACS Appl. Mater. Interfaces 2018, 10, 43650−43660

EC-CO_2RR to **C_2 products (C_2H_4)**

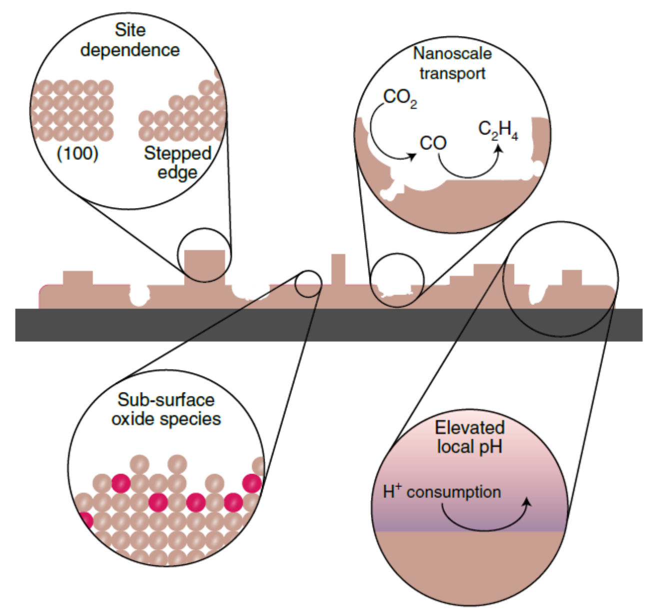
Hydrocarbons
CH_4
C_2H_4
CH_3OH
C_2H_5OH

- Shape → crystal orientation
  particle size
- Grain boundaries
- Oxidation state

Configuration: pH, GDE architecture

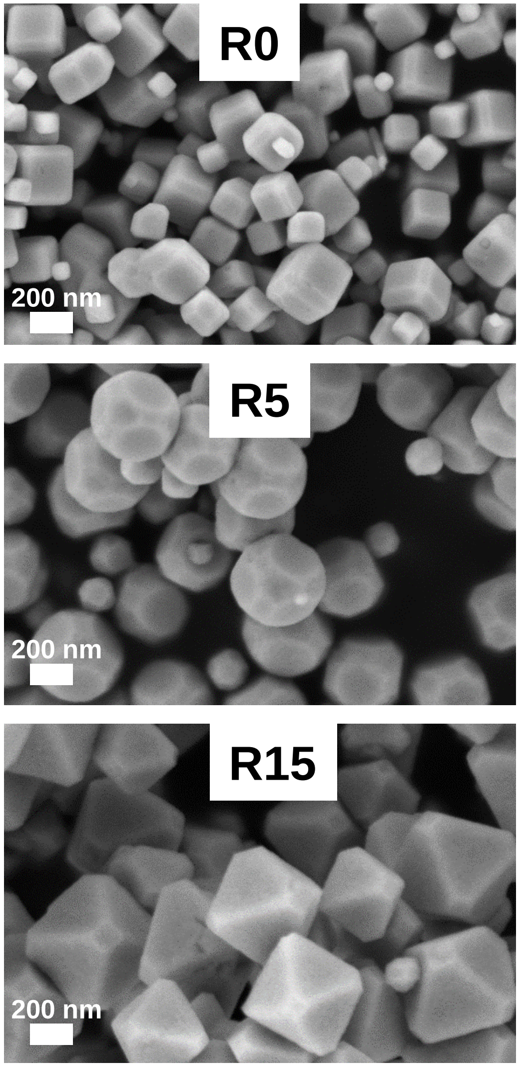


Nature Catalysis **volume 2**, pages198–210(2019)



Nature Catalysis **volume 2**, pages648–658(2019)

Evaluation of Cu_2O catalysts (R= Cu/PVP ratio)

