Gradient Amine Sorbents for Low Vacuum Swing CO_2 Capture at Ambient Temperature

DE-FE0031958

Steven S. C. Chuang

The University of Akron

U.S. Department of Energy

National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

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Program Overview

Funding

- Total project funding
  - DoE share: $752,002
  - Cost share: $200, 236

Project Participants

- PI: Steven. S. C. Chuang, Akron
- Co-PI: Redouane Begag, Aspen
  Nicholas Leventis, Aspen

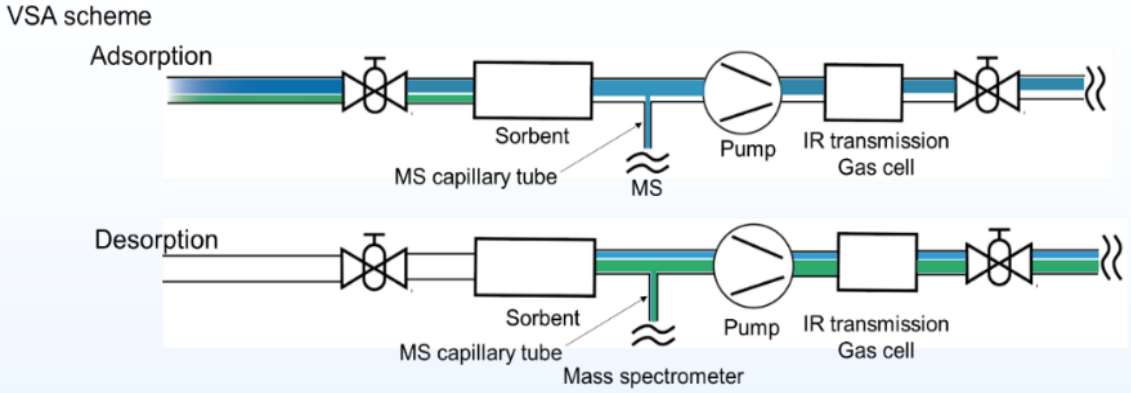
Overall Project Performance Dates

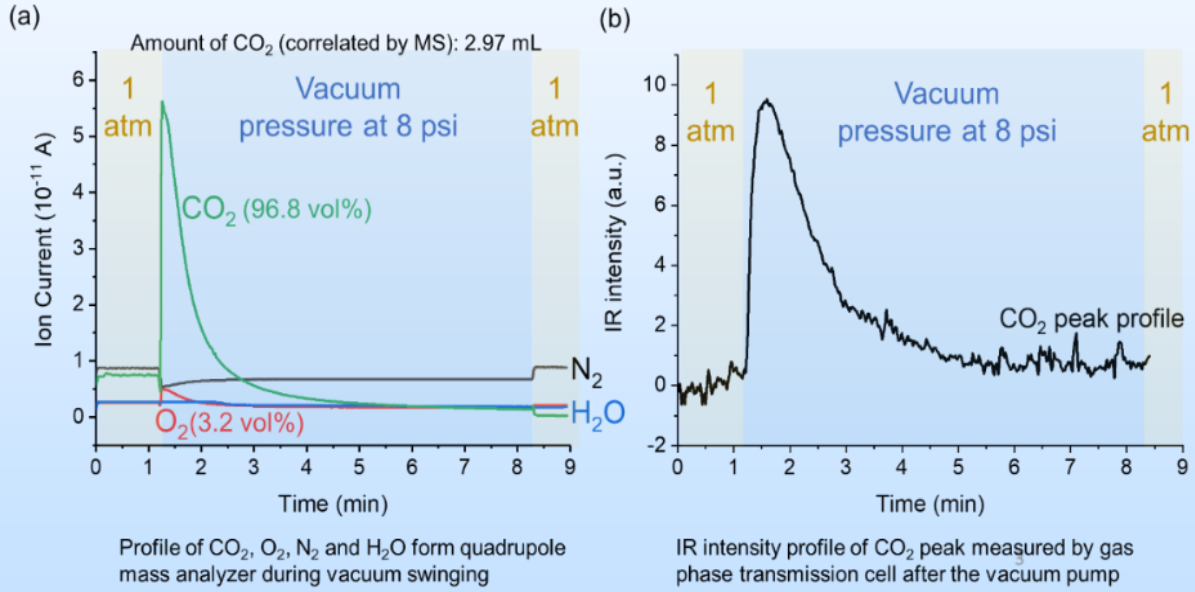
- Project start date: 1/1/2021
- Industrial partners start date:1/1/2022
- Project end date:06/30/2022

