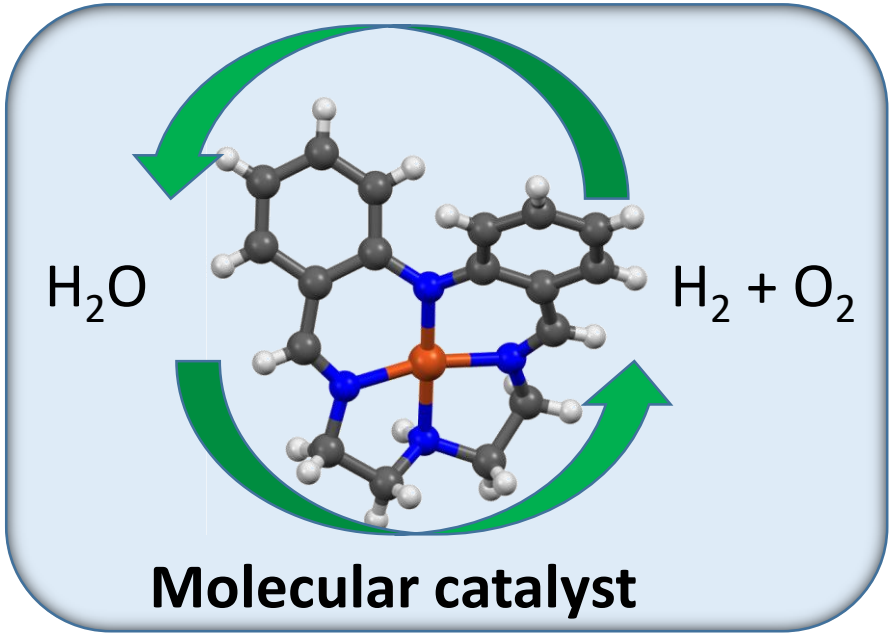
A copper electrocatalyst for H_2 production from a neutral water solution



Michael S. Bennington

Supervisor: Prof. Sally Brooker

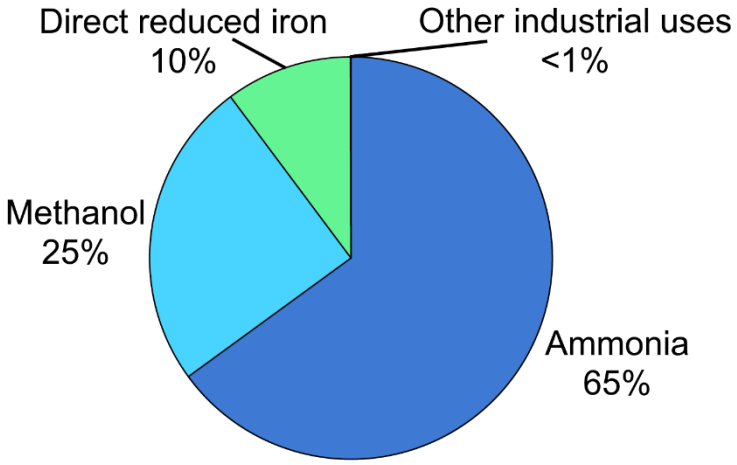
The MacDiarmid Institute
for Advanced Materials and Nanotechnology

University of Otago
Te Whare Wānanga o Otāgo
New Zealand

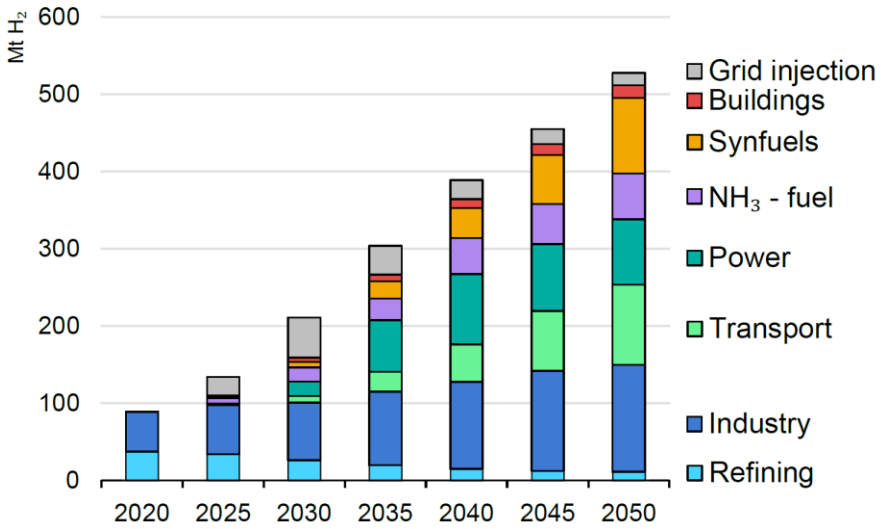
Why hydrogen?

