Integrated Process for Direct Air Capture of CO_2 and Electrochemical Conversion to Ethanol

TCF-20-20118

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Oak Ridge National Laboratory

ReactWell, LLC

U.S. Department of Energy

National Energy Technology Laboratory

Direct Air Capture Kickoff Meeting

February 24-25, 2021

OAK RIDGE National Laboratory

ReactWell

Program Overview

Funding: $1.5 mil/3 yrs (FE) + $1.5 mil in-kind match-up (ReactWell)

Overall Project Performance Dates: Jan 2021-Jan 2024

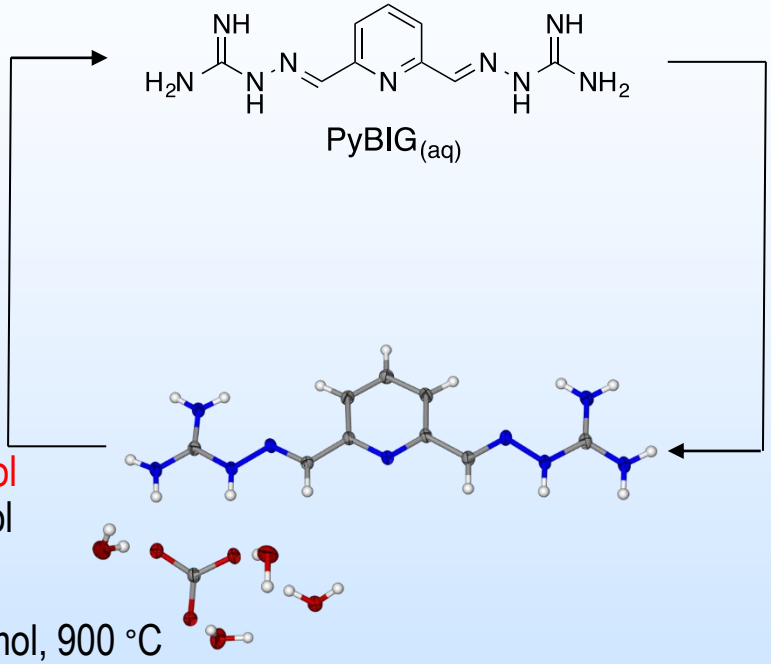
Project Participants: Radu Custelcean, Costas Tsouris, Kashif Nawaz (ORNL); Brandon Iglesias (ReactWell)

Overall Project Objectives: Develop an energy-efficient, cost-effective, net-zero emission technology that closes the carbon cycle by combining DAC with catalytic electrochemical conversion of CO_2 into ethanol

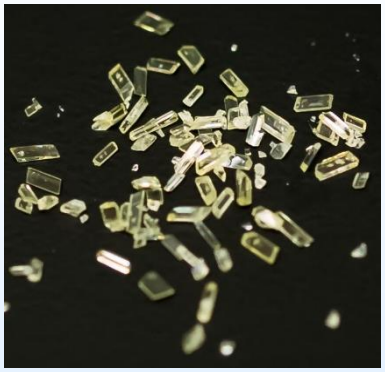
- DAC with aqueous amino acids and crystalline guanidine solids (ORNL)
- Electrochemical conversion of CO_2 into ethanol with Cu nanoparticles/carbon nanospike catalyst (ReactWell)
- Ethanol commercialization as hand sanitizer, spirits & fuel (ReactWell)

Technology Background

DAC cycle

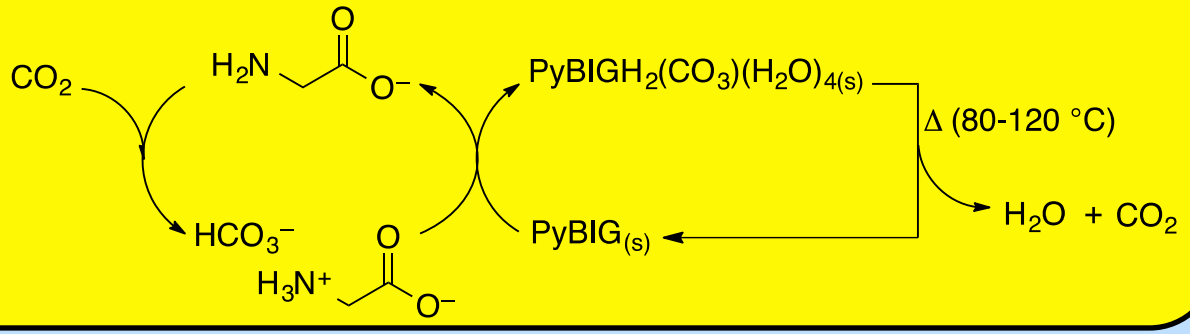


Benchmark:
$CaCO_3$ 179 kJ/mol, 900 °C



PyBIG-CO_3: $K_{sp} = 1.0 \times 10^{-9}$
$CaCO_3$: $K_{sp} = 3.4 \times 10^{-9}$

