Towards Sustainable Aviation Fuels via Electrochemical CO_2 Reduction

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GREEN & SMART RESEARCH

IMPERIAL

Aim: Develop Power to X (P2X) technology to convert CO_2 (directly captured from air) with renewable electricity to create energy-dense long-chain hydrocarbons for use in aviation and shipping.

Towards More Sustainable Energy Systems

- 73.2% of global greenhouse gas emissions are linked to energy use, mainly from fossil fuels (2.5% from aviation fuels) [1]
- Electrochemical CO_2 reduction to sustainably produce value-added products
- CO_2 electro-reduction to energy-dense long-chain hydrocarbons as sustainable “drop-in” replacement to fossil-derived jet fuel

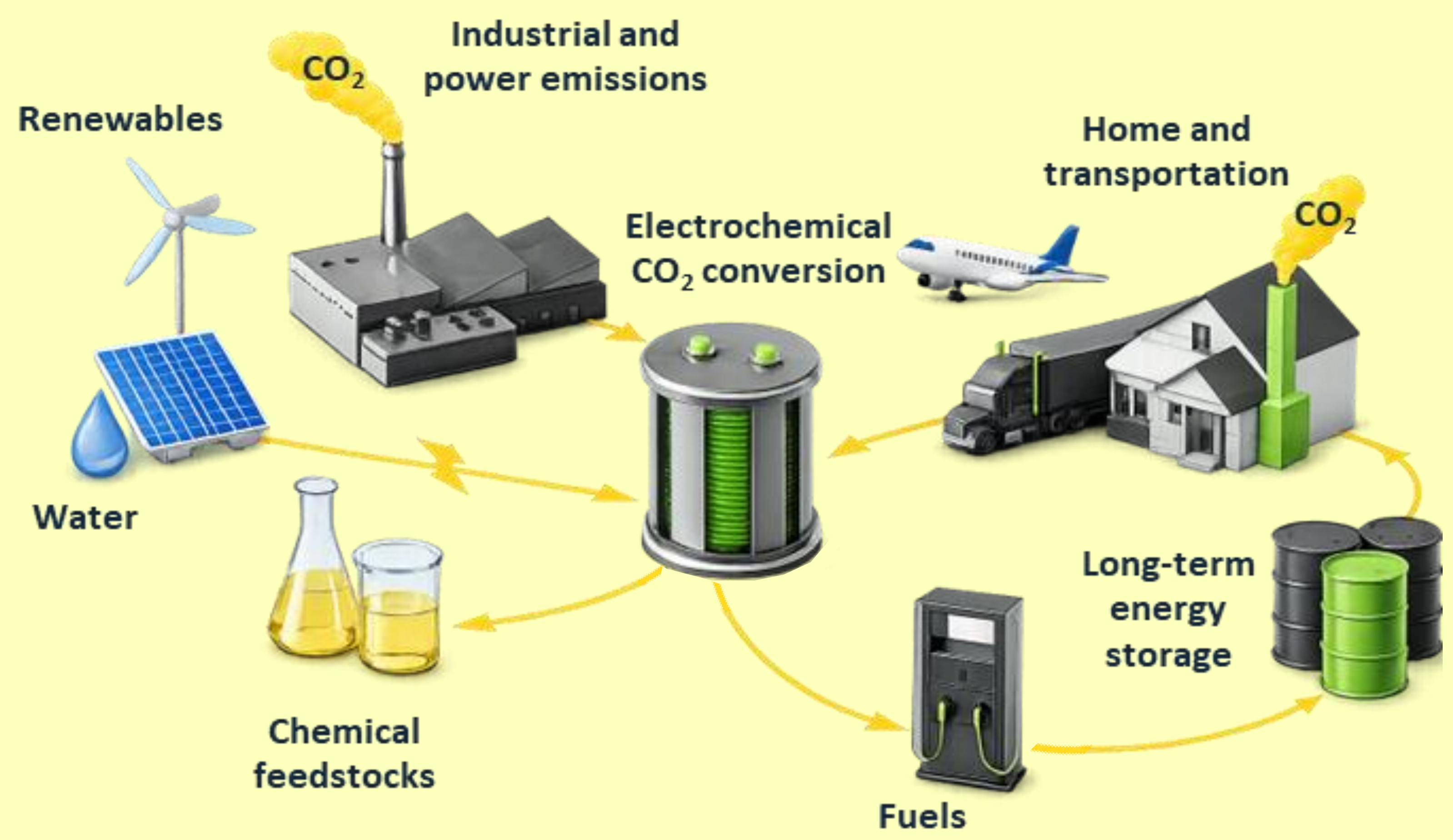


Figure 1: Electrochemical CO_2 technology integrated in an industrial system for fuels and chemical feedstocks synthesis.