Net Zero Emissions scenarios, 2020-2050

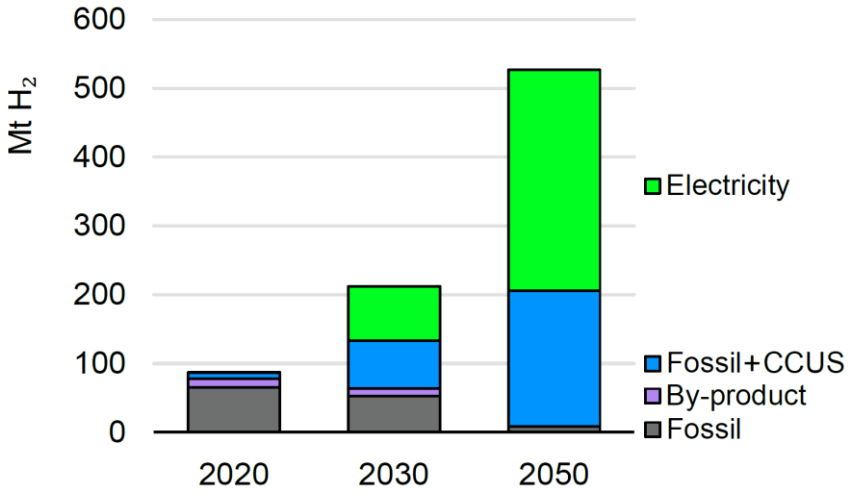
Industrial hydrogen demand, 2020



Hydrogen demand by sector



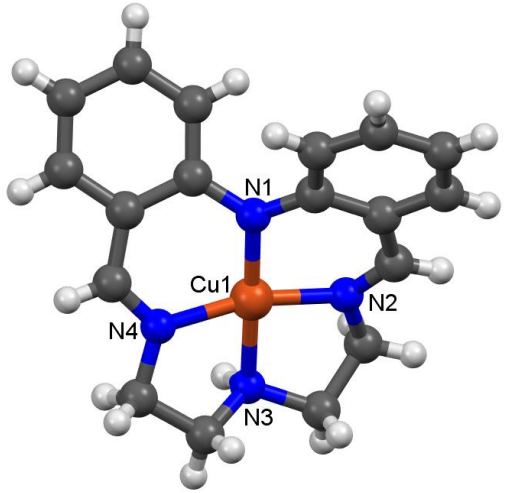
Sources of hydrogen production

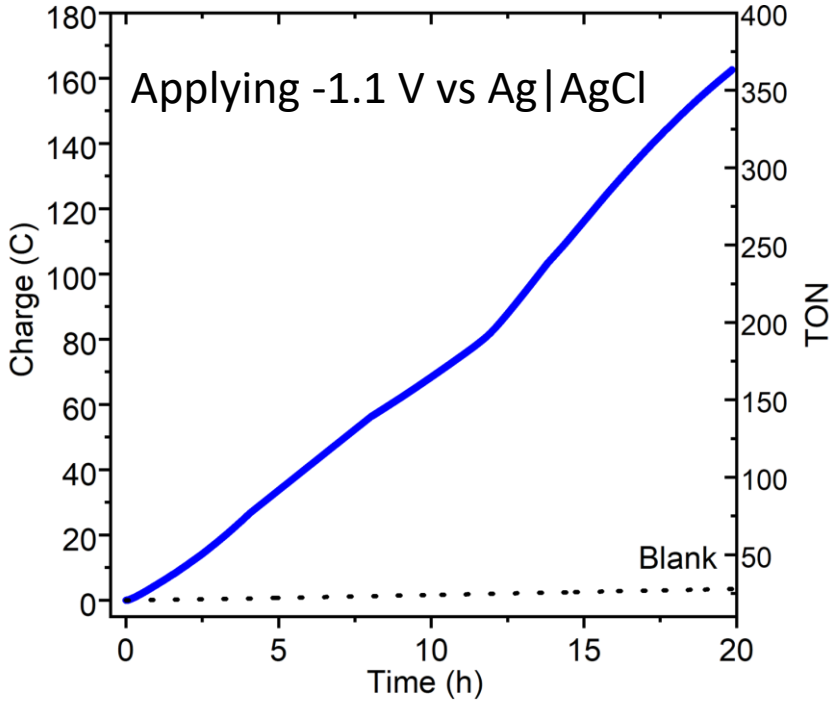


- We already use a large amount of hydrogen industrially
- To reach net zero emissions by 2050 we will likely need to be using a lot more
- Current hydrogen is mostly produced from fossil fuels, needs to be green instead!