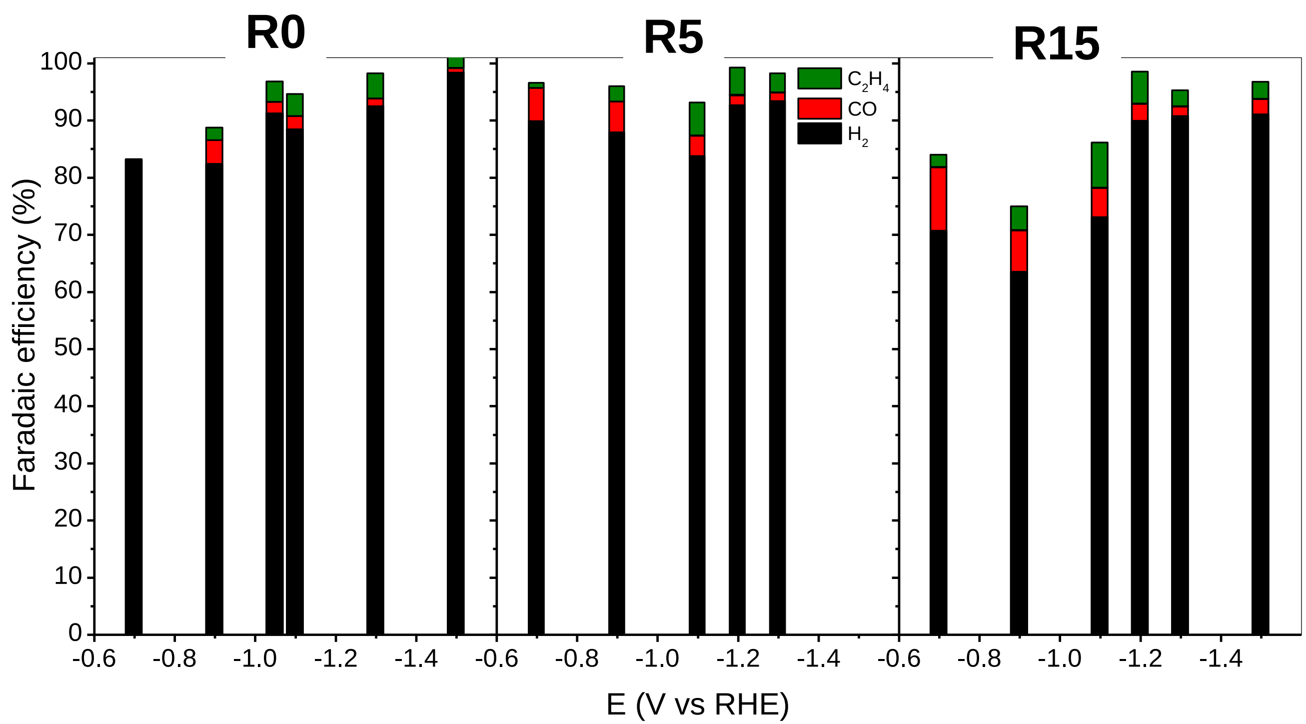


Sample	$I_{(111)}/I_{(200)}$
R0	2.6
R5	2.5
R15	11.8

Higher FE_{C2H4} at $-1.1V_{RHE}$

R15 > R5 > R0

Essentially, not so different



