# Accelerated Life Cycle Testing of Advanced Structured Material Systems for Direct Air Capture

## primary project goal

RTI International is partnering with Creare to design, fabricate, and test, at bench scale, a contactor coated with advanced solid sorbents for direct air capture (DAC) of carbon dioxide ($CO_2$). The project is focused on the operation of a bench-scale $CO_2$ removal unit inside an environmental chamber that will maintain constant, controlled test conditions for long-duration life testing (e.g., 1,000 cycles) and parametric testing.

## technical goals

- Develop a robust sorbent binder composite coating onto contactor structure.
- Identify the best coating thickness while maximizing the diffusivity and kinetics under optimal sorption and desorption conditions.
- Demonstrate high $CO_2$ capacity and excellent mechanical durability of coating, and assess the flow versus the pressure drop performance.
- Build a unique test system that will enable rapid, automated cycling of DAC contactors under conditions that simulate operation in a wind-driven system.
- Demonstrate performance and durability in parametric tests across a range of simulated environmental conditions (air speed, ambient temperature, relative humidity).
- Demonstrate long-term performance of the contactor using a controlled air stream (known flow rate, composition, temperature, and pressure) to ensure controlled test conditions over 1,000 cycles.
- Conduct a detailed techno-economic analysis (TEA) and life cycle analysis (LCA) using all experimental data collected.

## technical content

The system incorporates RTI's high-performance, high-durability amine sorbents in an innovative air contactor design that is optimized for wind-drive operation. Utilization of Creare's hybrid additive manufacturing technology enables the low-cost fabrication of high-performance, compact structures that exhibit efficient heat and mass exchange transfer and that are ideally suited for integration with sorbent materials. The sorbent/contactor design enables high $CO_2$ sorption, low regeneration temperature, and excellent tolerance for oxygen and water. The unique environmental chamber being built for testing purposes enables rapid, automated temperature-swing sorption cycling of DAC contactors under conditions that simulate operation in a wind-driven system. Testing in the chamber with constant, controlled test conditions allows for long-term cyclic testing and parametric testing. Ducted fans provide specified air flow rates to simulate constant wind speed throughout the test. Two modules operate 180°C out of phase to maintain steady $CO_2$ concentration during simultaneous adsorption and desorption operation.

program area:
Carbon Dioxide Removal

ending scale:
Bench Scale

application:
Direct Air Capture

key technology:
Sorbents

project focus:
Life Cycle Testing of Passive Sorbent/Contactor for DAC

participant:
Research Triangle Institute

project number:
FE0032099

predecessor projects:
N/A

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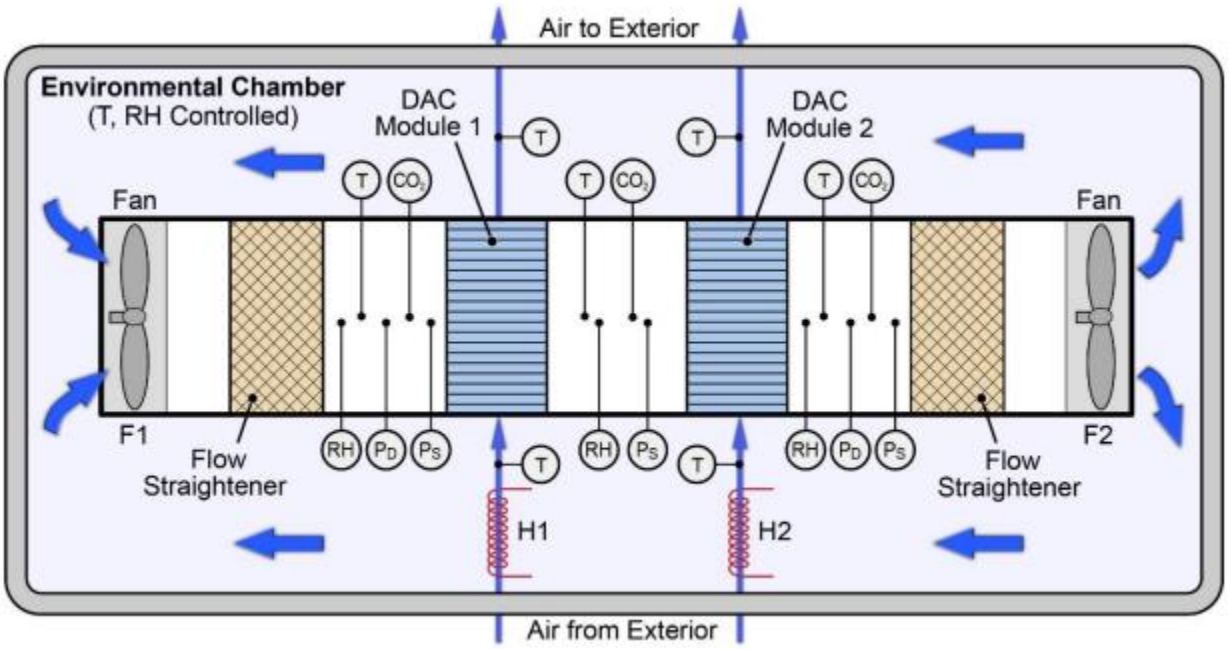


**Figure 1: Test chamber for long-term testing of contactor modules.**

## technology advantages

- Rapid and simple temperature-swing sorption cycling.
- Highly efficient mass transfer and low flow resistance of contactor enables low-power, wind-driven operation.
- Low-cost additive manufacturing process for fabrication of contactor.
- High surface area contactor designed with parallel-plate micro-channels.
- This project leverages the knowledge and experience gained through the Advanced Research Projects Agency–Energy (ARPA-E) efforts to complete the development of a bench-scale DAC process by optimizing the sorbent binder composite coating and enabling long-term cyclic testing to prove performance and durability.

## R&D challenges

- Sorbent coating durability and $CO_2$ sorption and regeneration performance during long-term cycling under relevant DAC conditions.
- Achieving a uniform sorbent coating layer with a thickness ≤ 10 mil (e.g., 0.254 mm) and strong film adhesion to the stainless steel plate surface.
- Achieving efficient $CO_2$ capture under minimal wind conditions.

## status

The project commenced in October 2021. The project team is preparing a sorbent coating formulation. Polymers under consideration as coating binders are phenolic resins, epoxy novolac resins, acrylates, and many others.

## available reports/technical papers/presentations

Mustapha Soukri, “Accelerated Life Cycle Testing of Advanced Structured Material Systems for Direct Air Capture,” Kickoff Meeting Presentation, December 2021. *https://netl.doe.gov/projects/plp-download.aspx?id=12664&filename=Accelerated+Life+Cycle+Testing+of++Advanced+Structured+Material++Systems+for+Direct+Air+Capture.pdf*.