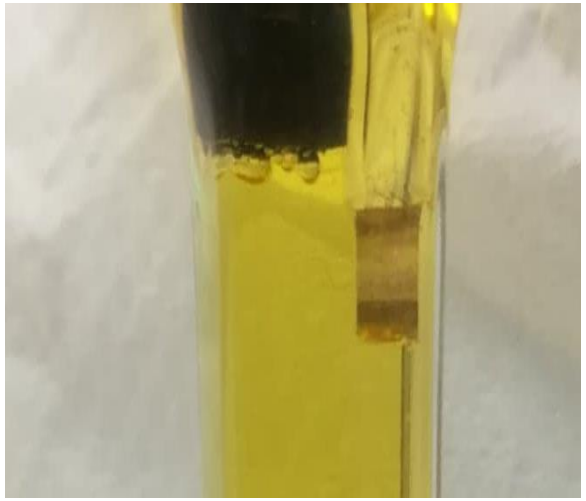
Figures taken from IEA report and slightly modified:
International Energy Agency, 'Global Hydrogen Review 2021', IEA, Paris, **2021**, https://www.iea.org/reports/global-hydrogen-review-2021

Electrocatalytic testing: Screening



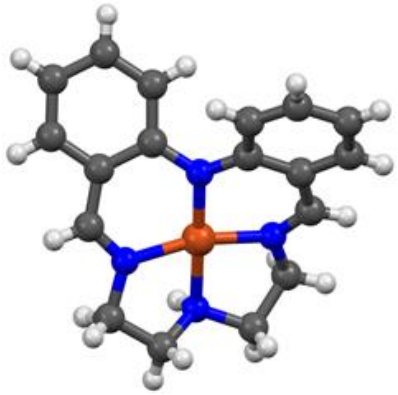


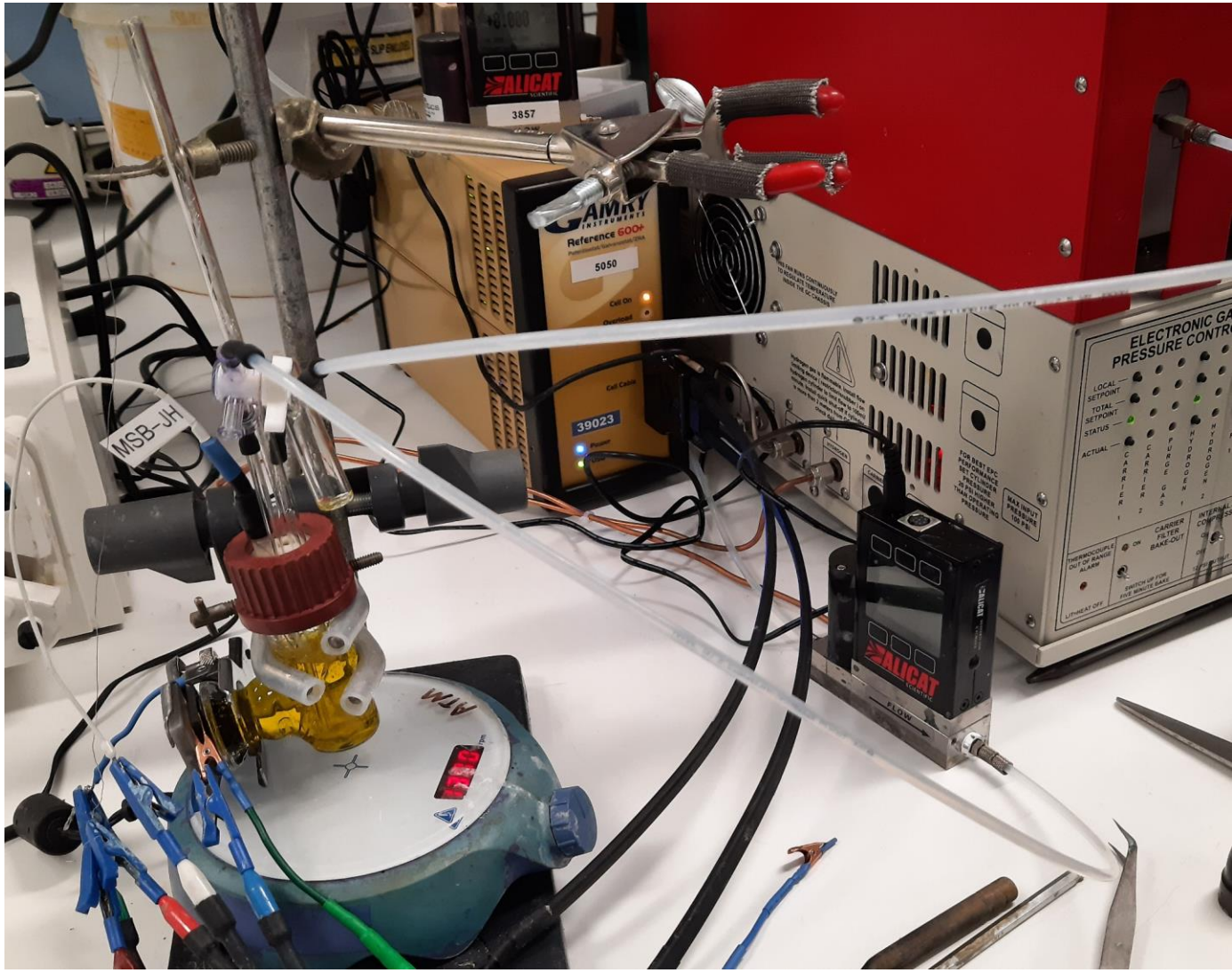
- Apply a potential and check for current => Hydrogen evolution
- Charge transferred suggests hundreds of H_2 for every catalyst molecule
- Visible bubbles formed at the electrode!