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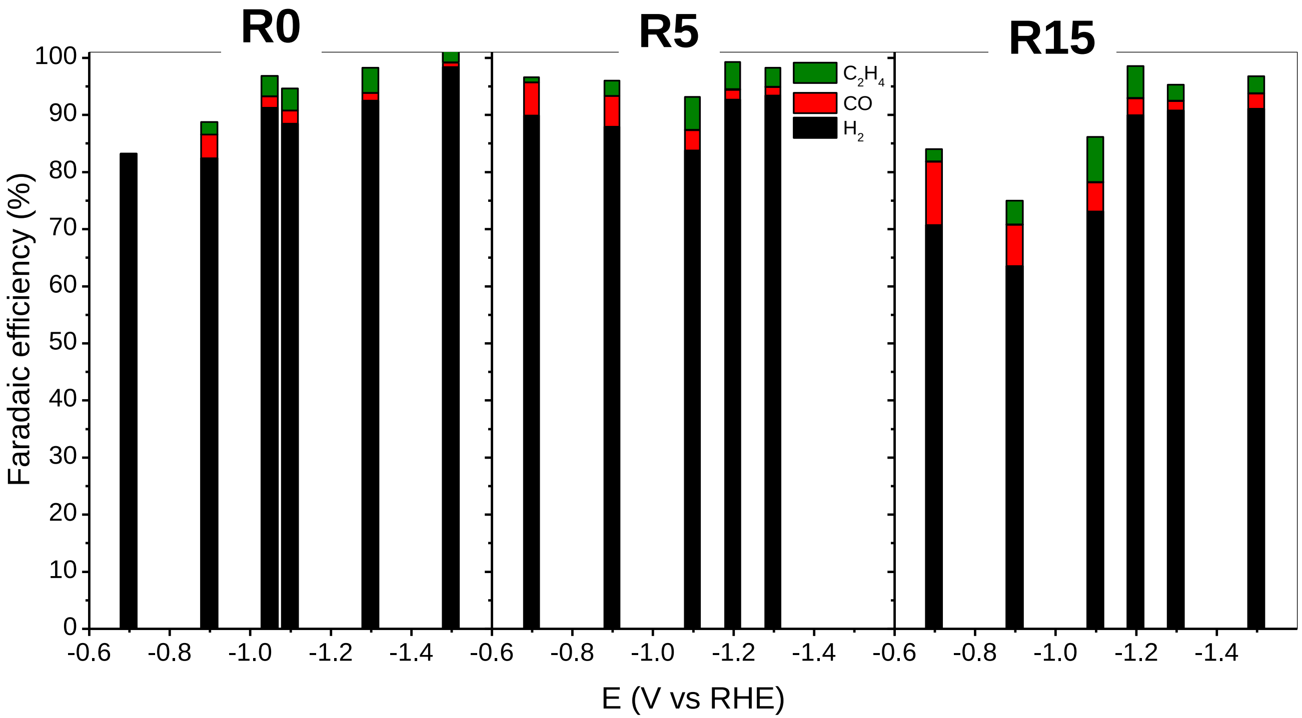
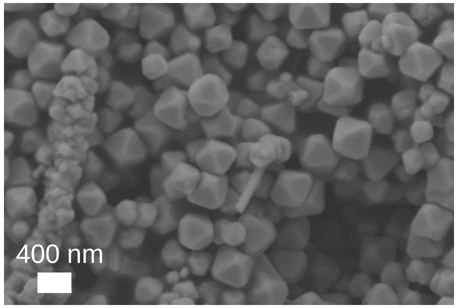
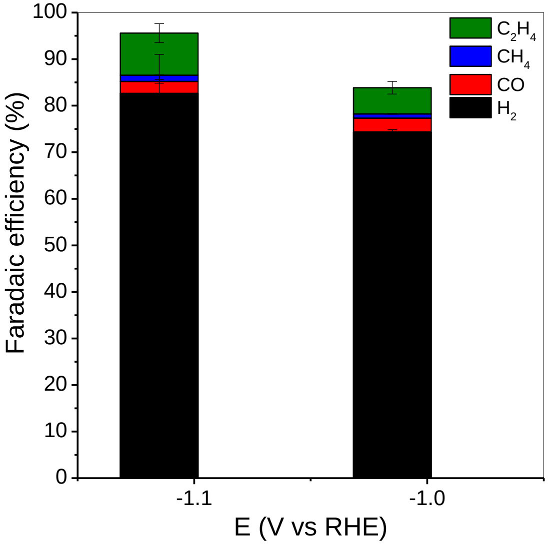
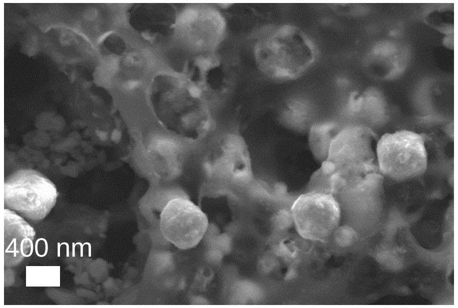




