Membrane Adsorbents Comprising Self-Assembled Inorganic Nanocages (SINCs) for Super-fast Direct Air Capture Enabled by Passive Cooling

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U.S. Department of Energy

National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

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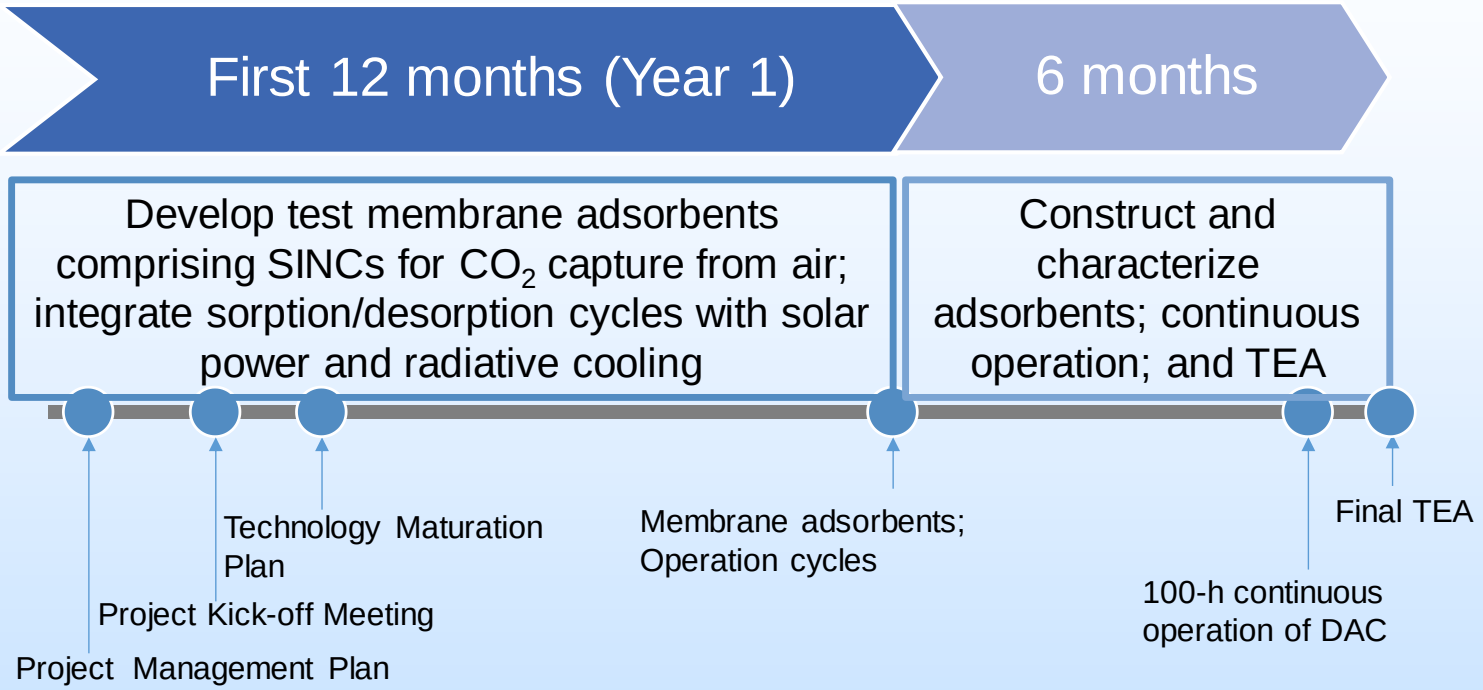
Program Overview

a. Funding (DOE: $800,000; Cost Share: $206,330)
b. Overall Project Performance Dates: 10/1/20 – 3/31/22
c. Project Participants: University at Buffalo (UB) and Trimeric Corporation (Trimeric)
d. Overall Project Objectives
   - Year 1: design and prepare membrane adsorbent based on CO_2-philic polymers and SINCs, and design operation cycles with solar heating and radiative cooling for CO_2 capture from air.
   - M13-M18: construct and characterize a DAC prototype, demonstrate the 100-h continuous operation for DAC, and complete the TEA.