Counter: Pt mesh; Reference: Ag|AgCl|sat KCl; Working: Glassy carbon (A: 0.071 cm^2)
Catalyst concentration: 0.3 mM; Electrolyte: 1 M aq. phosphate buffer (pH = 7, KH_2PO_4 and K_2HPO_4)
Abudayyeh A. PhD thesis **2021**

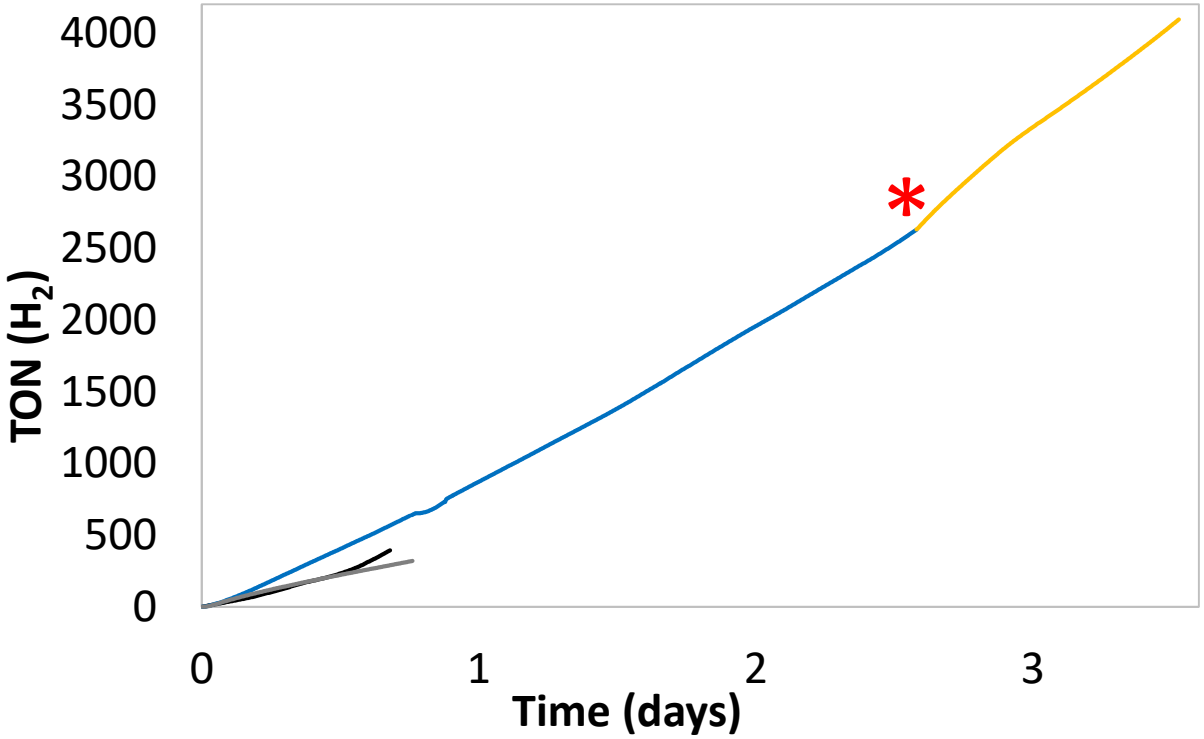
Electrocatalytic testing: Scale up and Faradaic Efficiency





