Enhanced Depolarized Electro-Membrane System (EDEMS) for Direct Capture of Carbon Dioxide from Ambient Air

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Program Overview

a. Funding: DOE $699,509 and UKRF Cost Share $174,904

b. Overall Project Performance Dates: 10/1/2020 – 03/31/2022

c. Project Participants: University of Kentucky and Smith Management Group

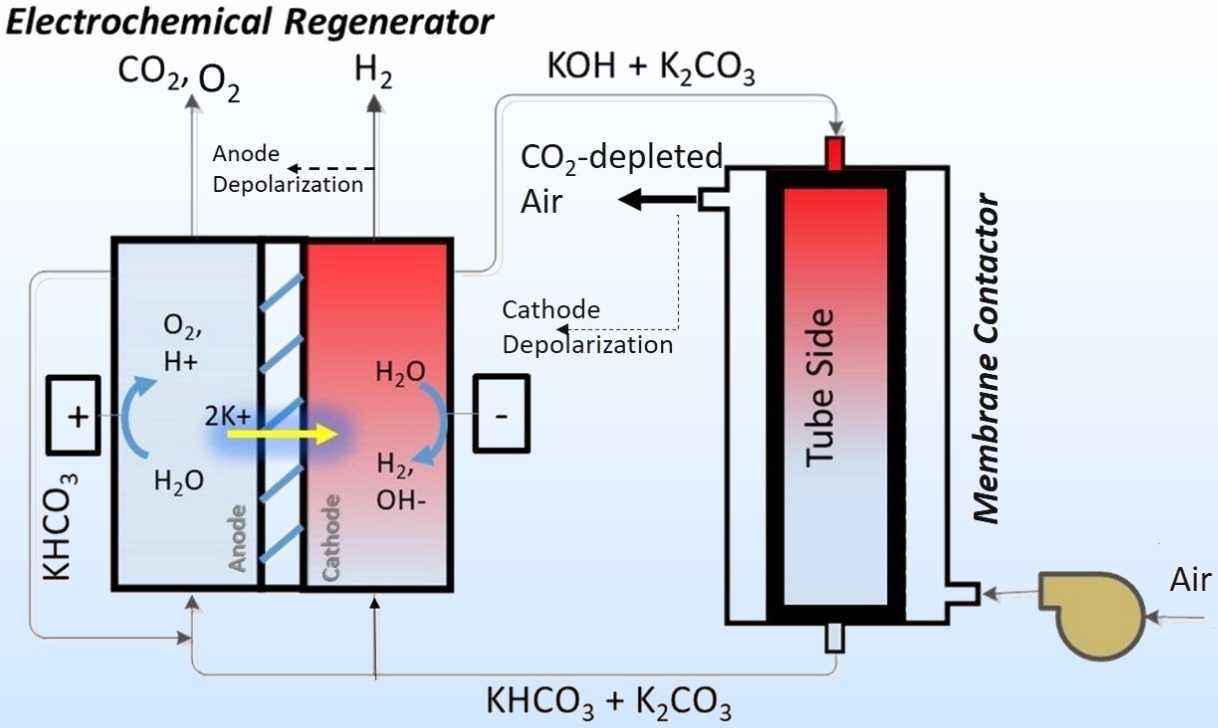
d. Overall Project Objectives:

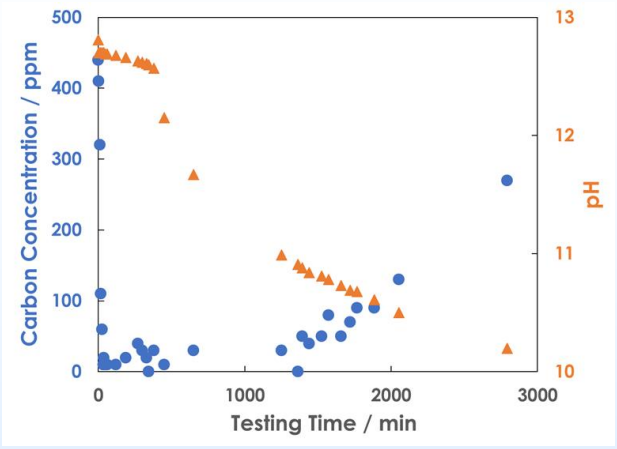
(1) Develop an inorganic membrane contactor including a patterned surface, and demonstrate its effectiveness and stability for ambient CO_2 removal

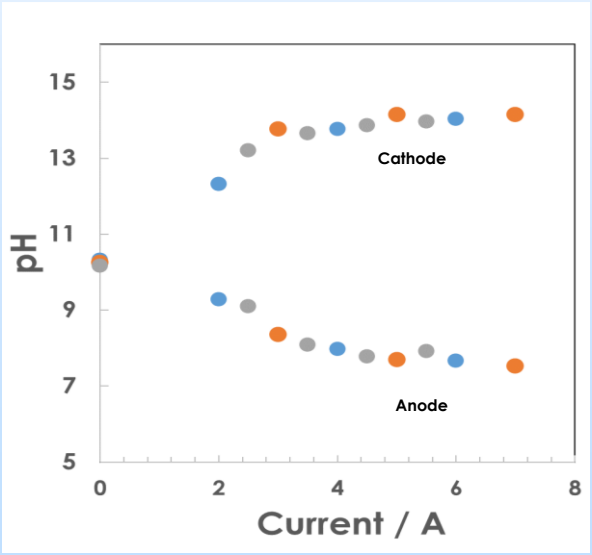
(2) Demonstrate the effectiveness and stability of a depolarized electrochemical reactor for solvent regeneration at low applied voltages

(3) Integrate and demonstrate the enhanced depolarized electro-membrane system (EDEMS) for 50% CO_2 capture from a >2 L/hour influent air with ~400 ppm CO_2.