Research Gaps

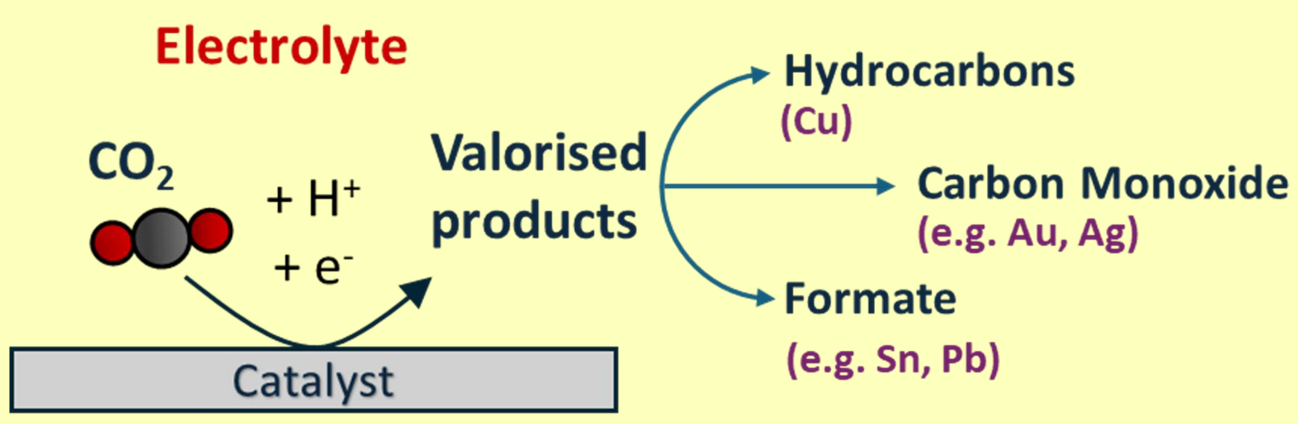


Figure 2: CO_2 electro-reduction to various catalyst-dependent product pathways.

- Copper (Cu) is the only catalyst to produce highly reduced species [2]
- Most of studies have been restricted to aqueous 25°C, 1 atm studies
- Challenges of aqueous CO_2 electro-reduction: low selectivity and electrolyte carbonation
- Aprotic solvents enhance selectivity and control reaction pathways by modulating solvation, cation interactions and proton availability [3]

Using optimised catalysts in non-aqueous (aprotic) solvent-based electrolytes

Research Aims and Objectives

1. Determine structure-property relationships of CO_2 electrocatalysts in non-aqueous electrolytes for enhanced C-C coupling
2. Designing catalysts for enhanced C-C coupling in non-aqueous electrolytes which can provide optimised performance via controlling the hydrogenation rate and kinetics
3. Developing a High Throughput workflow for facile electrocatalyst design (and building of a data library)