- Electrode area is 35x larger
- Continuous gas flow cell connected to GC

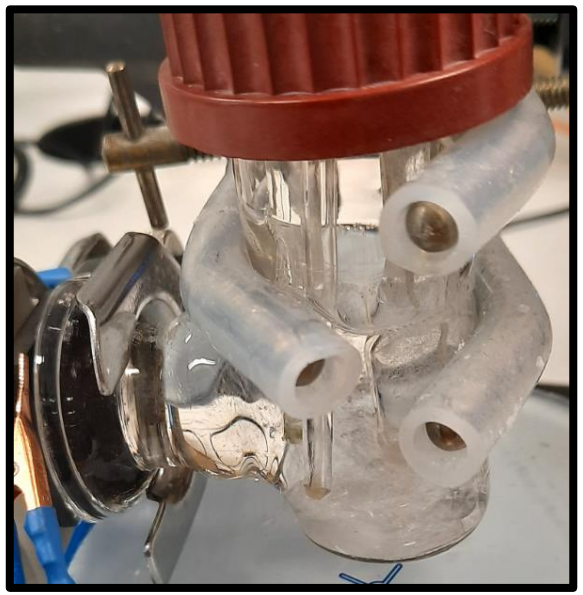
Counter: Pt wire; Reference: Ag|AgCl|sat. KCl; Working: Glassy carbon plate (A: 2.5 cm^2)
Catalyst concentration: 0.3 mM; Electrolyte: 1 M aq. phosphate buffer (pH = 7, KH_2PO_4 and K_2HPO_4)



Blue: homogeneous/pre-rinse runs
Gold: heterogeneous/after-rinse/electrode runs
Grey: control, $Cu(OAc)_2$; **Black:** control, $Cu(BF_4)_2.6H_2O$

- Active for days!
- Thousands of H_2 produced per catalyst
- Colour fades over time

