SORBENTS FOR CARBON CAPTURE

Program 147, August 2024

NATIONAL ENERGY TECHNOLOGY LABORATORY

The National Energy Technology Laboratory's (NETL) Point Source Carbon Capture (PSCC) Program is developing the next generation of advanced carbon dioxide (CO_2) capture concepts to support the United States in achieving ambitious goals for a greenhouse gas (GHG)-neutral economy by 2050, a carbon-pollution-free power sector by 2035, and a 50% reduction from 2005 levels in economy-wide net GHG pollution by 2030. The PSCC Program is accelerating commercially deployable solutions that can be applied to a wide spectrum of CO_2 emissions sources with varying characteristics, including facilities that produce power, hydrogen, chemicals, cement, or steel, as well as exhaust CO_2 emissions from mobile sources, such as marine vessels, long-haul trucks, and rail transport vehicles.

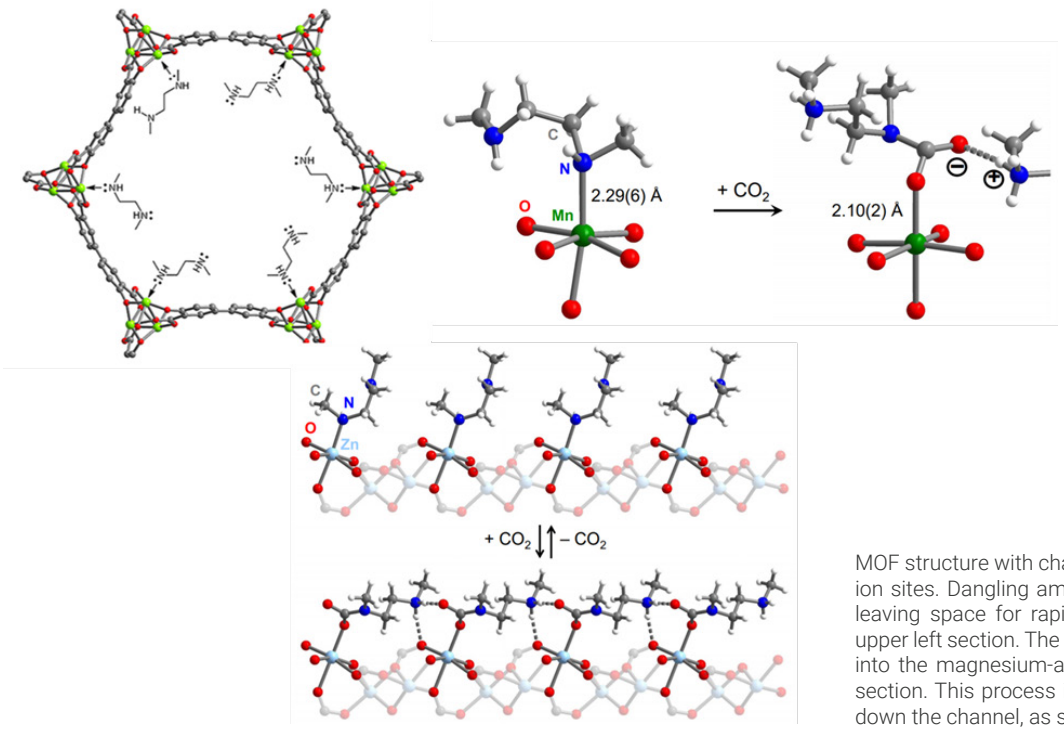
R&D efforts to date have led to reductions in both capital and operating costs through implementation of energy and process efficiencies and development of advanced CO_2 capture media (e.g., solvents, sorbents, and membranes). To achieve deep decarbonization of emissions sources, the program is focused on developing highly efficient, scalable carbon capture technologies with even further cost reductions that are capable of operation under a flexible duty cycle and that can achieve greater than 95% carbon capture.

SORBENT-BASED CAPTURE TECHNOLOGY

Sorbent-based CO_2 capture involves the chemical or physical adsorption of CO_2 from a gas using a solid sorbent. After capturing CO_2, the sorbent can be regenerated via pressure swing, temperature swing, and/or vacuum/concentration swing, or regenerated with low-carbon electricity, depending on the specific characteristics of the solid material. Sorbent-based capture systems offer several potential advantages, including the following:

- Absence of water reduces sensible heating and stripping energy requirements
- Higher capacity on a per mass or per volume basis than in solvent-based systems
- Chemical sorbents provide high capacity and fast kinetics allowing capture from low-concentration gas streams

Advancements in sorbent-based technology development are being pursued along three main innovation pathways: materials, processes, and equipment. R&D objectives include low-cost durable sorbents that have high CO_2 selectivity, high CO_2 adsorption capacity, resistance to oxidation, and can withstand multiple regeneration cycles with minimal attrition. Several solid sorbent classes offer promise for cost-effective CO_2 capture, including metal organic frameworks (MOFs), activated carbons, and supported amine sorbents. Structured material systems (e.g. monoliths, laminate structures) enable effective heat integration, low pressure drop, and high mass transfer for cost-effective carbon capture. System advancements include sorbent process intensification techniques, novel reactor designs, optimized 3D-printed modules, enhanced process configurations, such as rotating beds for CO_2 adsorption and desorption, and hybrid systems.



MOF structure with channels that are lined by open magnesium ion sites. Dangling amines coat the periphery of the channels, leaving space for rapid diffusion of CO_2, as illustrated in the upper left section. The capture process involves insertion of CO_2 into the magnesium-amine bond as shown in the upper right section. This process is then replicated – or stepped - moving down the channel, as shown in the bottom part of the Figure.

NETL is a U.S. Department of Energy (DOE) national laboratory dedicated to advancing the nation's energy future by creating innovative solutions that strengthen the security, affordability and reliability of energy systems and natural resources. With laboratories and computational capabilities at research facilities in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL addresses energy challenges through implementing DOE programs across the nation and advancing energy technologies related to fossil fuels. By fostering collaborations and conducting world-class research, NETL strives to strengthen national energy security through energy technology development.

Contacts

Ronald Munson
Technology Manager
Point Source Carbon Capture Program
Ronald.Munson@netl.doe.gov

Dan Hancu
Director, Point Source Carbon Capture Division
Headquarters, Fossil Energy and Carbon Management
Dan.Hancu@hq.doe.gov