DAC bi-cycle with amino acid/PyBIG

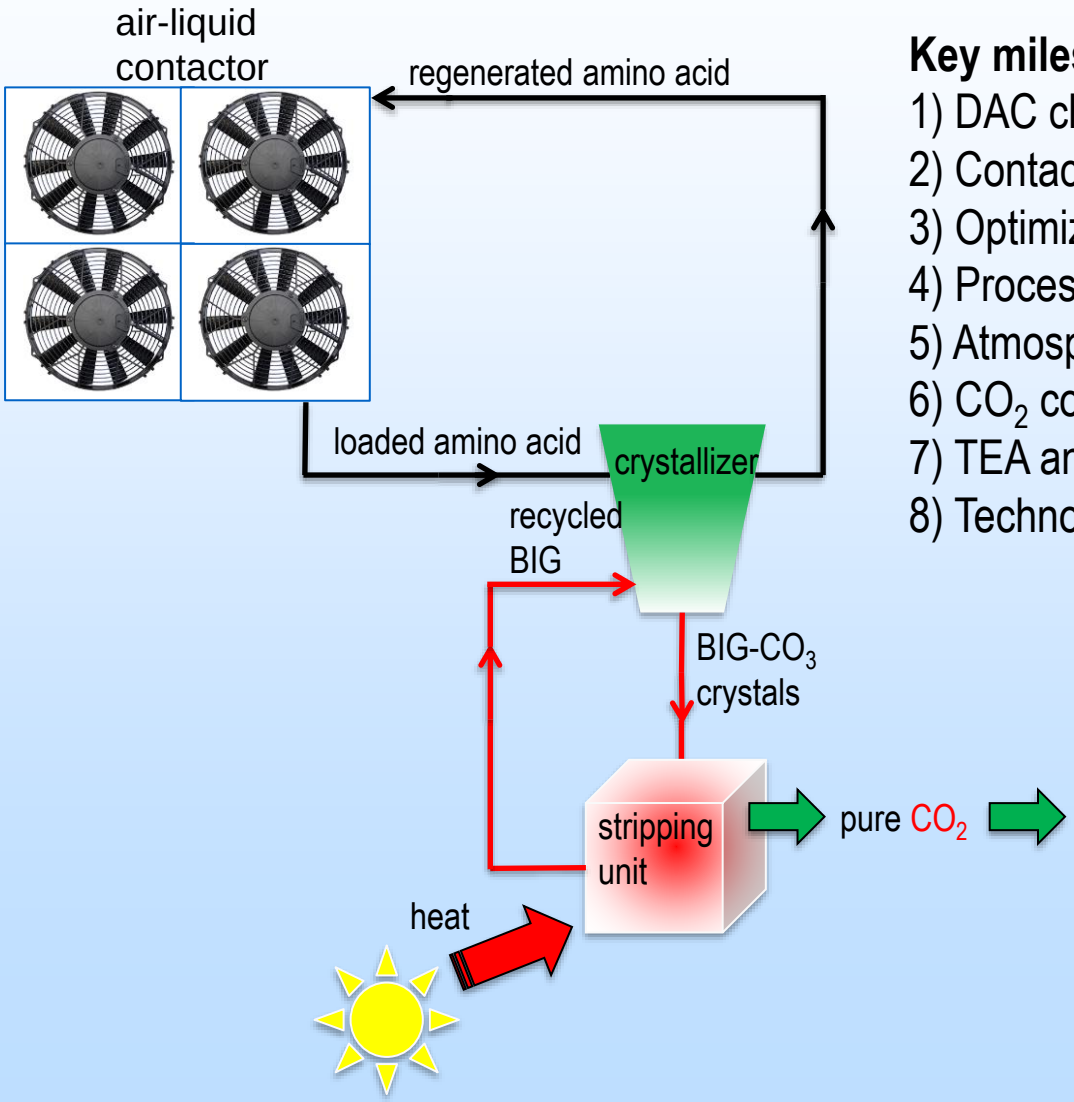


Angew. Chem. Int. Ed. **2017**, *56*, 1042
(highlighted in USA Today, Forbes)
Nature Energy **2018**, *3*, 553
(top 5 story from Office of Science)
Chem **2019**, *5*, 719 (highlighted in Science)
IUCRJ **2019**, *6*, 56.
Ind. Eng. Chem. Res. **2019**, *58*, 23338
ChemSusChem **2020**, *13*, 6381

US patent 10,583,387, **2020**.