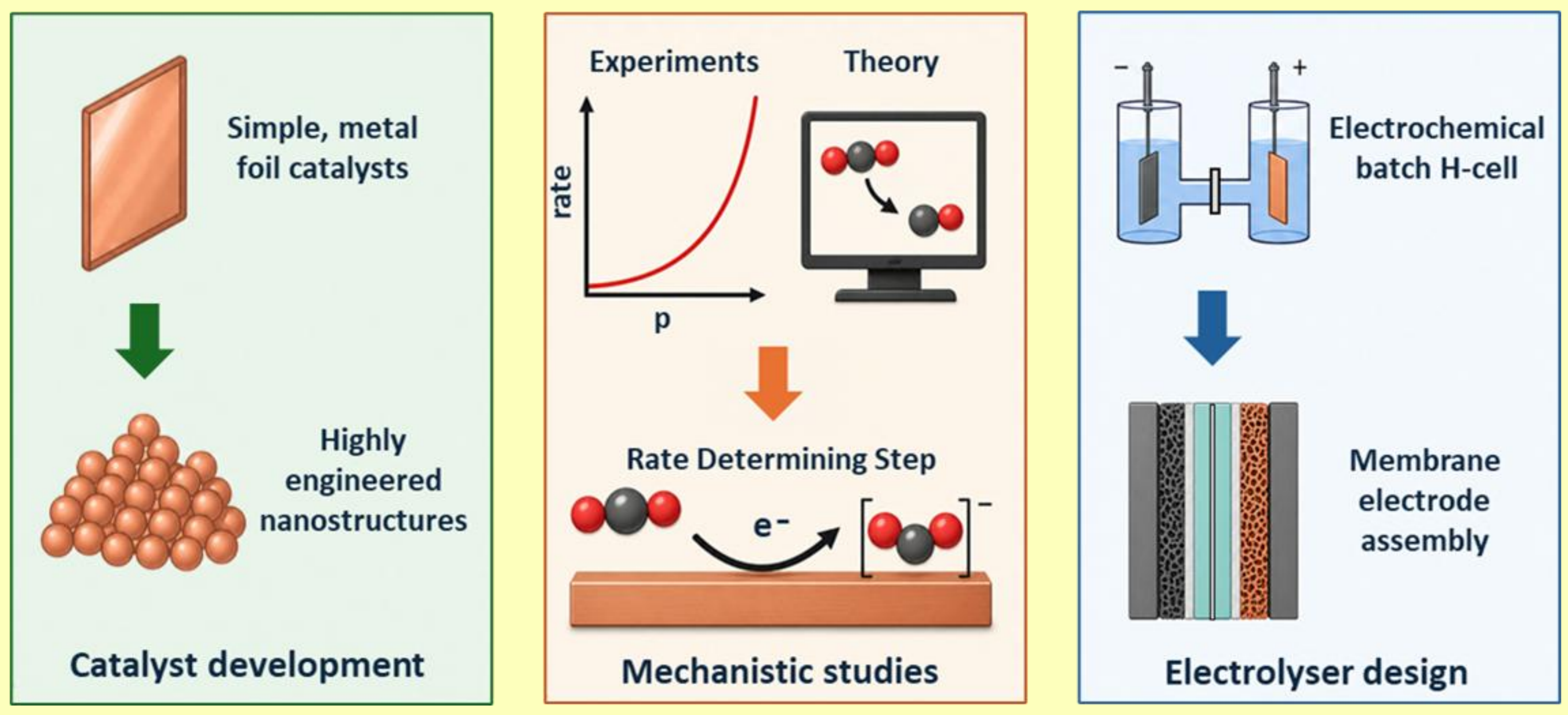
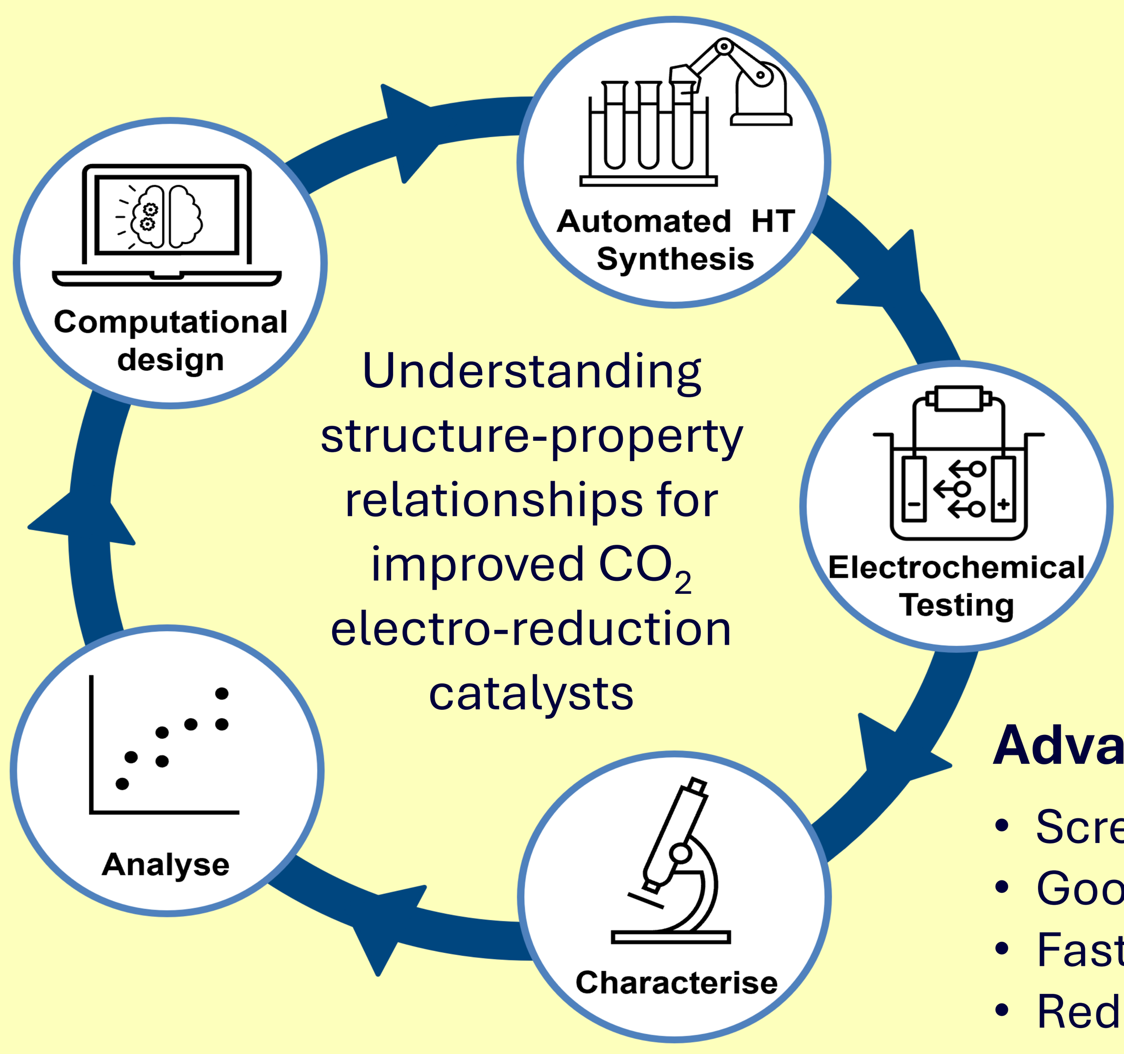