Overall Project Objectives

- To develop a novel VSA process by designing, fabricating, and refining the structure of amine sites which can accommodate various climate conditions, testing the low vacuum swing process, evaluating scalability, and cost and life cycle analysis.
- To determine the cost-effectiveness of the proposed technology.

Technology Background





Profile of CO_2, O_2, N_2 and H_2O form quadrupole mass analyzer during vacuum swinging

IR intensity profile of CO_2 peak measured by gas phase transmission cell after the vacuum pump

Sample	Capture capacity (mmol/g)	Weakly adsorption percentage	
		Vacuum swinging	N_2 purge
TPSENa	3.4	18.84%	24.76%
KD-240-24-9B sorbent	2.0	55.55%	/

VSA Scheme

- Adsorption by flowing a 0.04% CO_2 stream over a sorbent bed
- Desorption of weakly adsorbed species by vacuum

Data collection

- Obtaining the concentration profiles of the effluent form the sorbent bed with adsorbed CO_2 under 8 psi vacuum determined by (a) MS before vacuum pump, (b) IR gas cell after vacuum pump. 1 atm=14.7 psi.

Technical advantages:

- Operation at ambient temperature without the input and removal of thermal energy of the sorbent bed.
- Scalable and modular design

Technical challenges

- Production of high purity CO_2 (>99%)
- Fabrication of hierarchical sorbents with a high density of weakly adsorbed CO_2 sites.

Technical Approach/Project Scope

a. Experimental design and work plan

- Preparation, characterization and test of sorbents with weakly adsorbed CO_2 sites
- Fabrication and test of a Kg scale vacuum swing adsorption unit for capture of CO_2 from air.

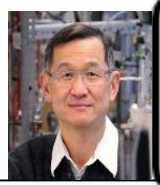
b. Project schedule

Task/ Subtask	Milestone Title & Description	Planned completion date	Actual Completion Date	Verification method
4.0	Determination of CO_2 capture capacity and stability (4 -15)	11/01/2021		Quarterly report
5.0	Fabrication of a Kg scale unit. (12-18)	11/01/2021		Quarterly report
6.0	Vacuum swing test (6-18)	02/01/2022		Quarterly report
7.0	Cost Analysis and Life Cycle Analysis.	05/01/2022		Quarterly report

c. Project success criteria

Decision Point	Date	Success Criteria
1	12/1/2021	Both sorbent plates and sorbent particles exhibit the same level in vacuum swing adsorption CO_2 capture capacity. Reaching the target listed in State-Point Data
2	2/1//2022	Completing the construction of the Vacuum Swing Adsorption unit

Team and Facilities



PI
Steven Chuang

UA leader
Steven Chuang

Aspen
Aerogels, Inc.

