Development of Advanced Solid Sorbents for Direct Air Capture

Project Number: DE-FE0031954

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U.S. Department of Energy

National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

February 24-25, 2021

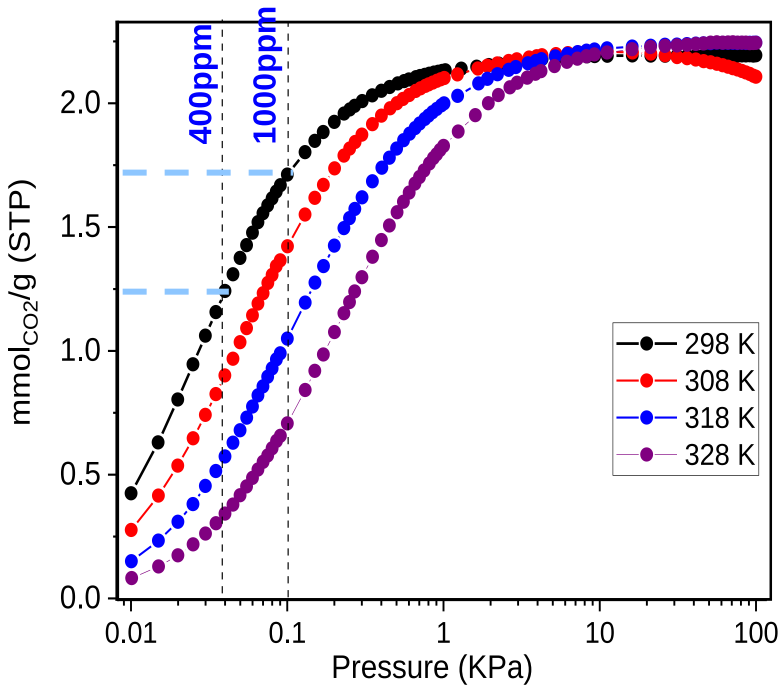
Program Overview

a. **Funding: DOE**:
   a. $800,000 Cost-Share: $200,502
b. **Overall Project Performance Dates**:
   a. 10/01/2020 – 03/31/2022
c. **Project Participants**:
   a. RTI International
   b. Mohammed VI Polytechnic University (UM6P)
   c. Creare LLC.
d. **Overall Project Objectives**:
   a. Development of two novel materials: metal organic frameworks (physisorption) and amine-based dendrimers (chemisorption), for direct air capture of CO_2.
   b. Select the best performing material based on technical merit comparison
   c. Scale-up and cost review of the selected candidate
   d. Preliminary process design

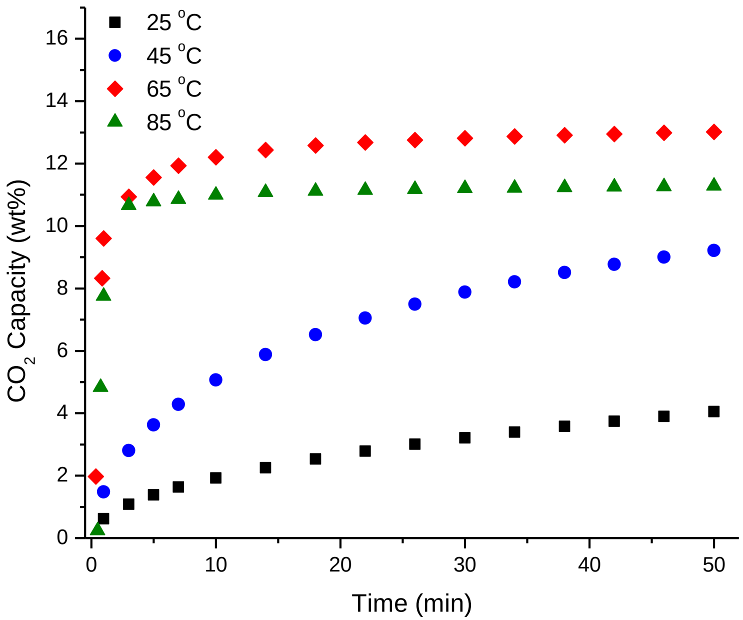
Technology Background

The most significant technical challenge with DAC is the very low atmospheric concentration of CO_2 (currently 415 ppm), thereby requiring sorbents that bind CO_2 strongly and selectively against other components in the air (i.e., nitrogen, water, oxygen, etc.).

Physisorption: *MOF*-Based Sorbent for DAC



Chemisorption: *Amine*-Based Sorbent for DAC



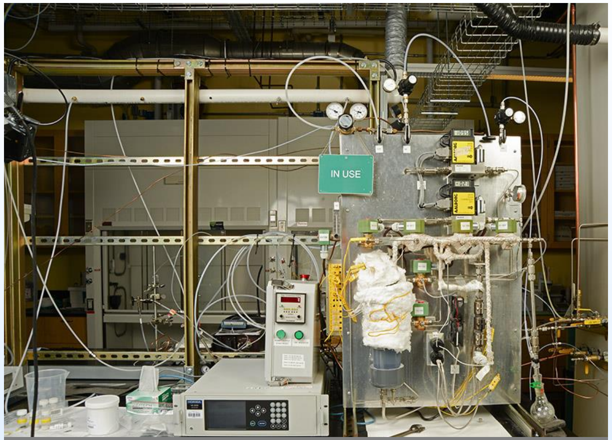
a. **Advantages**: Low-cost sorbents and strongly and selectively bind CO_2

b. **Challenges**: Performance under the presence of contaminants and scale-up

Technical Approach/Project Scope

A. Experimental design and work plan

a. Sorbents synthesis, characterization and CO_2 testing using TGA and packed bed reactor at different relative humidity's
b. Air-gas contaminants evaluation
c. Long-term sorbents CO_2 testing
d. CFD simulations of the sorbents
e. Kinetics, heat and mass transfer data for reactor design
f. Sorbent scale-up and cost evaluation
g. Preliminary process design



