the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

CO_2 Removal from Flue Gas Using Microporous Metal Organic Frameworks

Background

The mission of the U.S. Department of Energy's (DOE) Existing Plants, Emissions, & Capture (EPEC) Research & Development (R&D) Program is to develop innovative environmental control technologies to enable full use of the nation's vast coal reserves, while at the same time allowing the current fleet of coal-fired power plants to comply with existing and emerging environmental regulations. The EPEC R&D Program portfolio of post- and oxy-combustion carbon dioxide (CO_2) emissions control technologies and CO_2 compression and reuse is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints.

One area of control technology for post-combustion CO_2 capture utilizes solid sorbents to remove CO_2 from flue gas through chemical and/or physical adsorption. Adsorption occurs when molecules adhere to the surface of the sorbent. This innovative project will develop novel microporous metal organic frameworks (MOFs) and an associated process for the removal of CO_2 from coal-fired power plant flue gas, exploiting the latest discoveries in an extraordinary class of materials having extremely high adsorption capacities. MOFs are hybrid organic/inorganic structures that are essentially scaffolds made up of metal hubs linked together with struts of organic compounds, a structure designed to maximize surface area. MOF sorption properties can be readily tailored by modifying either the organic linker and/or the metal hub.

Description

UOP LLC, in collaboration with Vanderbilt University, the University of Edinburgh, the University of Michigan, and Northwestern University is working to develop a MOF-based CO_2 removal process and to design a pilot study to evaluate the performance and economics of the process in a commercial power plant.

During Phase I, UOP will use its combinatorial chemistry capabilities to systematically synthesize a wide range of state-of-the-art MOFs and related materials. UOP will screen the materials for hydrothermal stability and characterize materials of particular interest. Detailed isotherm data will be collected in the low-pressure regime in order to establish a consistent, relevant baseline for subsequent development and optimization. The results of the baseline studies will be used to guide the ongoing synthesis, screening, and measurement of new MOFs. In Phase II, up to 10 candidates will be

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PROJECT DURATION

Start Date	End Date
04/01/2007	06/30/2010

COST

Total Project Value
$2,834,798

DOE/Non-DOE Share
$2,256,750 / $578,048

PARTNERS

UOP LLC
Vanderbilt University
University of Edinburgh
University of Michigan
Northwestern University

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selected for optimization, based on Phase I results. The effects of water on CO_2 adsorption will be measured in parallel with the development and validation of material scale-up and forming procedures. During Phase III, one or two of the best materials will be selected for final optimization and scale-up to pilot-scale quantities. The effects of contaminants on the performance of scaled-up, formed materials will be optimized and detailed kinetic and equilibrium data will be collected. These data will be incorporated into a process design and process economic analysis, leading to the design of a pilot study.

Primary Project Goal

The primary goal of this project is to develop a low-cost, novel sorbent and associated process to remove CO_2 from coal-fueled power plant flue gas in a cost effective manner.

Objectives

The objective of this project is to develop a low-cost novel MOF-based sorbent and an associated process for CO_2 capture that demonstrates:

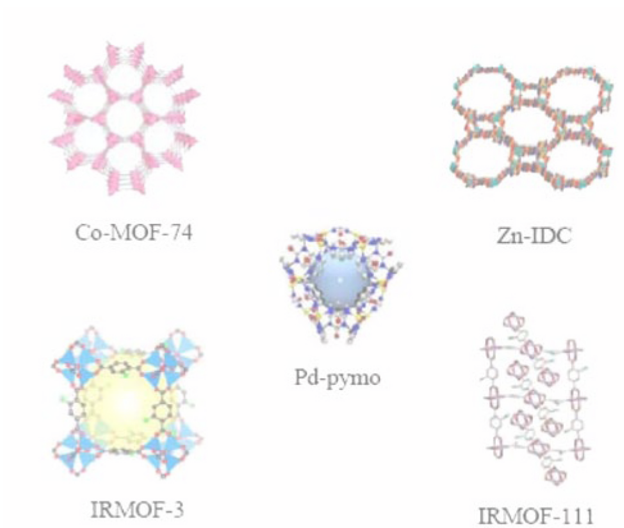
- High adsorption capacity
- High selectivity
- Good adsorption/desorption rates
- Ease of regeneration
- Hydrothermal and contaminant stability
- Potential to meet or exceed DOE's post-combustion CO_2 capture targets of 90 percent CO_2 capture at less than 35 percent increase in the cost of energy services

Benefits

Although oil production in the United States has been gradually declining, the nation has huge reserves of coal. Unfortunately, when coal is burned, it releases more CO_2 per unit of heat than any other fossil fuel, and anthropogenic CO_2 is believed to be contributing to global warming and climate change. Successful completion of this project could lead to a low-cost method of removing CO_2 from flue gas in electric power plants. The captured CO_2 could then be sequestered to prevent its emission to the atmosphere. This would enable the use of our coal reserves as an energy source without contributing to global warming, while simultaneously creating jobs and reducing our dependence on imported oil.

Accomplishments

- More than 50 different MOF materials have been prepared, exceeding the goal of up to 50 materials. A wide variety of MOF materials have been successfully synthesized, with linkers ranging from cheap to exotic and metals including zinc, copper, aluminum, chromium, vanadium, palladium, and lanthanides.
- The MOFs have been characterized by conventional techniques such as x-ray diffraction, thermal gravimetric analysis, and high-resolution electron microscopy to ultimately enhance the understanding of relationships among material properties and CO_2 capture performance.
- The MOFs have been evaluated for CO_2 capacity and hydrothermal stability; several top candidate MOFs were selected for further development and testing.
- Several MOFs have been formed into commercially viable products using techniques such as extrusion and pelletization.
- Formed MOFs have been evaluated to determine CO_2 capacity and hydrothermal stability, and to determine the effect of long-term exposure to impurities (e.g., SO_2, NOx) on MOF performance.
- Scale-up of MOFs to quantities sufficient for pilot testing has been initiated.
- A preliminary techno-economic analysis has been completed.
- A preliminary design has been developed for a pressure swing adsorption pilot unit.



Examples of several MOFs under investigation.