Electrochemical Cell Integration for In-situ Utilization of Captured Carbon Dioxide

Optimization of Membrane Electrode Assemblies for CO_2 Reduction and Chemical Production

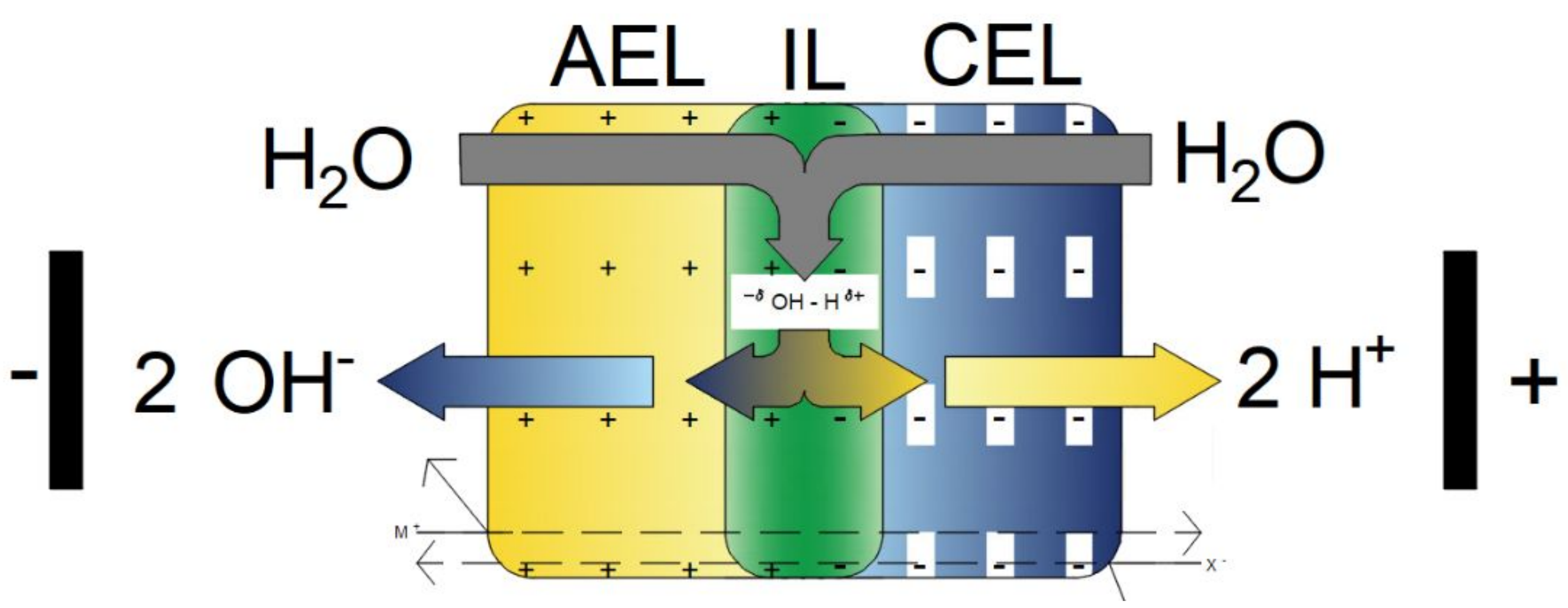
Hughes Clark, Rita Barrera, Abby Gardner
Department of Chemical and Biomolecular Engineering, Clemson University, SC

Audio:
https://drive.google.com/file/d/1jeXCGzimlGl_7MdWBApB-l2aESMbkXoY/view?usp=drive_link

CLEMSON CHEMICAL AND BIOMOLECULAR ENGINEERING

Introduction

This study focuses on enhancing the efficiency of membrane electrode assemblies (MEAs) coupled with bipolar membranes (BPMs) to optimize the parameters for converting CO_2 saturated electrolyte solutions into valuable chemicals like methane, ethylene, and methanol.