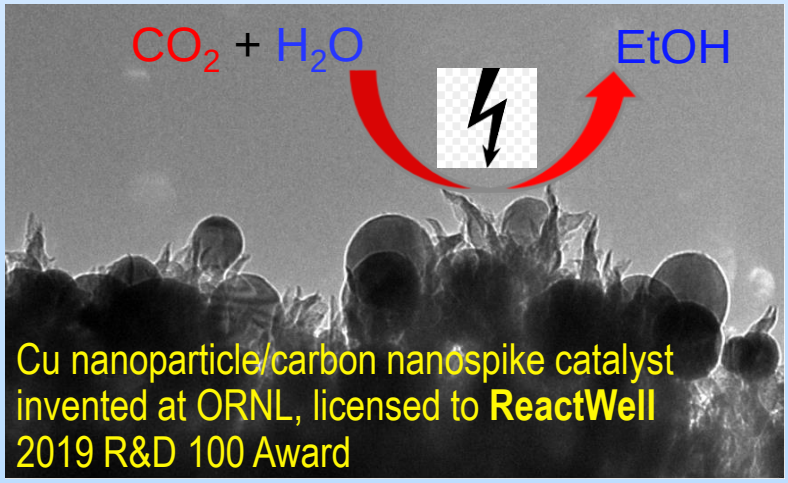
Phase-change DAC process – combines the benefits of aqueous solvents and solid sorbents

Technical Approach/Project Scope



Key milestones

1) DAC chemistry optimization
2) Contactor design, manufacturing, testing
3) Optimization of sorbent regeneration/CO_2 release
4) Process engineering & intensification
5) Atmospheric water capture
6) CO_2 conversion to ethanol
7) TEA and LCA
8) Technology scale-up and commercialization



Team and Facilities

ORNL


Radu Custelcean
organic chemist


Costas Tsouris
chemical engineer


Kashif Nawaz
mechanical engineer


Diana Stamberga
organic chemist

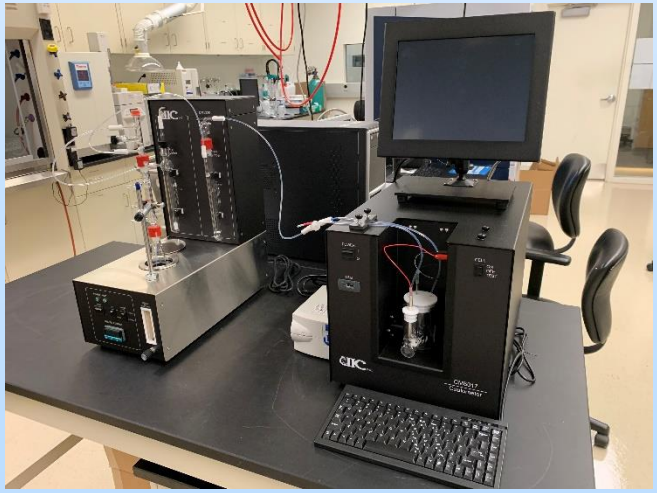

Abishek Kasturi
grad student (Georgia Tech)

