PCI
Precision Combustion, Inc.

Capture of Atmospheric CO_2

DOE SBIR Phase 1 Contract # DE-SC0020869
June 29, 2020-March 29, 2021
Contracted amount: $ 249,633.00

Company: Precision Combustion Inc.
Program Office : Office of Science
Program Manager: Andy O'Palko
Codruta Loebick (PI), Benjamin Baird, Jeff Weissman, Anthony Anderson

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U.S. Department of Energy
National Energy Technology Laboratory
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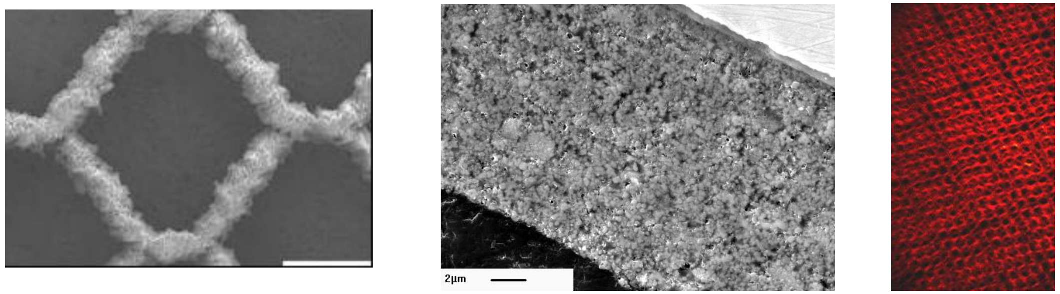
Program Overview

Main Objective: Develop and demonstrate a system for efficiently capturing CO2 from the atmosphere.

Technical Objectives: Address fundamental requirements of a competitive DAC Process

- uptake and high selectivity at the very low CO_2 concentration
- low cost and durability
- low pressure drop operation at high space velocity for energy efficiency
- low regeneration energy

PCI DAC system consists of MOF sorbents coated on Microlith mesh support system operating in temperature swing.



Thin, durable, metal mesh w. <u>*very high surface area*</u> that can be coated with catalysts or sorbents

PCI Microlith-based lab-scale CO2 Capture Unit operating at the National Carbon Capture Center (NCCC).

Technical Approach

Sorbent Development

- Leverage our experience with MOF for CO_2 capture
- Synthesize selective materials with good DAC capacity
- Synthesize materials that are resistant to humidity and impurities
- Focus on heat of adsorption to lower regeneration temperature

Contactor

- Employ a short contact time thin mesh substrate
- Substrate offers high mass and heat transfer for efficient capture and regeneration
- Substrate has very high surface area per unit volume
- Demonstrated low pressure drop in operation
- Modular Design Easily Scalable

System Design

- Full integration of Balance of Plant Components
- Design of pilot-scale DAC unit for Phase 2
- Energy Balance
- Technoeconomic analysis

Technology Background

Implement high internal volume nanosorbents (MOF) coated on a short contact time, low pressure drop and high mass transfer rate "Microlith®" mesh substrate to act as a CO2 filter .