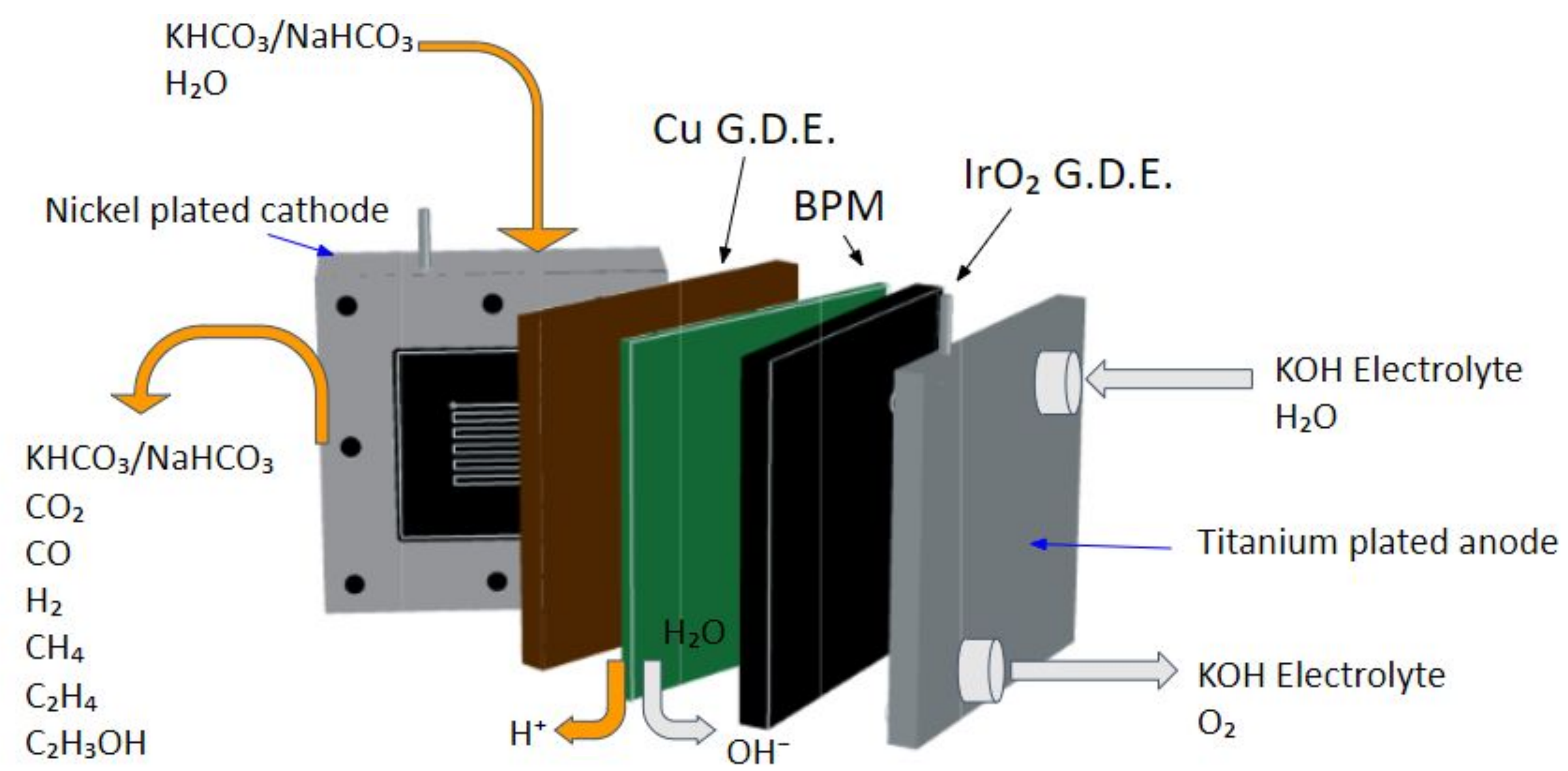
The BPM contains a anion and cation exchange layer to promote the dissociation of water into protons and hydroxide ions.

Future Efforts

Future work will focus improving CO_2 capture. The team will work to develop cathodic catalysts with enhanced CO_2 adsorption capacity, which is critical for improving CO_2 conversion efficiency, particularly under low-concentration conditions. The reactor set-up and electrolyte type will also be adjusted to improve capture. Additionally, advancing the understanding of how local pH changes on the catalyst surface affect CO_2 recovery and reduction efficiency will be crucial for mechanistic studies.

Materials/Methods

Several parameters were varied including the concentration of Cu nanoparticles, flow rates, current levels, and nafion solution concentrations. Different molar concentrations of KOH and $NaHCO_3$ in both cathodic and anodic solutions were evaluated to determine the optimal conditions for CO_2 reduction. Nafion was introduced in two methods to enhance proton transport efficiency.