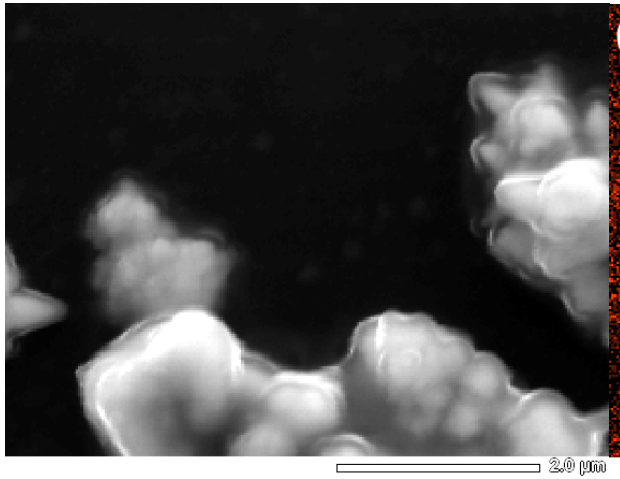
Start of the experiments

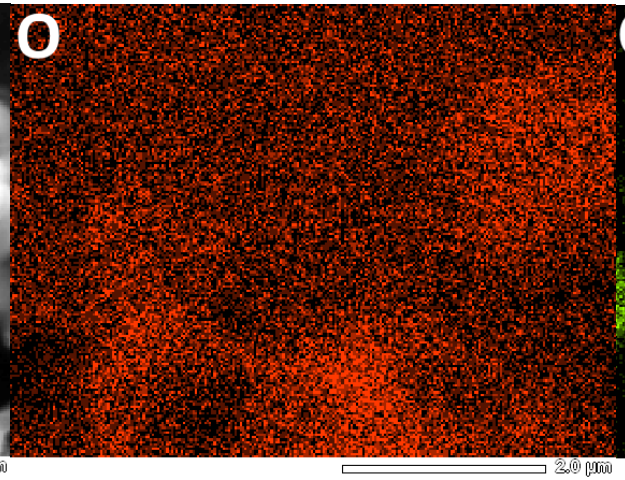


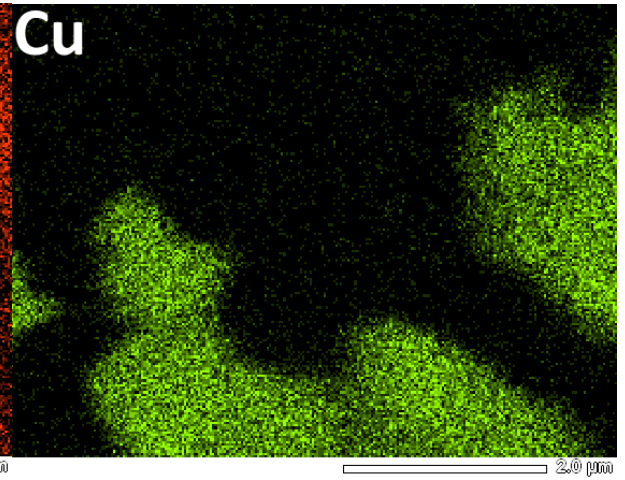
* End of the initial experiment

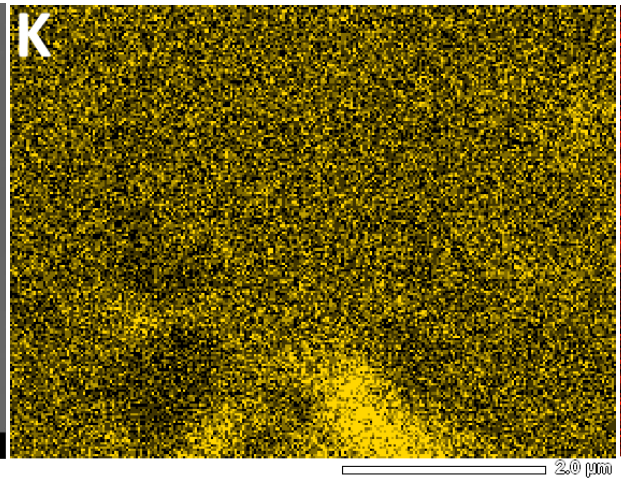
Heterogeneous catalyst ✓

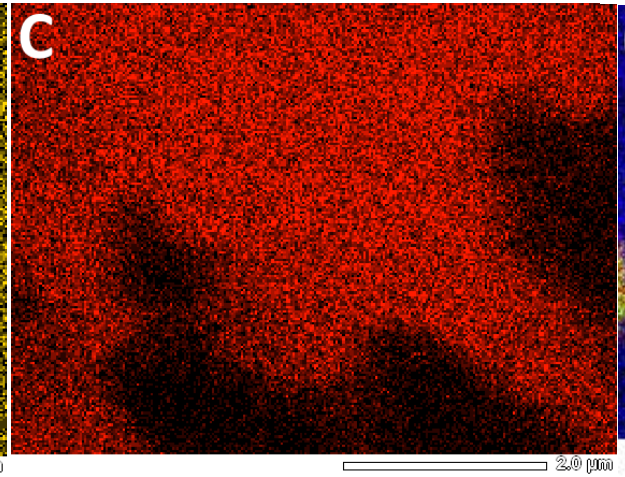
Surface analysis: SEM and EDS mapping

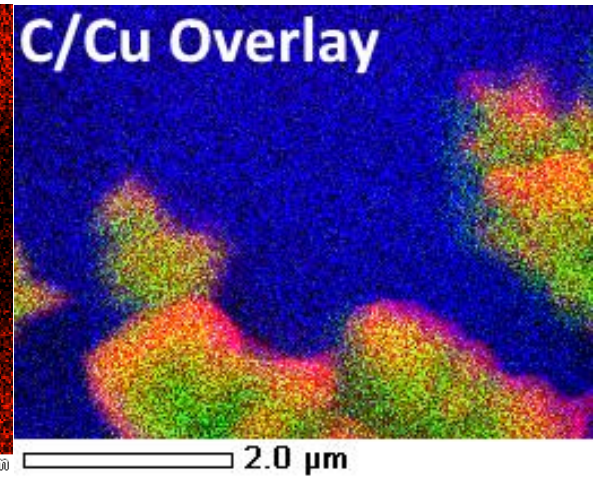












Overlay: carbon (blue), copper (green), and SEM image (red)

Heterogeneous catalyst deposit is rich in copper, but more analysis is needed...

Conclusions and Acknowledgements

- Robust highly active heterogeneous catalyst for H_2 production from neutral water

