Zeolite Membrane Sieves Fabricated on Low-Cost Alumina Hollow Fiber Substrates (#8080, 8167)

For gas separation in energy production technologies

Innovators at Georgia Tech have developed novel methods for fabricating low-cost zeolite membranes used in molecular separation techniques. Both methods offer a path forward for utilizing zeolite sieves to accelerate scale-up and applications of thin, selective membranes for separating gases and other molecules for energy production, greenhouse gas mitigation, and other applications.

One method fabricates high-silica zeolite membranes directly on low-cost alumina hollow fiber substrates. This one-step process does not require a separate seeding operation or a liquid-phase hydrothermal growth. The use of concentrated precursor gels leads to the generation of highly permeable and selective membranes that exhibit efficient separations.

A second method also fabricates zeolite membranes on alumina hollow fiber substrates but begins with 2D zeolite nanosheets rather than precursor gel. The nanosheets are first coated on the hollow fiber substrates via vacuum filtration and then transformed into molecular sieving membranes.

Both methods allow scalable zeolite membrane fabrication on hollow fibers and also eliminate the need for expensive, specially engineered substrate materials.

The membranes resulting from these methods perform efficient molecular separations. Examples include the removal of carbon dioxide (CO_2) from methane, nitrogen, and hydrocarbons in both dry and humid conditions; separation of butane isomers; and removal of higher hydrocarbons (natural gas liquids or NGLs) from methane.

Benefits/Advantages

- **High performance**: Enables lower-cost, scalable, membrane-based molecular separation
- **Convenient**: Can form a standalone complete separation or reduce bottlenecks in conventional separation processes

Potential Commercial Applications

- Removing CO_2 from natural gas (CO_2/CH_4 separation) and from power plant flue gas streams (CO_2/N_2 separation)
- Separating/splitting hydrocarbon mixtures in natural gas plants and petroleum refineries
- Producing purified hydrogen (H_2) from gas and hydrocarbon mixtures

Background/Context for This Invention

Zeolites are crystalline aluminosilicates with uniform pore sizes in the sub-nanometer range. They also possess excellent thermal and chemical stability. These features make them attractive molecular sieving membrane materials for energy-efficient separation for the emerging sustainable energy and chemical production sector. A key hurdle to their widespread adoption has been the high costs associated with expensive membrane substrates and complex membrane fabrication processes.

These Georgia Tech innovations offer effective fabrication techniques for low-cost zeolite membranes on inexpensive hollow fiber substrates, contributing to their accelerated development for molecular separation technologies.

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More Information

U.S. Application Filed - 62/831,388

Publications

Scalable One-Step Gel Conversion Route to High-Performance CHA Zeolite Hollow Fiber Membranes and Modules for CO2 Separation, Energy Technology, June 6, 2019

Continuous Zeolite MFI Membranes Fabricated from 2D MFI Nanosheets on Ceramic Hollow Fibers, Angewandte Chemie (International Edition), April 9, 2019

Example SEM images of (a) membrane surface and (b) cross-section

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Zeolite MFI membranes are prepared on ceramic hollow fibers, starting from 2D zeolite MFI nanosheet coatings and followed by secondary and tertiary hydrothermal treatments. These membranes show separation of butane isomers and of natural gas liquid components from methane.

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/zeolite-membrane-sieves-fabricated-low-cost-alumina-hollow-fiber-substrates