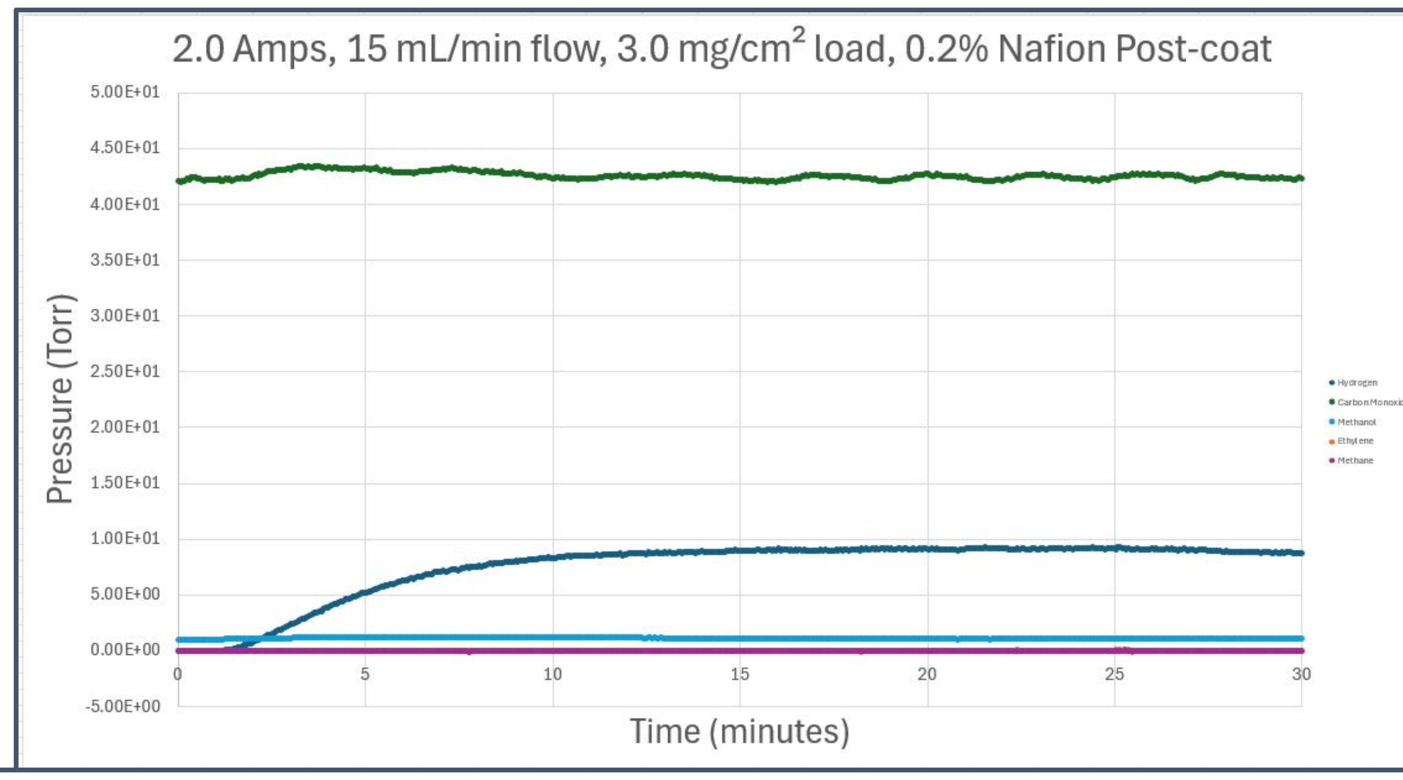
MEA structure, illustrating the arrangement of the anode, cathode, and bipolar membrane, as well as the precise placement and composition of the electrolytes used.