Technology Background







Key Benefits

- Provide stable performance facilitated by the depolarized electrochemical cell and hydrophobic contact absorber to reduce the capital cost and energy requirement by up to 30% by intensifying the electrochemical and CO_2 release reactions
- Provide-scalable technology with easy integration to renewable power sources for remote operation and reducing carbon emissions.

Technical Approach/Project Scope

a. Experimental design

- Independently develop the contactor and electrochemical reactor sub-systems for hydroxide-mediated DAC at low voltage requirement
- Integrate sub-systems, and demonstrate continuous DAC capture for 12-24 hours

b. Project Milestones

- 50% CO_2 capture efficiency for DAC using patterned superhydrophobic membrane absorber for 12-24 hours
- Depolarized Electrochemical Cell with capture solvent regeneration at <3.5 V, 1 A
- EDEMS for DAC at >2 L/hr influent air for >50% CO_2 capture for 12-24 hours

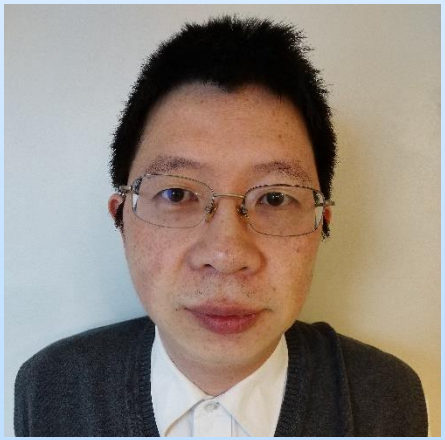
c. Project success criteria

- Produce patterned membrane contactor with 10-25% improved membrane area compared to un-patterned membrane
- Membrane contactor achieves 50% CO_2 capture efficiency
- Depolarized electrochemical cell achieves > 50% faradaic efficiency at 1 Amps
- EDEMS achieves >50% CO_2 capture efficiency at < 3.5 V DEC

Project Team

PI: Dr. Ayokunle Omosebi

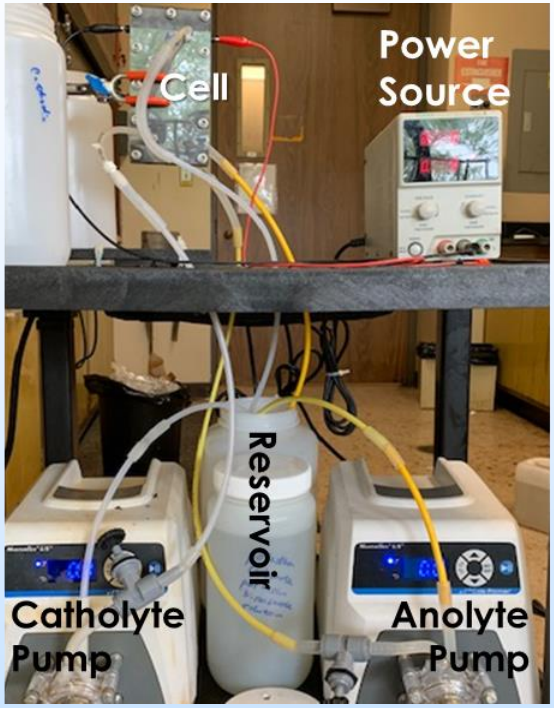
Co-I: Dr. Jesse Thompson



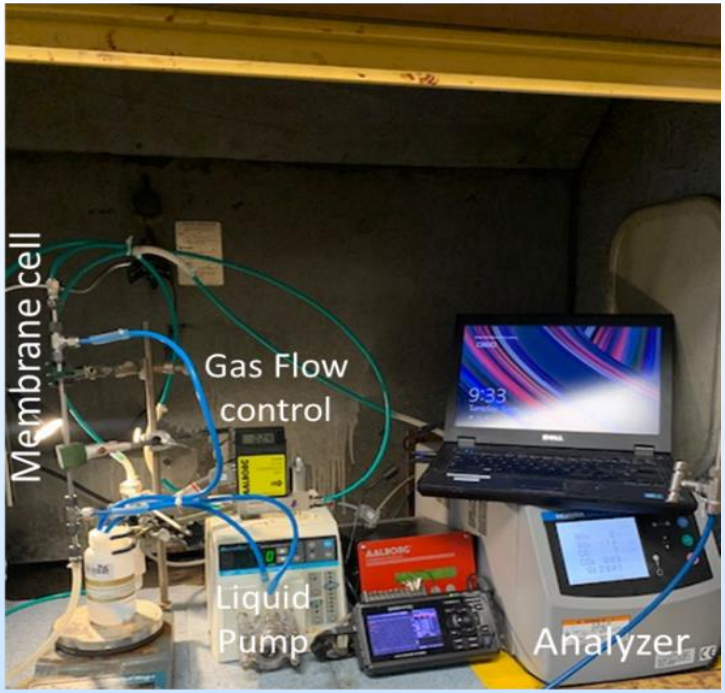
Co-I: Dr. Jinwen Wang

EH&S: Mr. Clay Whitney

Progress and Current Status



Electrochemical Testing Setup



Membrane Testing Setup

Achieved CO_2/O_2 ratio of >1 at the anode and pH ~14 at the cathode from influent hydroxide-based solvent; cell operating at > 1 Amp

Achieved 20% capture with 15 cm^2 non-patterned inorganic contactor (2.3 s residence time) with hydroxide based capture solvent. Target:50%

Opportunities for Collaboration

Potential areas of complementary work include

a. system and device modeling to elucidate material speciation, provide predictive capability, and process control information
b. component fabrication for more effective materials to aid in selective facile charge transport and CO_2 capture