Acknowledgments

The Brooker Bunch

Past and present

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A/Prof. Aaron Marshall
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Johan Hammonet
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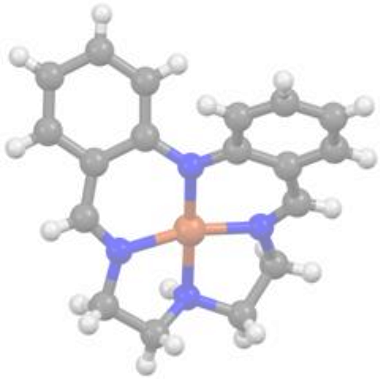
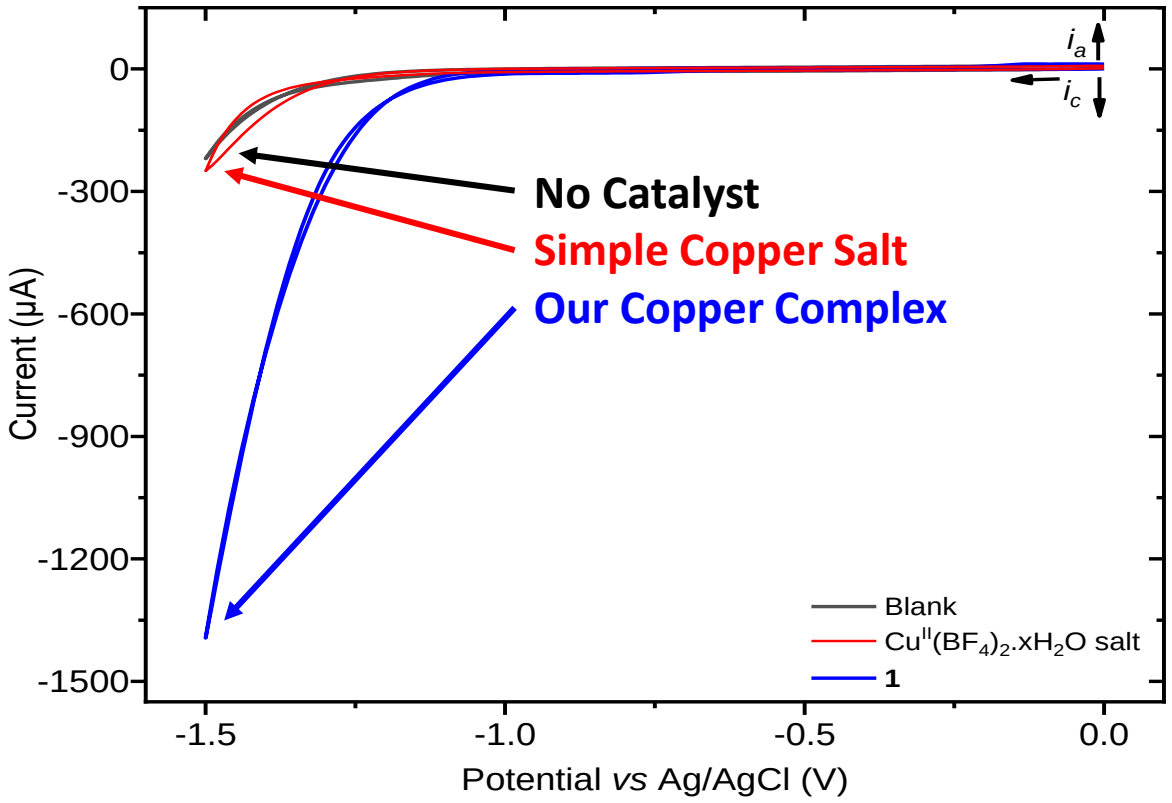
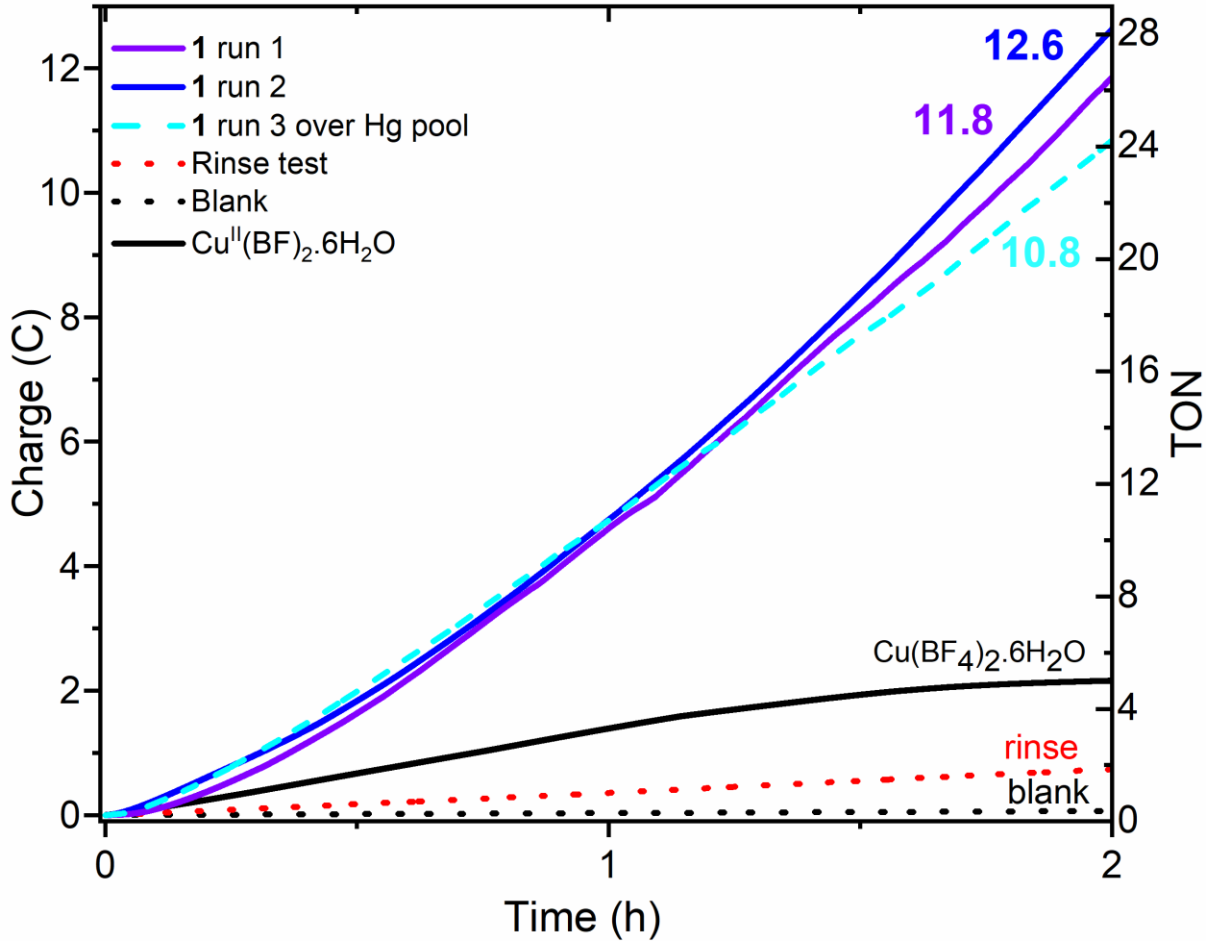
Electrocatalytic testing