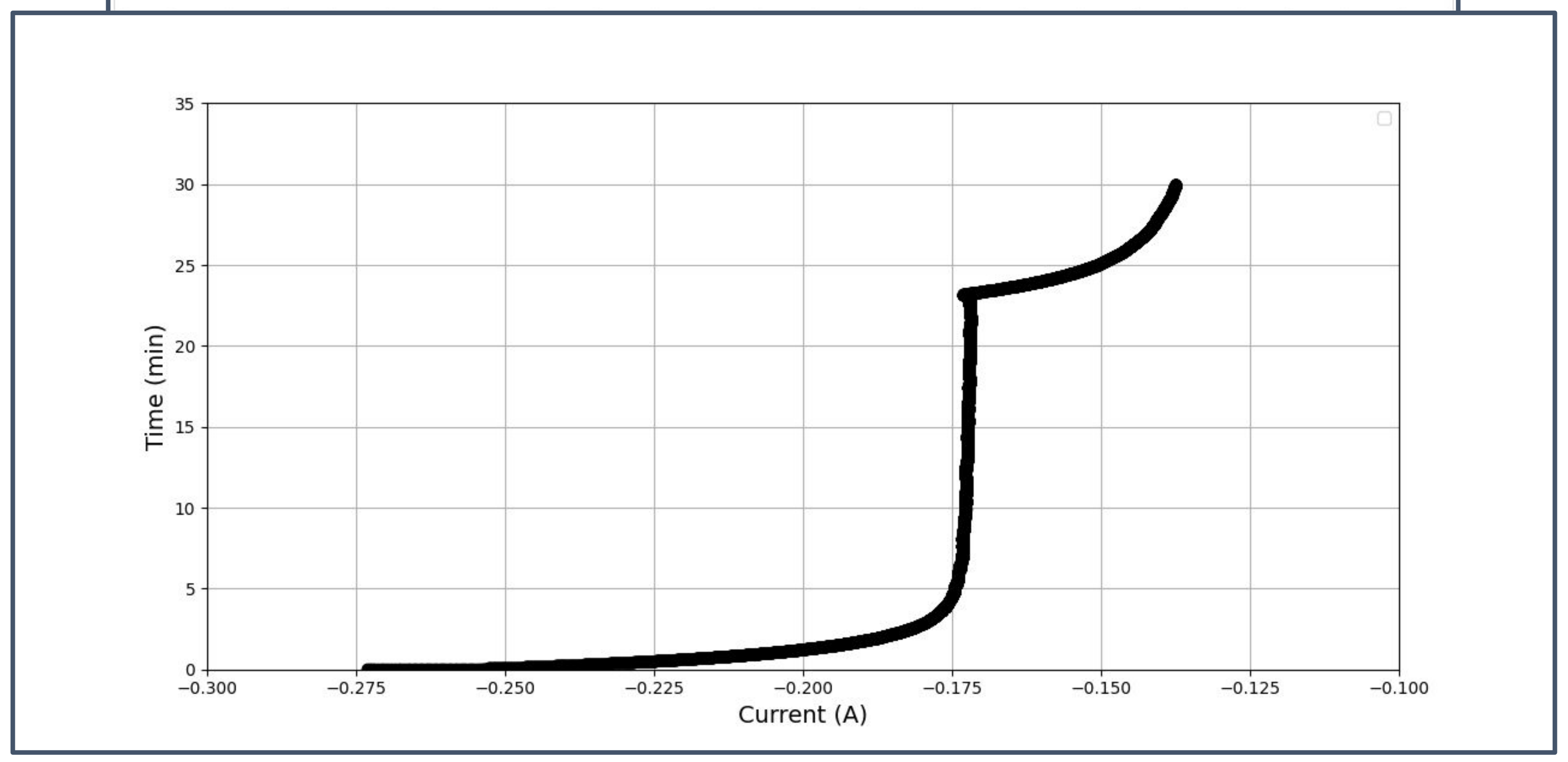
Aerospace Applications

Efficiently converting CO_2 into valuable chemicals is crucial for developing advanced space life support systems. Chemical applications include fuel, plant growth hormones, anti-freeze, and various polymers.

Results/Conclusion

Figures below show the results measured via the mass spectrometer and electrochemical station. The MS data is a reflection of the relative pressure exerted by the products of the reaction. The amperometric curve is a reflection of the reaction rate taking place within the MEA reactor.





References

(1) Pärnamäe, R.; Mareev, S.; Nikonenko, V.; Melnikov, S.; Sheldeshov, N.; Zabolotskii, V.; Hamelers, H. V. M.; Tedesco, M. Bipolar Membranes: A Review on Principles, Latest Developments, and Applications. *Journal of Membrane Science* 2021, *617*, 118538. https://doi.org/10.1016/j.memsci.2020.118538.

(2) Meda, U. S.; Rajyaguru, Y. V.; Pandey, A. Generation of Green Hydrogen Using Self-Sustained Regenerative Fuel Cells: Opportunities and Challenges. *International Journal of Hydrogen Energy* 2023. https://doi.org/10.1016/j.ijhydene.2023.03.430.

(3) Rusmussen, Kai. "The Ethylene Problem on Space Station Mir." *Astrobotany.Com*, 11 July 2018, astrobotany.com/the-ethylene-problem-on-space-station-mir/.

(4) Ethylene." *Marspedia*, 24 Feb. 2022, marspedia.org/Ethylene#:~:text=Ethylene%20is%20an%20important%20building,of%20In%2Dstiu%20resources%20utilization.