Packed Bed Reactor

B. Key milestones

a. Identify one MOF adsorbent and one amine adsorbent for DAC
b. Perform CFD simulations of the MOF and amine adsorbents and validate them with experimental data
c. Select one adsorbent for DAC
d. Demonstrate the scale-up of selected candidate and perform cost review evaluation
e. Perform a preliminary process design

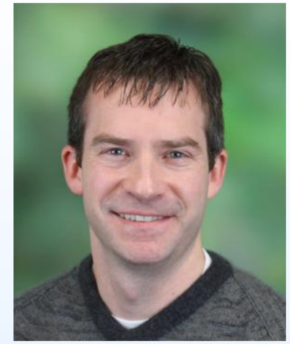
C. Success criteria

a. Demonstrate that the two novel materials, improve DAC cost, performance, and efficiency.
b. Demonstrate that selected adsorbent has cost-effectiveness, longevity, high CO_2 capacity, improved mass and heat transfer, and integration in a multichannel monolith-type reactor

Team and Facilities





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Progress and Current Status

A. MOF-Based Sorbent for DAC

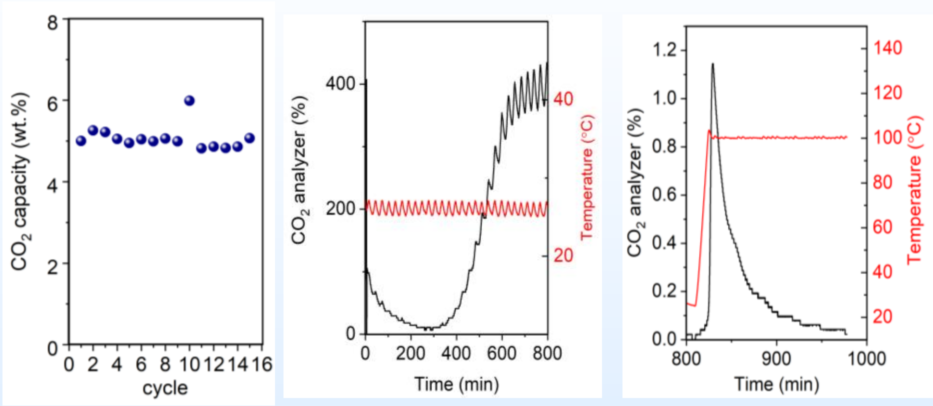
a. MOF synthesis and characterization of 3 different MOFs were accomplished in collaboration with UM6P.

b. One MOF was already evaluated in TGA and PBR for CO_2 capture uptake under relevant DAC conditions

c. CO_2 capture uptake and kinetics under the optimal conditions were determined

d. Pressure drop challenge was addressed using pellets vs powder

Adsorption: Compressed air 25 ˚C (400 ppm CO_2, 1600ppm water)
Regeneration: N_2 100 ˚C



B. Amine-Based Sorbent for DAC

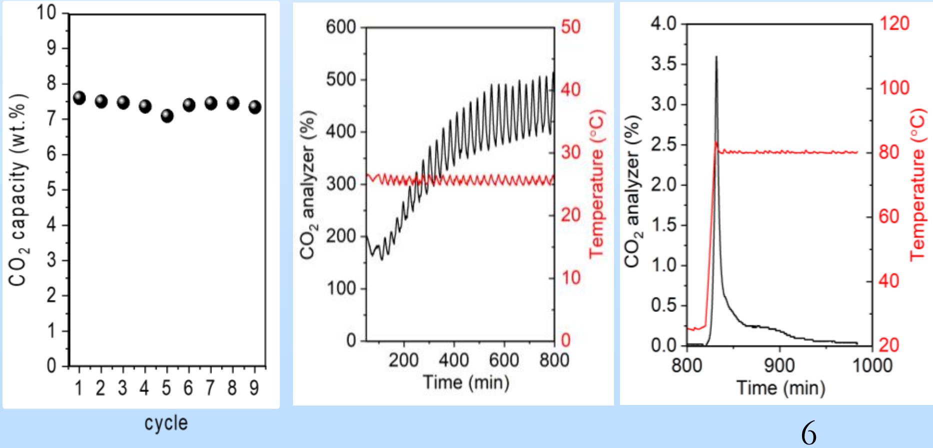
a. Amine sorbents were prepared using different amines ranging from short amine (ethylene diamine) to branched amine (polyethylenimine), and tested in PBR to determine CO_2 capture uptake under the optimal conditions

b. The best performing amine sorbent works very well under different humid conditions

c. Low regeneration energy requirement was accomplished with this amine sorbent (e.g., 80 ^{o}C)

d. The best performing amine sorbent is under evaluation for regeneration performance under different relative humidity, multicycle performance, and chemical stability .

Adsorption: Compressed air 25 ˚C (400 ppm CO_2, 80% RH)
Regeneration: N_2 80 ˚C, 80% RH



Opportunities for Collaboration

Synergistic effects & Potential areas of complementary work

a. Novel processes
b. large-scale demonstration
c. DAC coupled with utilization