Technical Approach/Project Scope

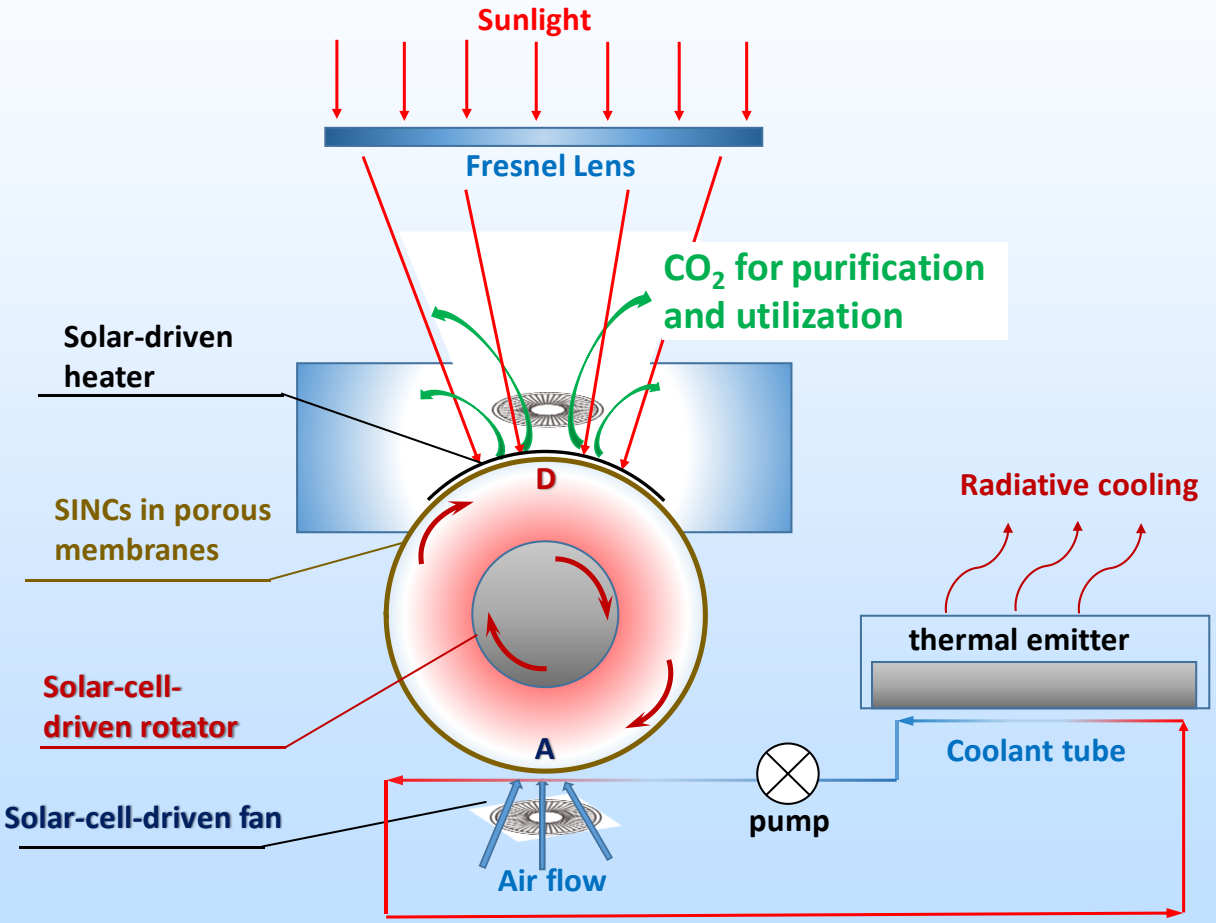


Success criteria

- Lab-scale tests demonstrate CO_2 sorption of >2.0 mmol/g and excellent stability les for 100-h continuous operation.

- TEA shows that the process is economically competitive with the state-of-the-art sorbent technologies ($600/ton CO_2)

