Direct Air Capture Using Trapped Small Amines in Hierarchical Nanoporous Capsules on Porous Electrospun Fibers

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National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

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Program Overview

Funding: $800,000 from DOE; $200,000 Cost Share

Overall Project Performance Dates: 2/1/2021-7/31/2022

Project Participants:

University at Buffalo
The State University of New York

ASU

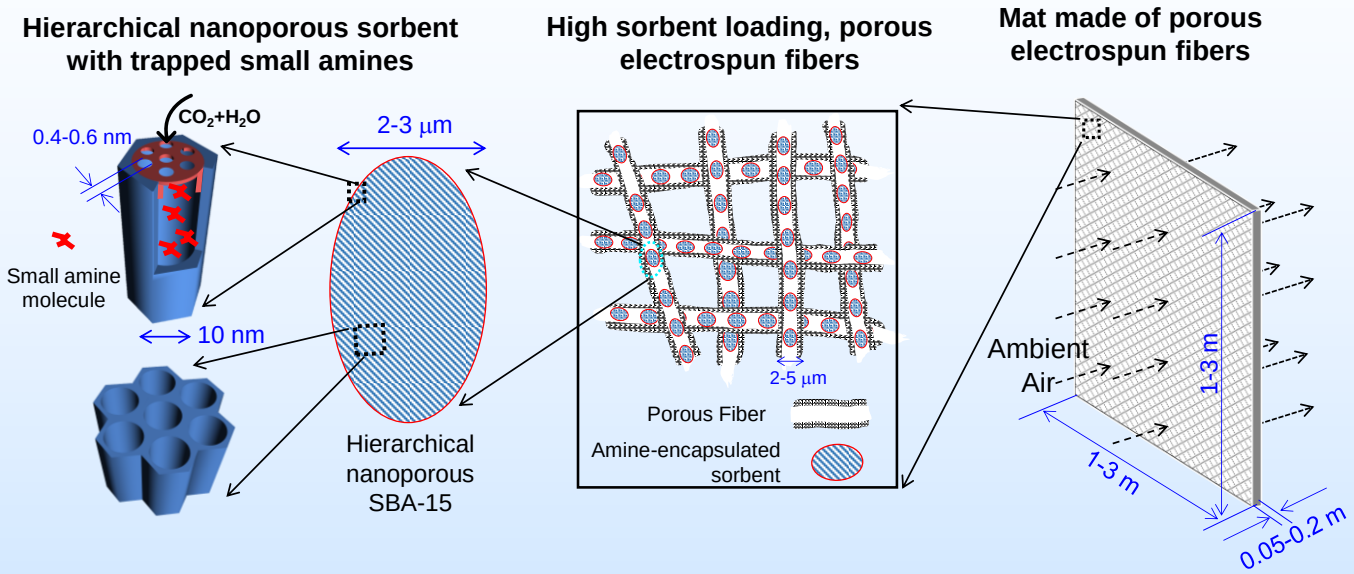
gti

Overall Project Objectives:

Develop an innovative sorbent structure of trapped small amines in hierarchical nanoporous capsules (HNC) embedded in porous electrospun fibers (PEF) for direct air capture (DAC). This involves the tailoring of both sorbent and PEF materials to achieve a compact system for DAC with high capacities for CO_2 at concentrations typically available in air and at near ambient conditions.

Technology Background

Transformational Adsorbent Utilizing Small Trapped Amines



Technical and Economic Advantages

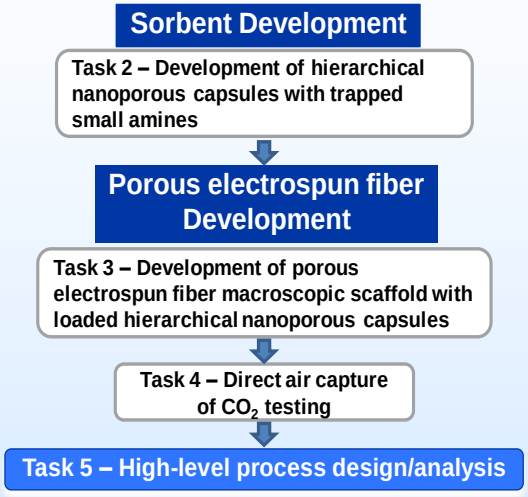
- Fast reaction kinetics and high amine efficiency
- High CO_2 adsorption capacity and good stability
- High sorbent loading on PEFs and fast exposure of sorbent material to air;
- Low energy penalty from the low support fraction/high sorbent loading;

Challenges of our technology

- Precise control of the surface coating pores
- Loading of sorbent particles in PEFs

Technical Approach/Project Scope

Experimental design and work plan



Member	Specific project roles/responsibility
University at Buffalo The State University of New York	• Project management and planning • Sorbent material development • PEF embedded sorbent direct air capture of CO_2 tests • Supporting high-level process design and analysis
ASU	• PEF development • Supporting high-level process design and analysis
gti	• High-level process design and analysis

Project schedule

- **Month 6:** Achieve microporous coating pore size <0.7 nm and amine loss <5% after 10 heating-cooling cycles (M2.1)
- **Month 13:** Achieve >75% sorbent loading in PEF and CO_2 capacity loss <10% relative to powder sorbents (M3.2)
- **Month 15:** Achieve CO_2 equilibrium capacity >8 mmol/g sorbent at ambient temperatures and pressures (M2.3)
- **Month 15:** Achieve CO_2 working capacity >4.5 mmol/g fiber sorbent material and $t_{1/2}$ <30 min (M4.1)

Project success criteria

- Achieve CO_2 working capacity of 3.5-5 mmol/g fiber sorbent material and $t_{1/2}$ <30 min
- CO_2 working capacity loss <10% and $t_{1/2}$ increase <10% after cyclic testing
- Issue high-level process design/analysis topical report
- Submit Final Technical Report

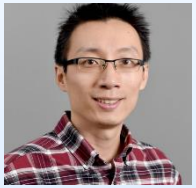
Team and Facilities

Team members


Prof. Miao Yu


Dr. Qiaobei Dong


Kaleb Friedman


Prof. Bin Mu


Dr. Shiguang Li

Facilities


ALD/MLD system


TGA-DSC system


Mass spectrometer


Gas chromatography


PEF fabrication system

Opportunities for Collaboration

Synergistic effect on advancing DAC technologies via collaboration

- Data sharing/fundamental mechanism understanding may stimulate new ideas
- Available equipment sharing can greatly improve R&D efficiency
- Collaborator's expertise can accelerate advancing technology to higher TRL

Potential areas of complementary work

- Sorbent nanostructure clarification: HRTEM
- Scale-up of sorbent materials
- Engineering design