H-cell

Flow-cell



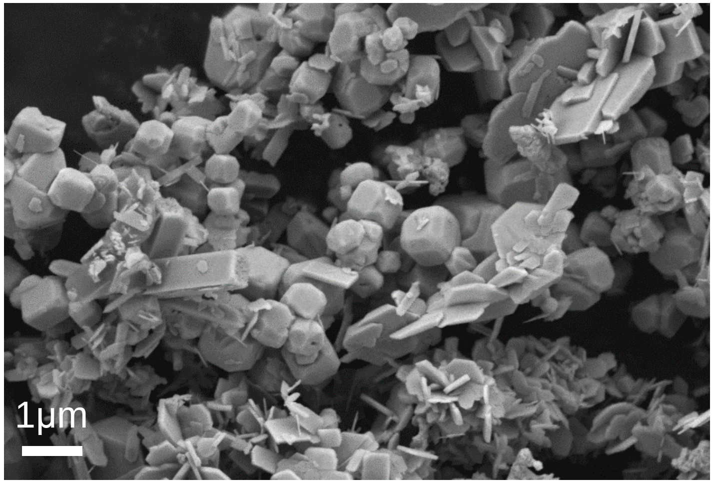


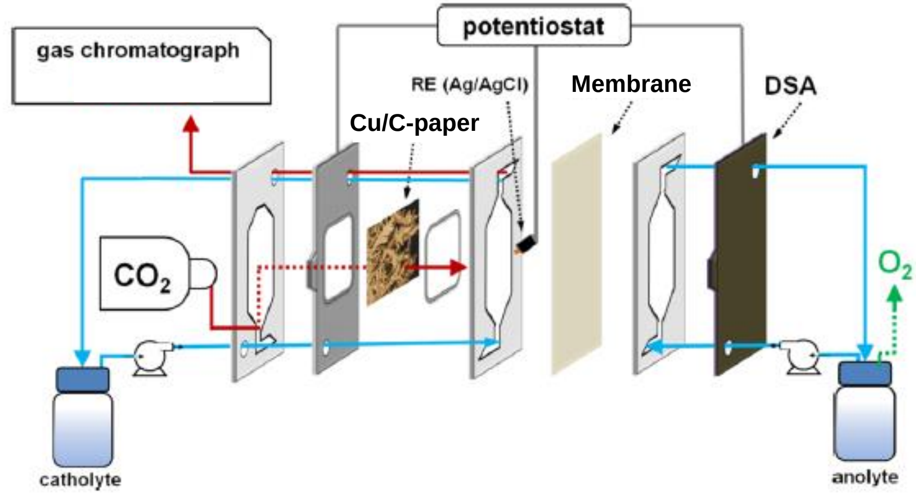
High productivity of H_2

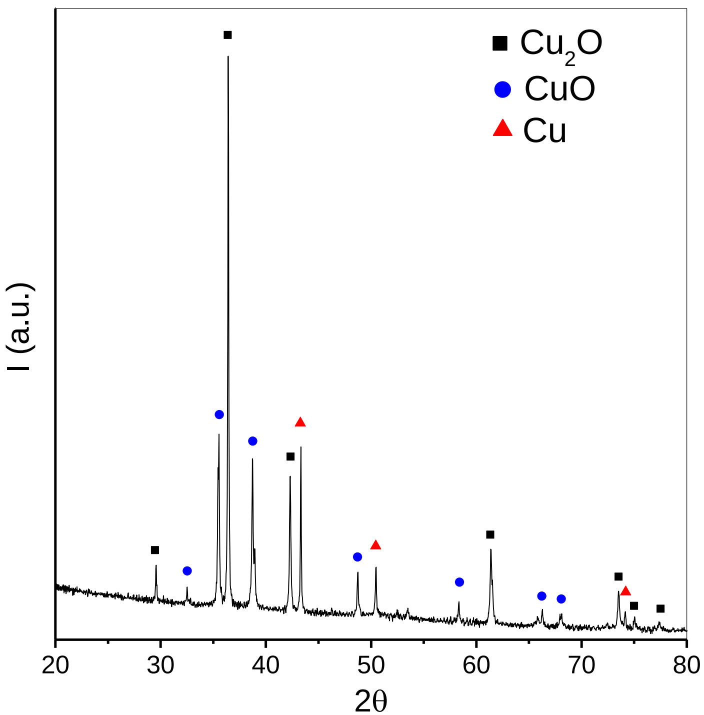
CH_4 formation slightly enhanced

