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

U.S. Department of Energy
National Energy Technology Laboratory
Direct Air Capture Kickoff Meeting
February 24-25, 2021
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 CO₂ 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. very high surface area 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 CO2 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
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

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

**Capital and operating cost savings**
- 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

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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

<table>
<thead>
<tr>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorbent amount, kg</td>
<td>1000</td>
</tr>
<tr>
<td>CO₂ captured per cycle, kg</td>
<td>50</td>
</tr>
<tr>
<td>Adsorption Temperature, °C</td>
<td>20</td>
</tr>
<tr>
<td>Regeneration Temperature, °C</td>
<td>80</td>
</tr>
<tr>
<td>Total air per cycle, m³</td>
<td>56.104</td>
</tr>
<tr>
<td>Adsorption high-cycle length, min</td>
<td>40</td>
</tr>
<tr>
<td>Air flow rate, m³/s</td>
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<tr>
<td>Estimated pressure drop, Pa</td>
<td>250</td>
</tr>
<tr>
<td>Blower Energy per ton CO₂ recovered, kWh</td>
<td>54</td>
</tr>
<tr>
<td>Total Energy Expense per ton of CO₂</td>
<td>721.8</td>
</tr>
</tbody>
</table>

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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.