MEMBRANES FOR CARBON CAPTURE

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NATIONAL ENERGY TECHNOLOGY LABORATORY

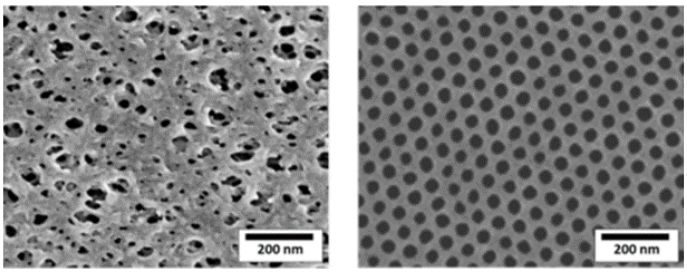
The National Energy Technology Laboratory's (NETL) Point Source Carbon Capture (PSCC) Program is developing the next generation of advanced carbon dioxide (CO_2) capture concepts to support the United States in achieving ambitious goals for a greenhouse gas (GHG)-neutral economy by 2050, a carbon-pollution-free 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.

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.

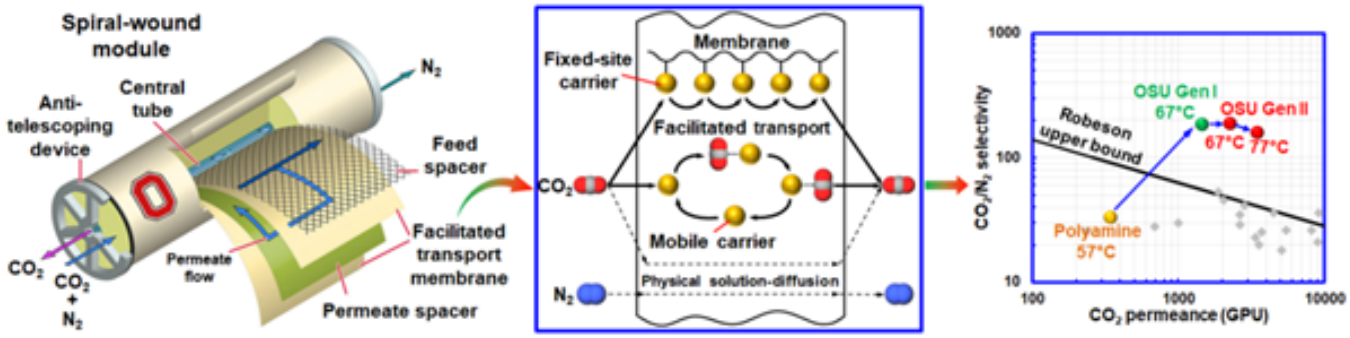
MEMBRANE-BASED CAPTURE TECHNOLOGY

Membrane-based CO_2 capture uses permeable or semi-permeable materials that allow for the selective transport and separation of CO_2 from a gas stream, taking advantage of differences in the relative transfer rates or permeation of the various gases present and is affected by both relative diffusivity and surface adsorption. Membrane processes offer potential advantages when compared to other CO_2 separation technologies, including no hazardous chemical storage, handling, disposal, or emissions issues; tolerance to high sulfur oxide and nitrogen oxide content; simple operation with no moving parts; a reduced plant footprint with lower capital cost; and the ability to incorporate modular unit design, which reduces scale-up complications.

Advancements in membrane-based technology development are being pursued along three main innovation pathways: materials, processes, and equipment. R&D objectives include development of low-cost, durable membranes (e.g., polymeric membranes, facilitated transport membranes, carbon molecular sieve membranes, mixed matrix membranes, sub-ambient temperature membranes) with improved permeability and selectivity for CO_2, thermal and physical stability, tolerance to gas contaminants, and improved system configurations such as solvent/membrane hybrid systems, and subambient operation integrated with CO_2 liquefaction. Process enhancements for membrane-based capture systems include low-pressure drop membrane modules, hybrid systems, novel process conditions (e.g., systems that operate at subambient temperatures), dual-phase membranes, hollow fiber membrane contactors, 3D-printed contactors, and nanomaterials with highly tuned functionality.



Surface of conventional versus enhanced membrane support material that improves permeance and selectivity, driving down capture cost



Facilitated transport membrane currently being tested at small pilot scale – membrane module (left), transport mechanism (center), and performance (right)

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.

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