Figure 3: Overview of research areas.

Research Approach

- Using Automated High Throughput (HT) workflow



Advantages:

- Screen larger parameter space
- Good reproducibility
- Fast result accumulation
- Reduced manual labour
- More cost effective

Output

- A new integrated reactor combining CO_2 reduction reaction (CO2RR) and H_2 oxidation reaction (HOR) for optimised C-C coupling towards multi-carbon products which can be blended into jet fuels

Impacts

- Mitigation of CO_2 emissions
- Storage of renewable electricity by converting surplus energy from intermittent sources into chemical energy
- More sustainable, low-carbon chemical industry that aligns with the principles of green chemistry
- Ensuring equitable and widespread access to the resulting products

7 AFFORDABLE AND CLEAN ENERGY — 12 RESPONSIBLE CONSUMPTION AND PRODUCTION — 13 CLIMATE ACTION

Project relation to UN Sustainable Development Goals

LinkedIn

(1) International Energy Agency, Net Zero by 2050 - A Roadmap for the Global Energy Sector, (2021)
(2) A. Bagger, et al., Electrochemical CO2 Reduction: A Classification Problem, *ChemPhysChem* 18, 3266–3273, (2017)
(3) A. Chu and Y. Surendranath Aprotic Solvent Exposes an Altered Mechanism for Copper Catalyzed Ethylene Electrosynthesis, J. Am. Chem. Soc. 144, 5359–5365, (2022)

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