ReactWell


Brandon Iglesias
chemical engineer

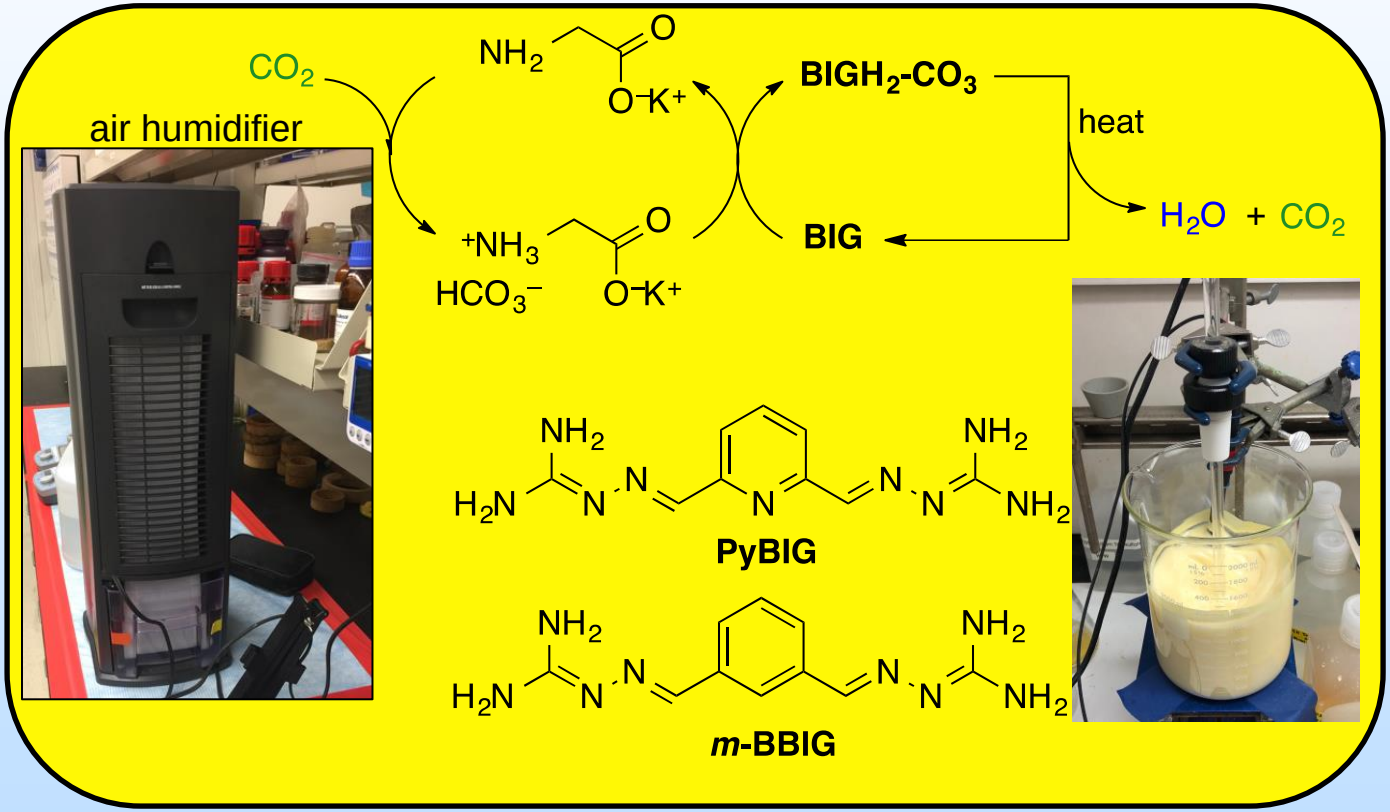
Chem Chip catalyst

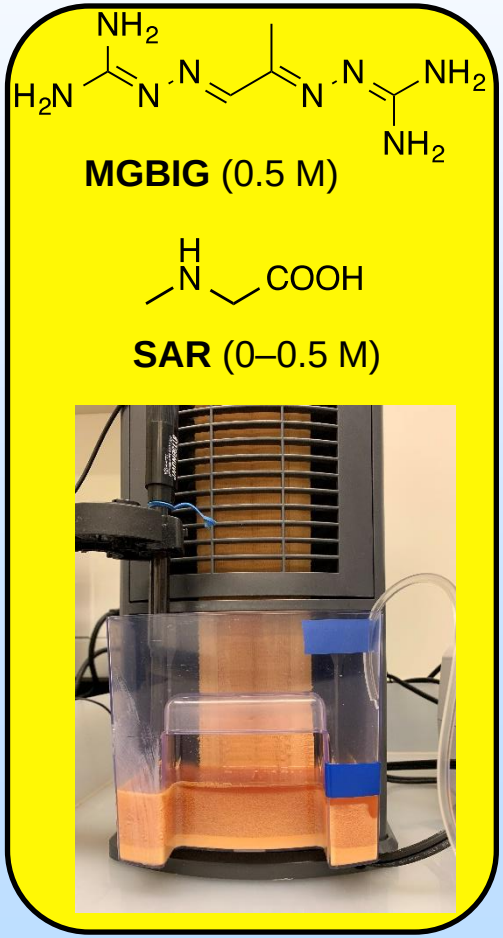
Carbonate analyzer



Progress and Current Status

DAC Chemistry: Identify the optimal amino acid/BIG combinations and reaction conditions leading to fastest rate of CO_2 absorption, highest cyclic capacity, and lowest regeneration energy.





Preliminary results (MGBIG/SAR): Catalytic amount of amino acid (10 mol%), no KOH, enhanced crystallization yield (from 28% to 84%), intensified 3-phase (gas+liquid+solid) process

Opportunities for Collaboration

Internal collaborations

Synergy between **BES** (sorbent design & synthesis, structural analysis, thermodynamics) and **FE** (process optimization, scale up, commercialization)

External collaborations

Electrochemistry (solvent regeneration, CO_2 to EtOH conversion)

Membrane contactors (reactive membrane crystallization)

Industrial crystallization (controlling crystal form, nucleation & crystal growth, crystal morphology, particle size distribution)