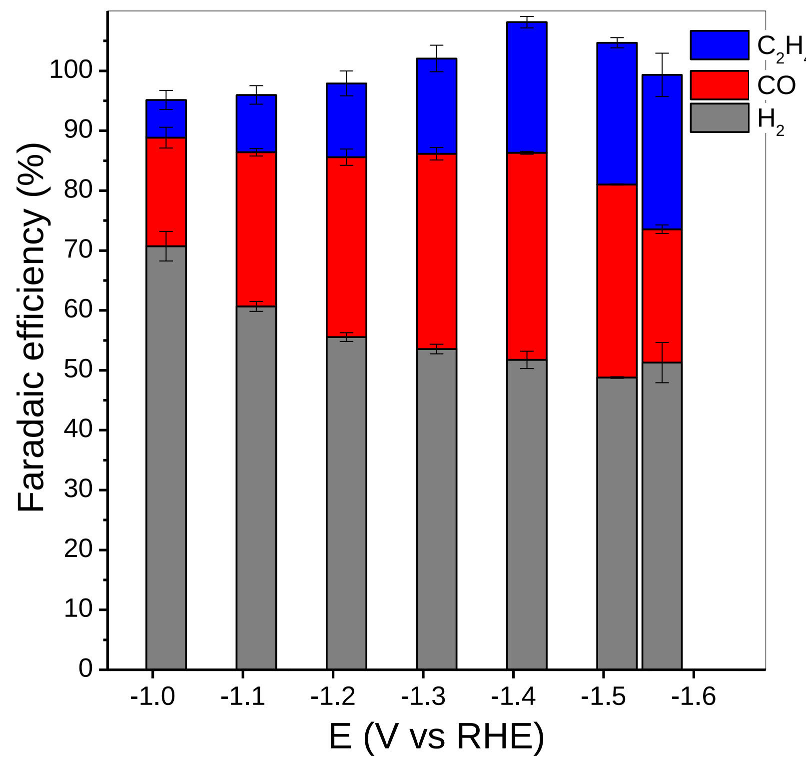
Similar FE_{C2H4}

Evaluation of CuO_x catalysts









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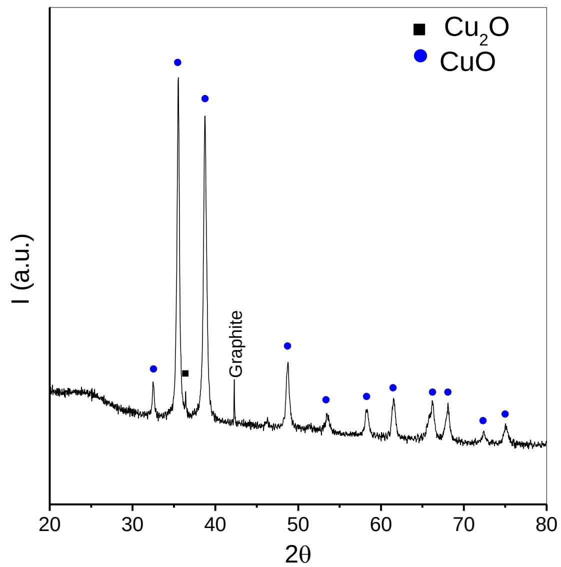

