Experimental Demonstration of Alkalinity Concentration Swing for Direct Air Capture of CO_2

Project Number: FE0031964

Daniel P. Schrag, Michael J. Aziz

Harvard University

U.S. Department of Energy

National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

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Program Overview

a. Funding $900,906

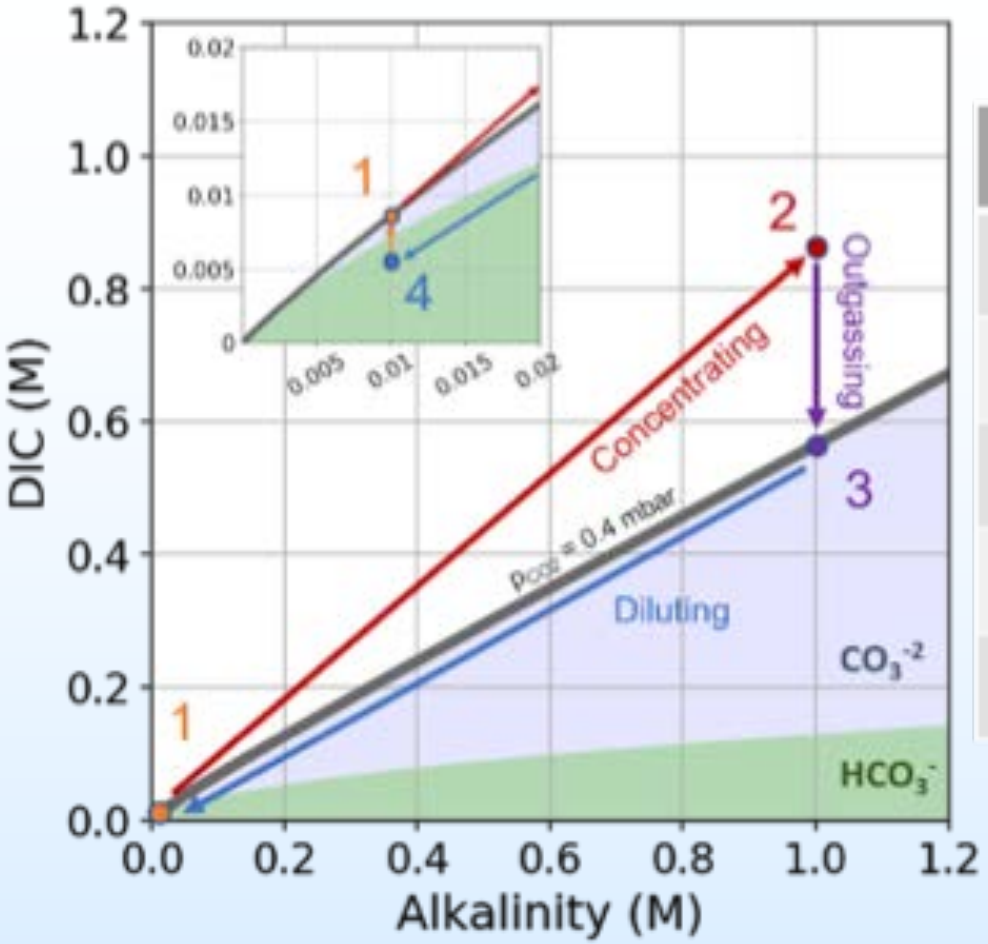
($720,047 from DOE; 180,859 from Harvard)

a. Start: 2/8/2021; End: 8/8/2022

b. Project Participants: Daniel Schrag (PI), Michael Aziz (Co-I), Grad students: Andrew Bergman, Anatoly Rinberg

c. Overall Project Objectives: We will conduct experimental demonstration of a new approach for Direct Air Capture of CO_2 (DAC) called the Alkalinity Concentration Swing (ACS). ACS will be implemented by taking a dilute alkaline solution that has equilibrated with air, and then concentrating it using commercially available technologies including reverse osmosis (RO) and capacitive deionization (CDI). The more concentrated solution has a higher partial pressure of CO_2 relative to the initial solution, allowing the CO_2 to be separated and stored.

Technology Background: Conceptual diagram of ACS



State	A (M)	C_{DIC} (M)	pH	P_{co2} (mbar)
1	0.01	0.0086	8.74	0.40
2	1	0.86	8.75	40
3	1	0.56	9.99	0.40
4	0.01	0.0056	9.95	0.047
1	0.01	0.0086	8.74	0.40

Step
1->2: Concentrating
2->3: Outgassing
3->4: Diluting
4->1: Absorbing

- There are tradeoffs between starting alkalinity, magnitude of the concentration swing, energy costs, and volumes of solution required.
- Advantage of ACS is 1) potentially low energy costs, 2) use of existing technologies (e.g., desalination plants) that already exist at large scale.
- Kinetics of re-equilibration with atmosphere are slow, which implies large land area.

Technical Approach/Project Scope

a. Experimental design and work plan: The goal of our project is to test the ACS concept in a laboratory setting using both RO and CDI for the concentration step. We hope to measure the energy costs of CO_2 extraction using both methods.

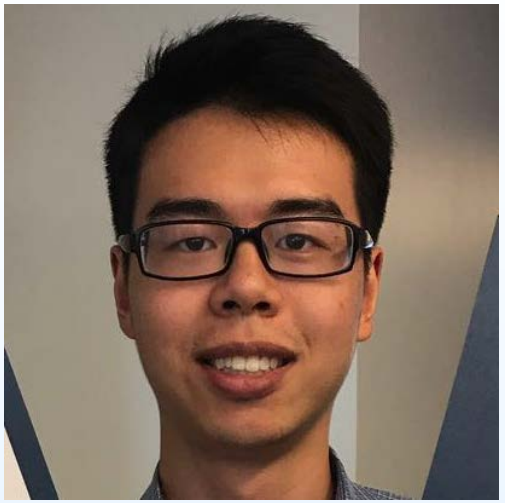
b. The project has just started. We are in the process of equipment design and acquisition and initial experiments on equilibration and CO_2 extraction. Initial results on RO and CDI should be available by the end of summer, 2021.

c. Project success criteria: Experimental demonstration of ACS; exploration of different parameter choices; energy efficiencies of RO vs. CDI.

Team

Andrew Bergman

Toly Rinberg



Martin Jin

Tommy George

Mike Aziz

Dan Schrag

Progress and Current Status of Project

a. Equipment: For the experiments we are designing customized RO and CDI units. We are also purchasing DIC and CO_2 analyzers.

b. Accomplishments and performance achieved so far: We have just received official notice of the award, so we can now start to purchase equipment. More updates soon!

Opportunities for Collaboration

We are eager to collaborate with any groups working on DAC using aqueous solutions. There may be a variety of synergies in thinking about accelerating kinetics of equilibration with air, and for CO_2 extraction.