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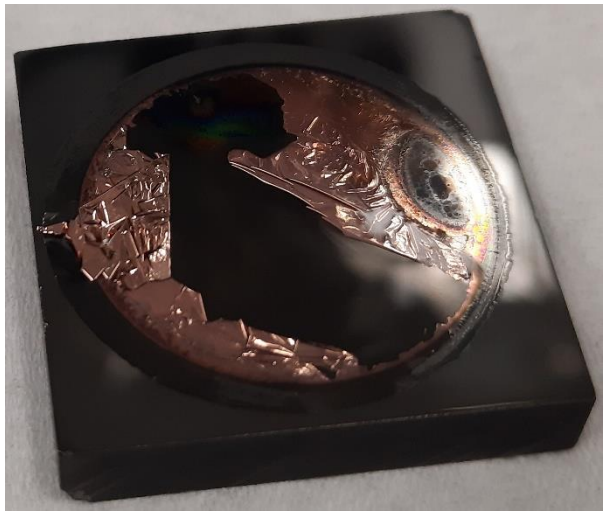
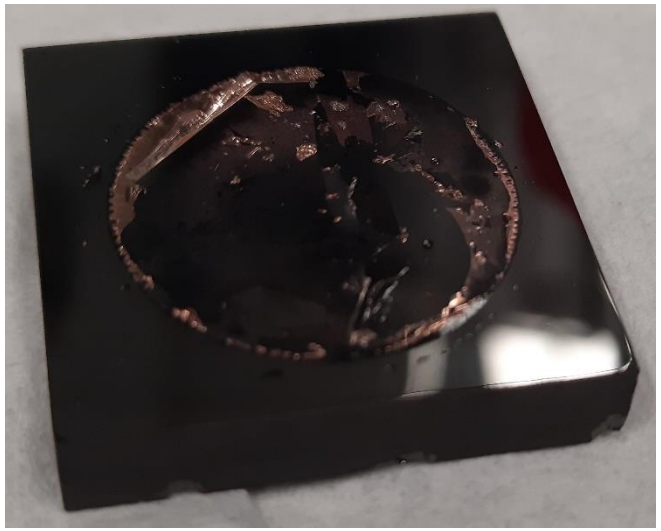
Heterogeneous catalysis: Glassy Carbon electrode



After CPE: $Cu(OAc)_2$



After CPE: $Cu(BF_4)_2.6H_2O$

After CPE: $Cu(\mathbf{L}^{Et})]BF_4$

What are the nature of the deposits and long term activity of the simple Cu salts?