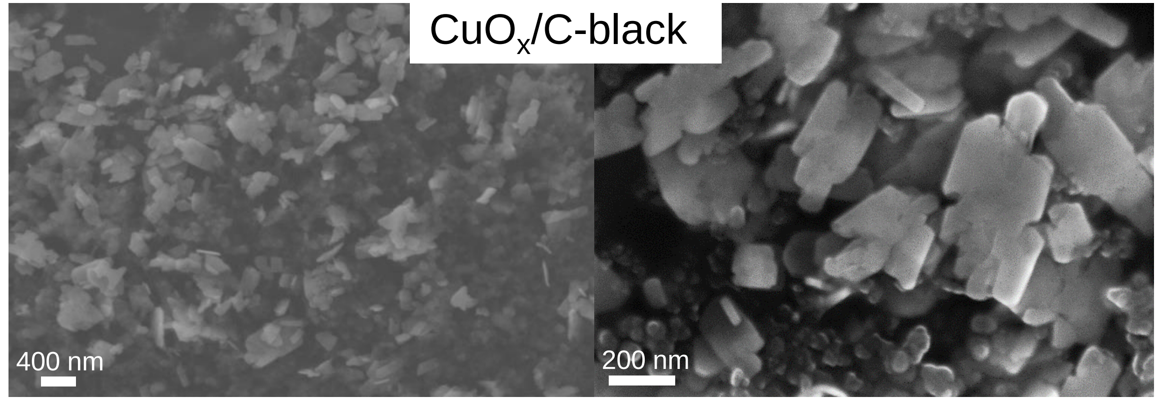

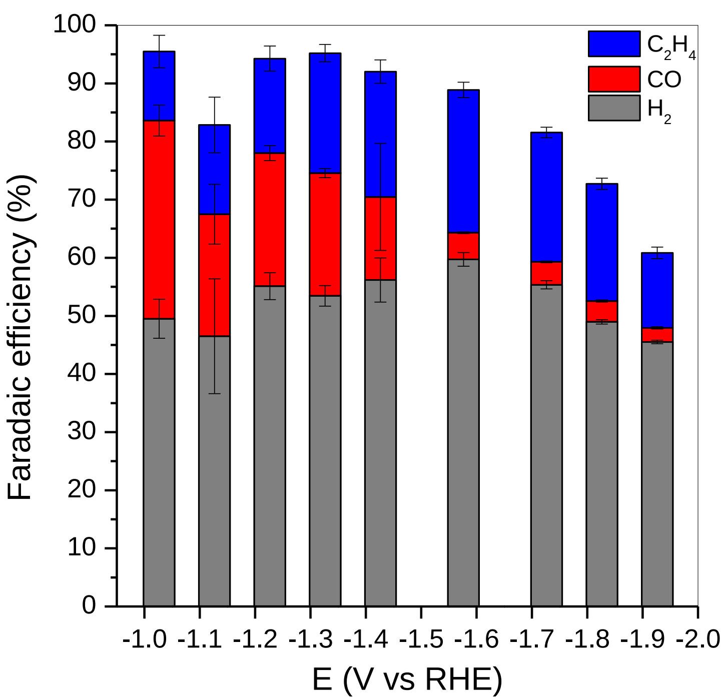

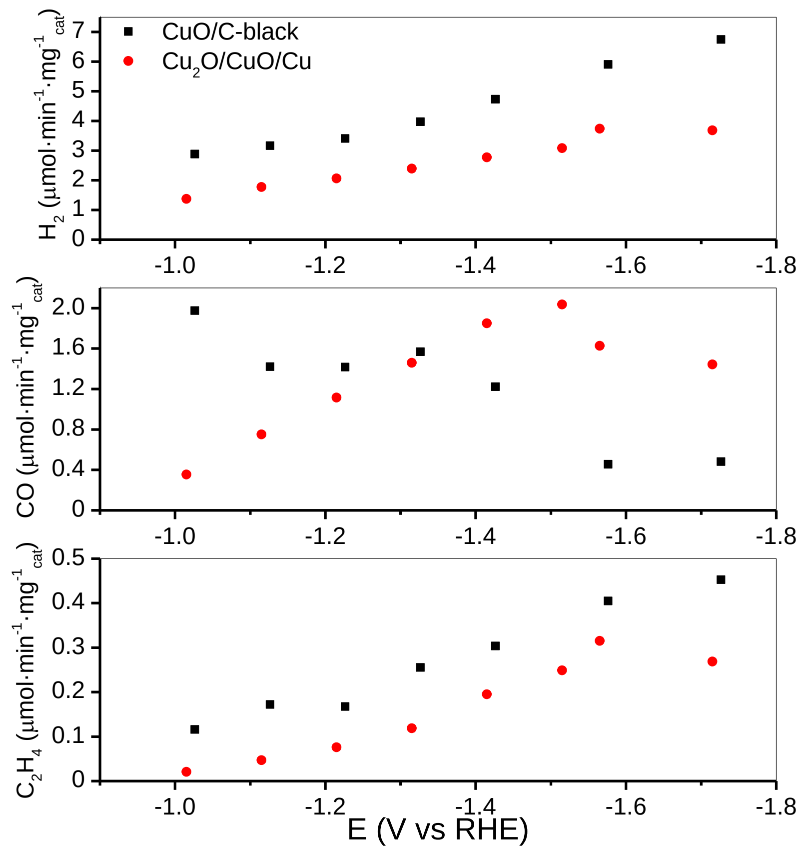

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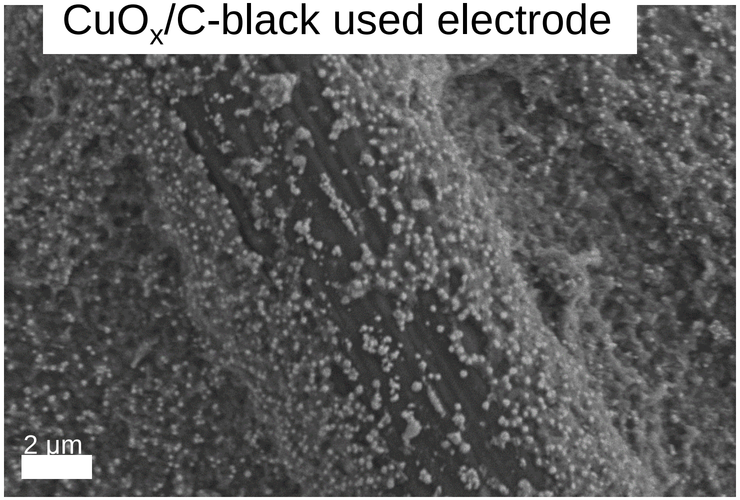

