**Electrochemical Extraction and Conversion of CO₂ from Seawater**

Ibadillah Digdaya, Ian Sullivan, Meng Lin, Lihao Han, Sophia Cheng, Harry Atwater and Chengxiang Xiang

Joint Center for Artificial Photosynthesis, and Division of Chemistry and Chemical Engineering, California Institute of Technology, USA

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**CO₂ from seawater**

- CO₂ in the atmosphere is in constant equilibrium with the ocean.
- World's ocean represents a natural carbon sink that absorbs 25% of CO₂ entering the atmosphere.
- More than 98% of CO₂ of the carbon atmosphere-ocean system is stored in the oceans as dissolved inorganic carbon (DIC).
- The effective concentration of CO₂ in seawater is a factor of 128 times larger than in the air.

**Bipolar Membrane Electrodialysis**

**CO₂ capture process**

- Replacing the water splitting process at the electrodes with one-electron redox couple reactions, significantly reduced the cell voltage.
- At an optimum solution concentration and flow rate, the total cell voltage was close to the BPM voltage.
- The electrode reactions were limited by mass transport of the redox couple at low electrolyte concentrations and flow rates.

**Electrodialysis performance**

- CO₂ with output flow rate of 2 sccm was extracted from seawater with an input seawater flow rate of 37 ml min⁻¹.
- The extracted gas was a mixture of CO₂ (93%), O₂ (1.5%) and N₂ (5.5%).
- The extraction efficiency (measured CO₂ output/DIC input) was 71% and the membrane contactor efficiency (measured CO₂ output/theoretical CO₂ output flow at the given pH and seawater flow rate) was 76%.
- Record electrocatalysis energy of 0.98 kWh kg⁻¹ CO₂ or 155.4 J mol⁻¹ CO₂ from seawater.

**Key performances**

- Direct coupling of electrochemical CO₂ extraction and conversion by using a bipolar membrane (BPM) electrodialysis cell and a vapor-fed CO₂ reduction cell.
- Record low electrochemical energy consumption of 0.98 kWh kg⁻¹ CO₂ or 155.4 J mol⁻¹ CO₂ from seawater.
- Record high CO₂ extraction efficiency of 71% of total DIC in seawater.
- Highly selective conversion of CO₂ with more than 70% into fuels and chemicals in the vapor-fed device.

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**Electrochemical CO₂ conversion**

- Extracted CO₂ from seawater was electrochemically converted in tandem oxygen reduction (O₂/R) and CO₂ reduction (CO₂/R) vapor fed cells.
- The CO₂/R reaction achieved selectivity as high as 73% of CO₂ converted to fuels and liquid products for a vapor fed cell containing a Cu-GDE, and 98% of CO₂ conversion to CO for a vapor fed cell containing an Ag-GDE.

**Experimental setup**

- The O₂/R cell used Ag catalyst on a gas diffusion electrode (GDE) to mitigate oxygen flow into the CO₂/R cell.
- The proof-of-concept system provides a unique technological pathway for CO₂ capture and conversion using electrochemical processes only.

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This material is based on work performed by the Joint Center for Artificial Photosynthesis, a DOE Energy Innovation Hub, supported by the Office of Science of the U.S. Department of Energy under Award Number DE-SC0004935. Meng Lin acknowledges support from the Swiss National Science Foundation through the Early Postdoc Mobility Fellowship, Grant P2ELP2_178290.