Electrocatalytic Reduction of CO$_2$ using Flow Cells with Gas Diffusion Electrodes

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Bipolar membrane development
- Bipolar membranes (BPMs) prevent CO$_2$ (CO$_2$-) and product crossover in CO$_2$ electrolyzers.
- BPMs maintain pH gradient permitting water oxidation to occur in alkaline environment where earth-abundant electrocatalysts can be used.
- Dual fiber electrospinning of Nafion and PFAEM results in a 3D interface that has higher mechanical stability and lower area specific resistance (better performance) than a 2D BPM
- Adding catalysts, like graphene oxide, to BPM interface lowers water dissociation resistance
- Electrospinning is a versatile platform that enables fabrication of an array of membrane architectures

Component fabrication & device testing
- NREL’s Energy Systems Integration Facility (ESIF) houses capabilities that span multiple scales and levels of integration – from materials synthesis to systems testing
- Over a decade of research in hydrogen fuel cells and water electrolysis systems has established an expertise and understanding needed to accelerate CO$_2$ electrolyzer development
- Techniques used to measure, model, and elucidate transport phenomena in gas diffusion electrodes in fuel cells can be applied to CO$_2$ electrolytization
- In-situ electrochemical diagnostics on devices that span mW - kW

CO$_2$ electrolysis test stands
- Testing CO$_2$ electrolyzers has more complex product analysis requirements than are needed for water electrolysis
- No commercially available test stands for CO$_2$ devices
- Experience gained from building and maintaining over a dozen fuel cell and water electrolysis test stands applied to design and assemble CO$_2$ electrolysis test stands
- Highly automated operation and on-line product analysis
- Standardized test bed to reproducibly evaluate and benchmark promising CO$_2$ reduction catalysts under conditions relevant to upscaling

Preliminary results: Formate
- GoNoGo Milestone: “Demonstrate a CO$_2$ electrolyzer that has an area of 25 cm$^2$ and integrates a BPM with a catalyst-loaded MEA that can operate at over 150 mA/cm$^2$ for 10 hours with FE >80% non-hydrogen products”.
- Targeted formate as the CO$_2$ reduction product for integration with biological upgrading to higher value products
- Hydrogen is the primary product without catholyte
- Starting to incorporate NiP$_2$ and Cu catalyst in cathode to achieve C-C products