Technology Background

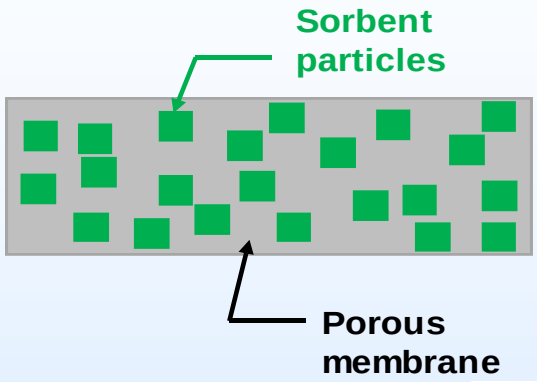


Each cycle

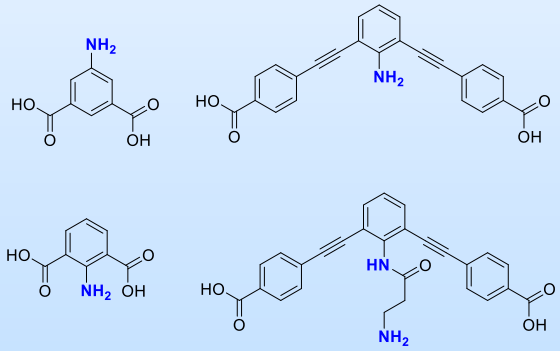
1. **Sorption**
2. **Desorption by heating provided by solar cell**
3. **Radiative cooling**

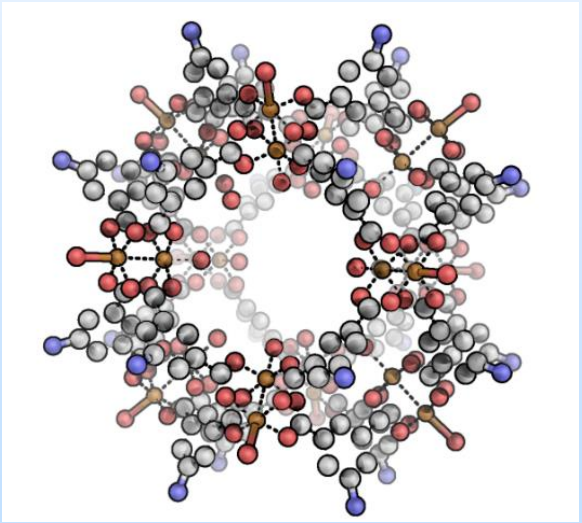
- **Porous membrane adsorbents**
- **Nanocages**
- **electricity-free radiative cooling**
- **solar heating and desorption**

Our Technology: Membrane Adsorbents



Flat-sheet membrane adsorbents with porosity 60 – 95% comprising CO_2-philic SINCs and polymers





$$CO_2 + 2RNH_2 \leftrightarrow RNH_3^+ + RNHCOO^-$$

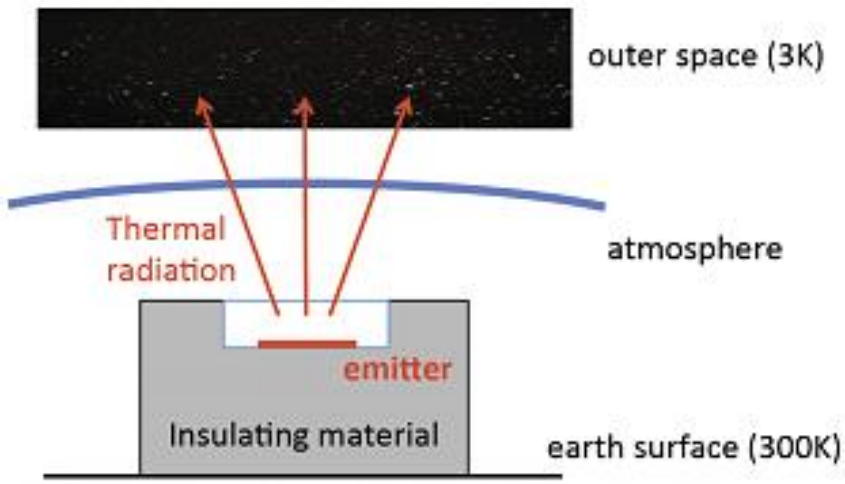
$$CO_2 + 2R_1R_2NH \leftrightarrow R_1R_2NH_2^+ + R_1R_2NCOO^-$$

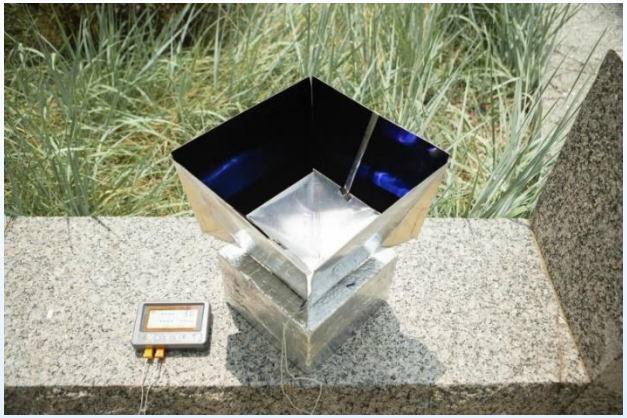
$$CO_2 + R_1R_2NH + H_2O \leftrightarrow R_1R_2NH_2^+HCO_3^-$$