George Gould

Chief Technology Officer

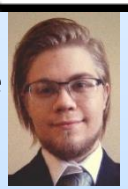
PhD student A

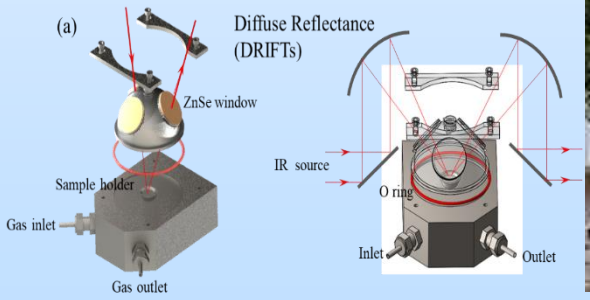
PhD student B

Redouane Begag
Scientist

Nicholas Leventis
Director

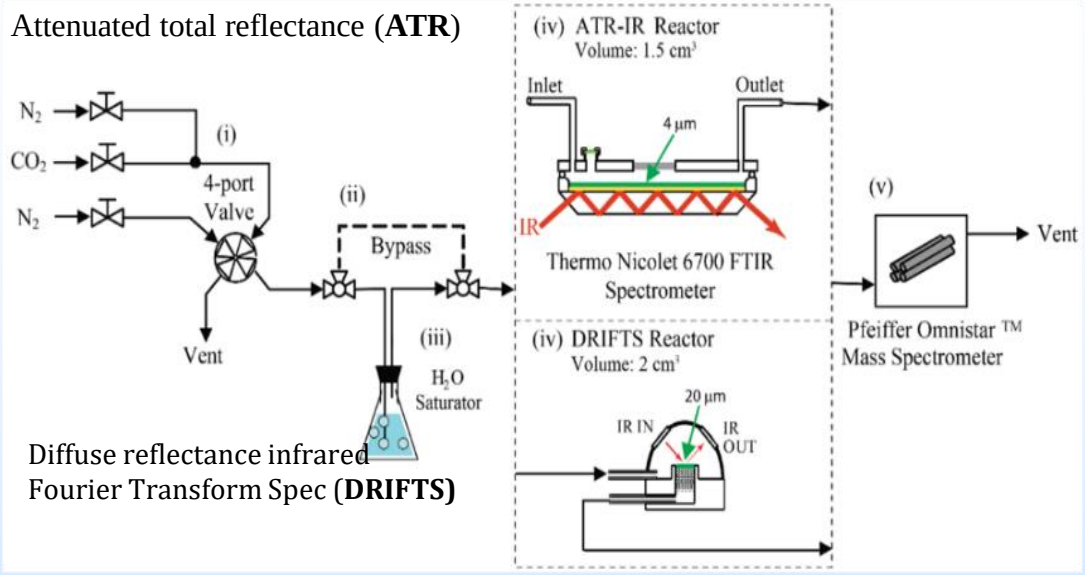
Undergraduate Assistant



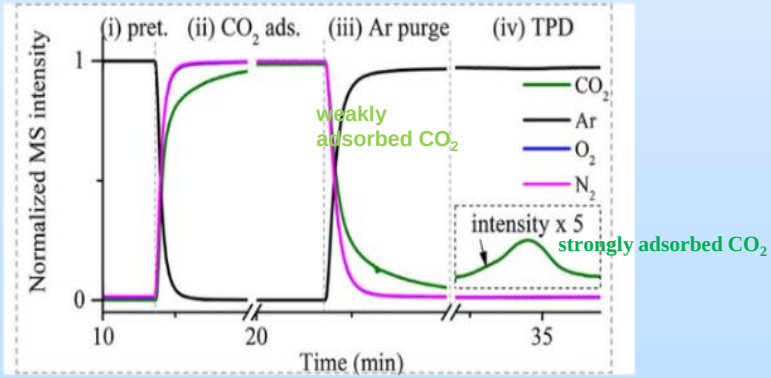


Progress and Current Status of Project

(a)



(b)



(a) In situ infrared (IR) spectroscopy coupled with mass spectroscopy (MS) allows simultaneous monitoring the dynamics of adsorption and desorption of strongly and weakly adsorbed CO_2 on amine sorbents.

(b) Identification of weakly adsorbed CO_2 sites allows design and preparation of a hierarchically structure of amine sorbent for low vacuum swing adsorption.

(c) The project goal is to populate the porous and stable structure with high density of weakly adsorbed CO_2 sites for the vacuum swing adsorption.

Opportunities for Collaboration

a. Seeking collaborative opportunity in developing approaches and capabilities for the preparation of high surface area porous materials with pore size in the range of 9 -10 nm.

b. Complementary work

- Design of a pilot scale unit.
- Development of models for cost analysis