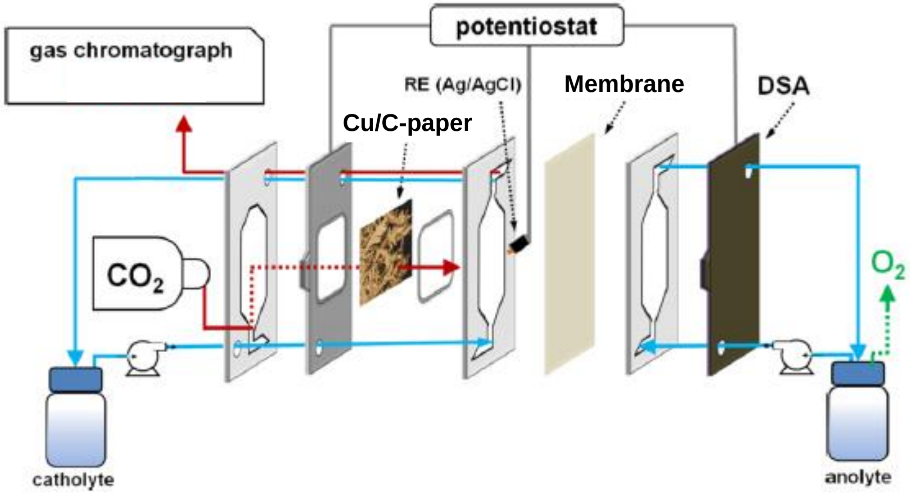

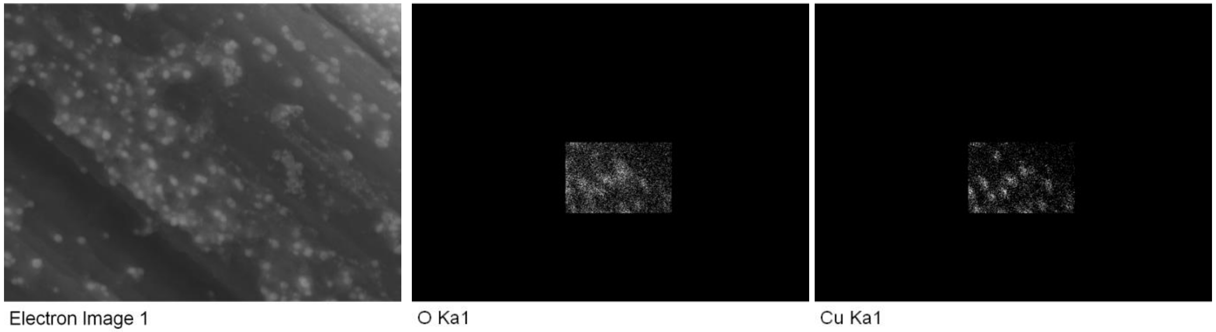

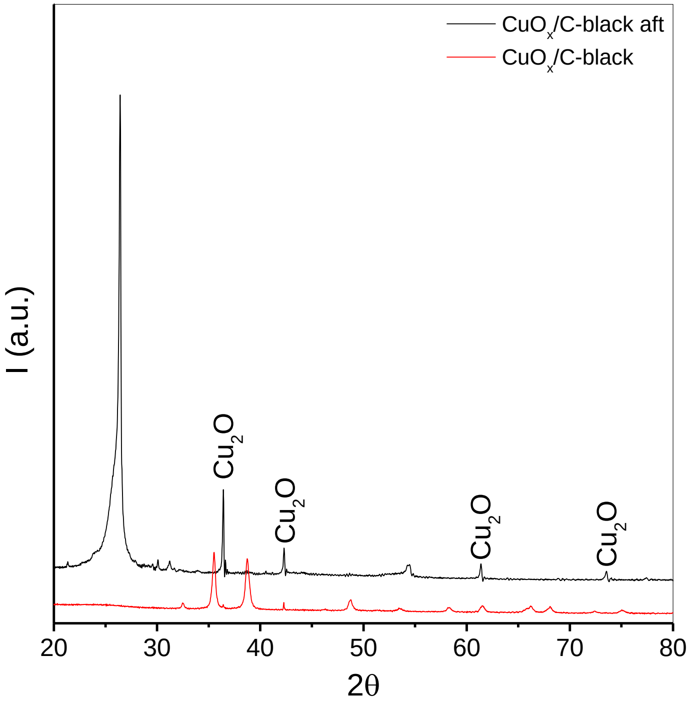

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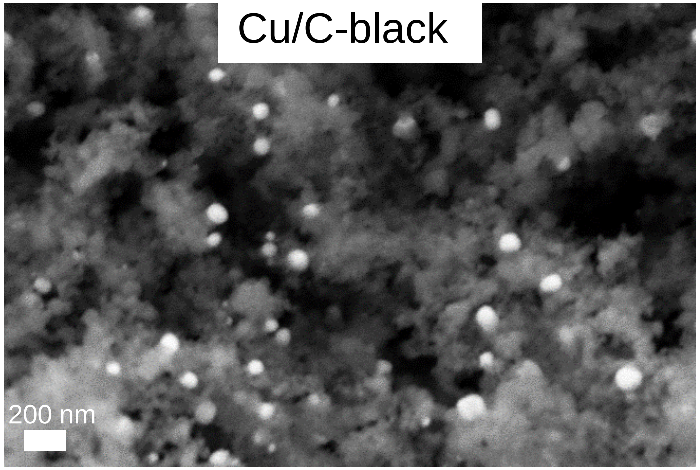