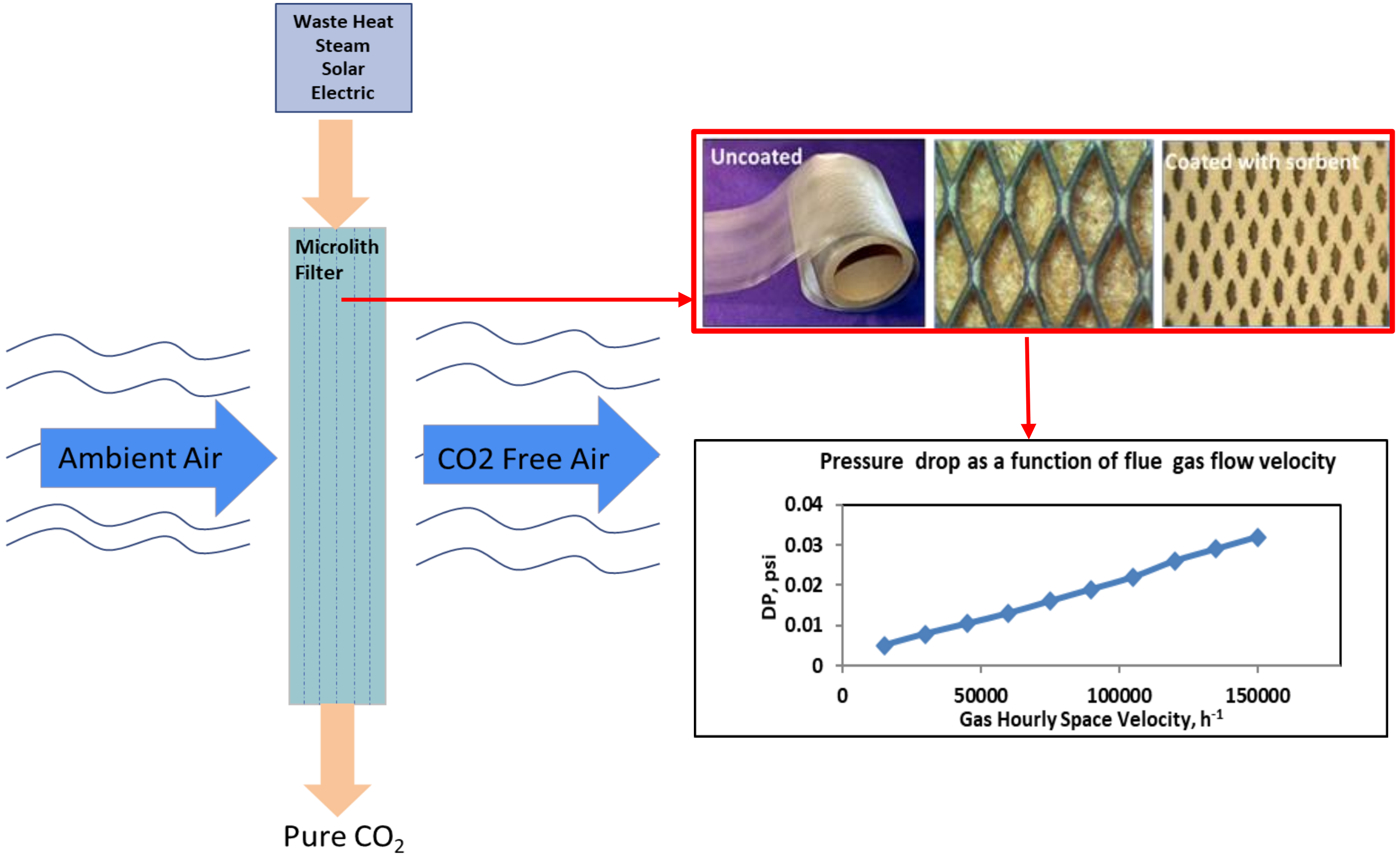
- **Flexible design**
- **Meets system performance requirements**

<u>Energy savings</u>

- Use of solid physisorption
- Reduced regeneration temperature 80 -100°C;
- Lower pressure drop during sorption and desorption;
- Faster regeneration times

<u>Capital and operating cost savings</u>

- Predicted cost of MOF at large scale;
- Higher sorbent bed utilization;
- High mass transfer rates and reduced channeling;
- Reduced gross energy requirements



Team and Facilities

Codruta Loebick (Principal Investigator)

- Senior Research Engineer
- Ph.D Chemical Eng.
- Yale University
- @ PCI since 2011
- Expertise:
  - *Nanomaterials*
  - *Sorbents*
  - *Gas separation*
  - *Liquid separation*
  - *Catalysis*

Benjamin Baird (Technical Lead)

- Senior Comb. Res. Eng.
- Ph.D. Aero Eng.
- Univ. of Oklahoma (OU)
- @ PCI since 2005
- Expertise:
  - *Combustion*
  - *Catalytic Enhancement*
  - *CFD Analysis*
  - *Glow plug integration*

Jeffrey Weissman (Catalyst, Coatings)

- Principal Scientist
- Ph. D. Chem E
- Carnegie Mellon Univ.
- @ PCI since 2009
- Expertise:
  - *Heterogeneous Catalyst*
  - *Fuel Reforming*
  - *Chem. Kinetics*
  - *Material Synthesis*
- Prior affiliations:
  - Delphi Automotive
  - Texaco R&D

