Decarbonization through Conversion of CO_2 and Renewable Energy to Chemicals Fuels via Synthesis Gas

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The success of global efforts to achieve net-zero CO_2 emissions is contingent on cost-effective methods of closing the carbon loop. Utilizing renewable energy to drive the electrochemical reduction of CO_2 (CO_2RR) to value-added chemicals (i.e. renewable Power-to-X) offers the dual advantage of converting intermittent renewable energy to a stable chemical form, whilst simultaneously reducing the emission of waste CO_2 to the atmosphere.[1,2]

A highly favourable product of CO_2RR is synthesis gas (or syngas), generated by the conversion of CO_2 and water (present in the humidified CO_2 inlet stream) to CO and H_2. Syngas is a key building block for the production of a wide range of chemicals, including synthetic liquid fuels such as ethanol and methanol, and plastic packaging materials.[3] The syngas and derivatives market is projected to grow significantly (over 6% p.a.) over the next decade, driven by increased demand for syngas derivatives, as well as a global push for more environmentally-friendly sources of energy and products.[4,5]

My research focuses on designing both nanomaterials and electrochemical systems for the application of CO_2RR to syngas on a commercial scale. Catalyst engineering on a nano scale involves the creation, tuning, and manipulation of active sites within a catalyst structure, promoting high activity towards a desired syngas ratio (H_2:CO ratio). Furthermore, our catalysts are developed using low-cost and scalable materials and synthesis approaches, as well as exhibiting tolerance to input stream impurities. We also focus on macroscale electrode engineering, involving fabrication of gas diffusion electrodes exhibiting specialised components, devoted to charge transfer, liquid inhibition, vapour transport, and catalyst bonding. Finally, we look at the overall system development and optimisation at a large scale, including a cell setup capable of continuous, vapour-fed CO_2RR, as well as investigating reduction of operational expenditure, through methods such as application of waste heat to increase production rate.

References

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