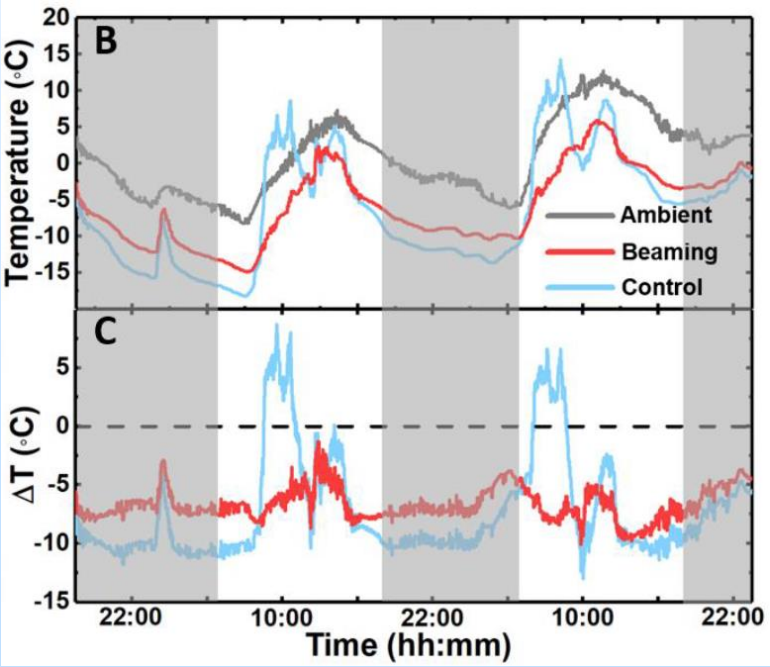
$$CO_2 + R_1R_2R_3N + H_2O \leftrightarrow R_1R_2R_3NH^+HCO_3^-$$

Larger ligands expand the cavity to ~3.4 nm, providing room for alkyl amines

Radiative Cooling







Outdoor continuous measurement of proposed radiative cooling architecture.

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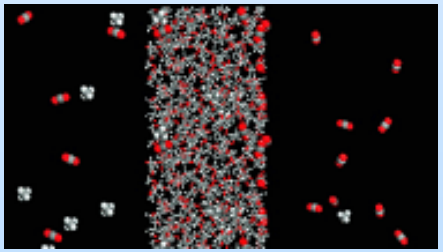
Team and Facilities

Haiqing Lin

Novel membrane materials for CO_2 capture



Tim Cook

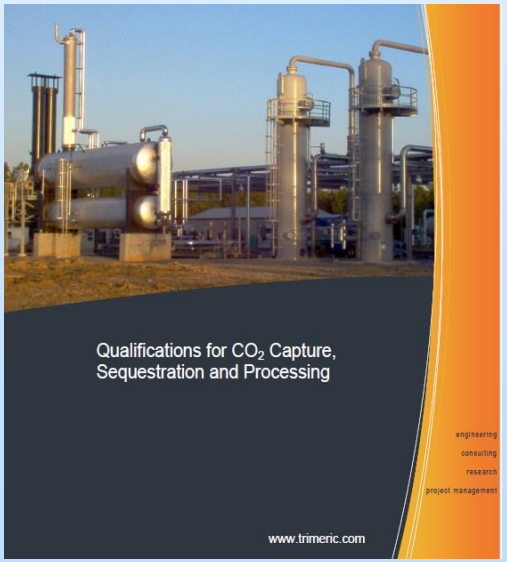
Self-assembly of discrete inorganic metallacycles & cages

Qiaoqiang Gan

Thermal management

Andrew Sexton

TEA



Opportunities for Collaboration

a. Collaboration in our project
   - New CO2 adsorbents: porous membranes; SINCs
   - Electricity-free thermal management and TSA
   - Materials and TEA

b. Potential areas of complementary work
   - High performance adsorbents
   - System analysis: life cycle analysis
   - Design of rapid sorption/desorption systems