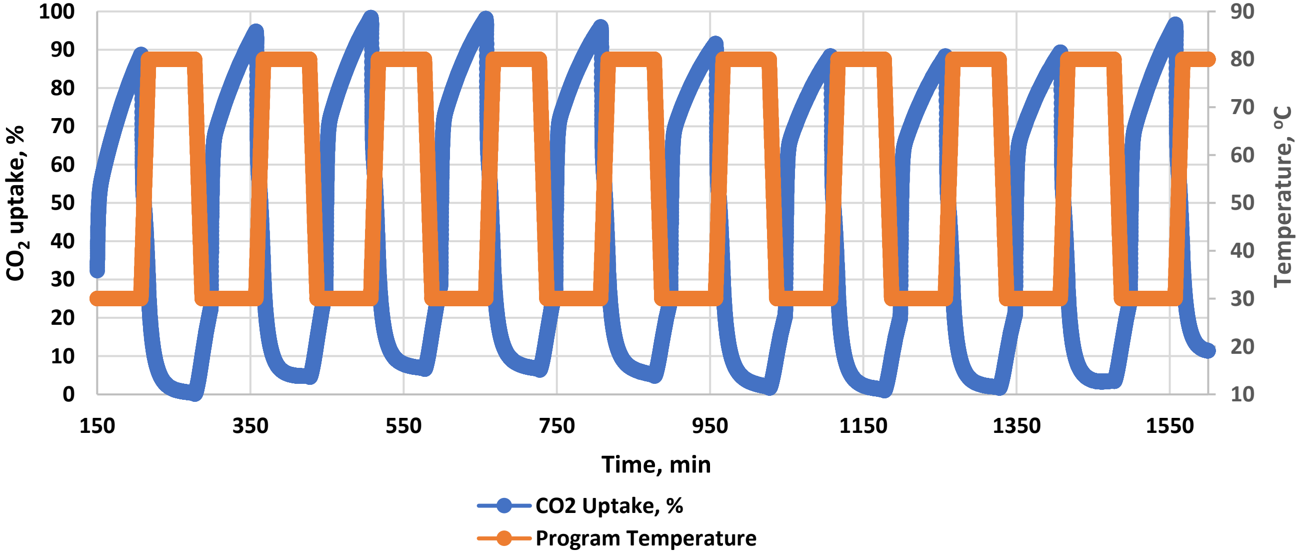
Tony Anderson (Commercialization)

- Director, Bus. Dev.
- B.S. Missouri (Rolla)
- M.S. Boston U.
- MBA (Carnegie Mellon)
- @ PCI since 2001
- Expertise:
  - *Manufacturing*
  - *Commercialization*
  - *QA/QC*
  - *Business planning*
- Prior affiliations:
  - McDonnell Douglas
  - Sikorsky

In-house: *Mechanical Design and Pilot Assembly , Sorbent /coating experts; Mechanical/electrical/chemical techs*

Progress and Current Status

- Select and evaluate MOF composites for DAC and demonstrate low-temperature regenerability of the material.
- Evaluate the material properties as-coated on thin mesh substrates for further system level integration – Ongoing. DAC lab-scale unit assembly finalized, testing in progress.
- Establish a proof-of-concept techno-economic analysis of a DAC system



Unit	Value
Sorbent amount, kg	1000
CO_2 captured per cycle, kg	50
Adsorption Temperature, °C	20
Regeneration Temperature, °C	80
Total air per cycle, m^3	56,104
Adsorption high-cycle length, min	40
Air flow rate, m^3/s	23.4
Estimated pressure drop, Pa	250
Blower Energy per ton CO_2 recovered, kWh	54
Total Energy Expense per ton of CO2 recovered, kWh	721.8

Opportunities for Collaboration

- Sorbent-based DAC systems could take advantage of PCI's sorbent module and operations software within their own systems

Areas of complementary work for contribution to our project

- Provide candidate MOF materials for evaluation
- Provide input to the techno-economic analysis of the PCI DAC system
- Provide commitment and funding for a Phase II proposal to be submitted in April, 2021.