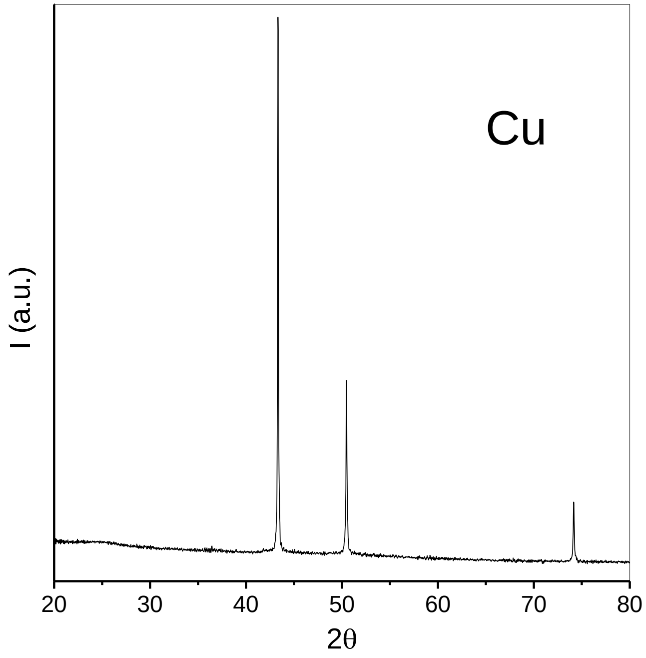

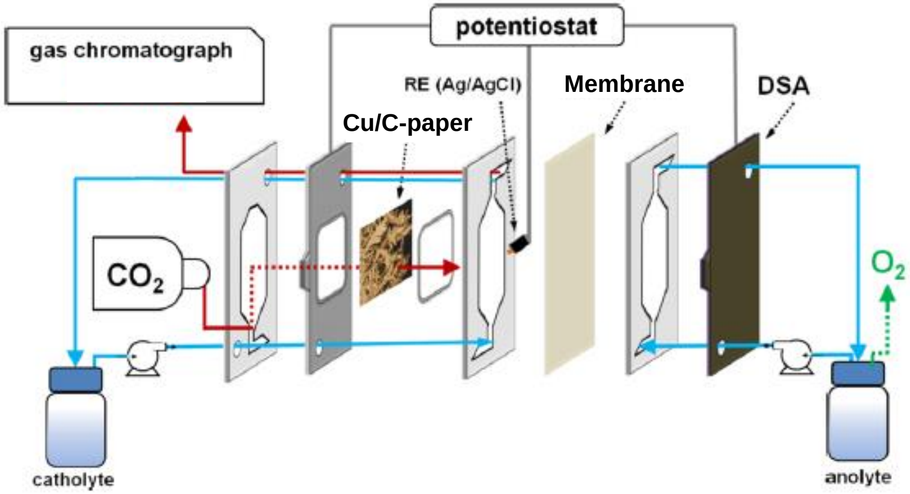

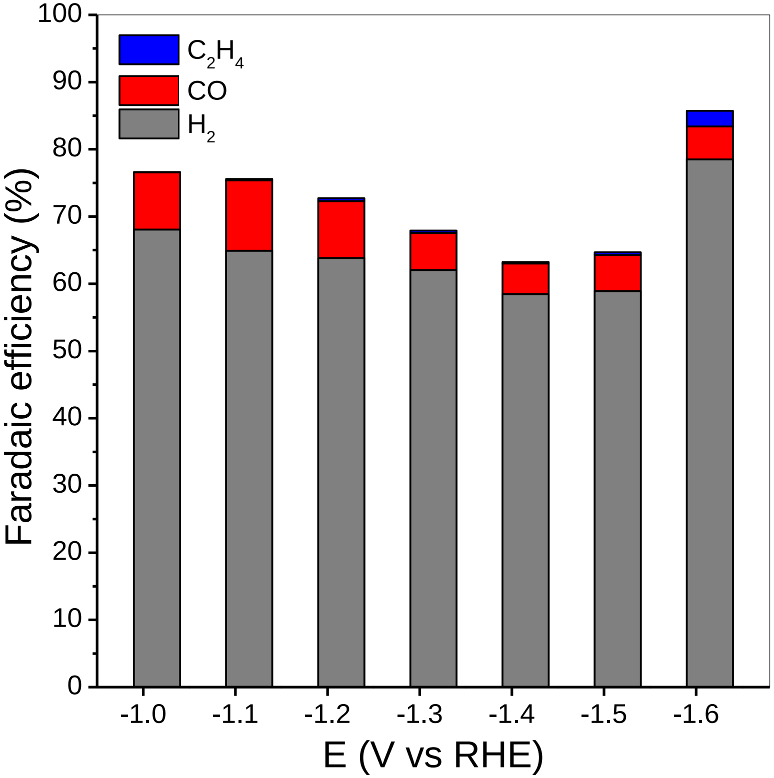

Summarizing

Presence of Cu(II) favors C-product formation
Less influence of morphology
CuO_x/C leads to higher productivity

Next steps: GDE and cell optimization

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