PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

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HYBRID MEMBRANES FOR CO_2 REMOVAL

Background

As the stabilization of CO_2 concentrations in the atmosphere becomes increasingly important, the capture and sequestration of CO_2 emissions from advanced power generation will become a necessity. Currently, separation and capture represent the greatest expense in the overall reduction of CO_2 emissions. Improvements in capture have a great potential to affect the cost of CO_2 mitigation, and membrane technology holds significant promise in this area.

Membranes have innate advantages over other separation techniques, including simple design with no moving parts, limited maintenance, lower energy requirements due to their lack of phase transitions, a single-step separation cycle, and exceptional reliability. An initial systems study that considered only a portion of these advantages has shown the superiority of membranes over the more conventional Selexol process. However, it is necessary to make use of all these advantages to accomplish the Carbon Sequestration Program goal of only a 10 percent increase in electricity cost, while achieving 90 percent reduction of CO_2 emission from syngases.

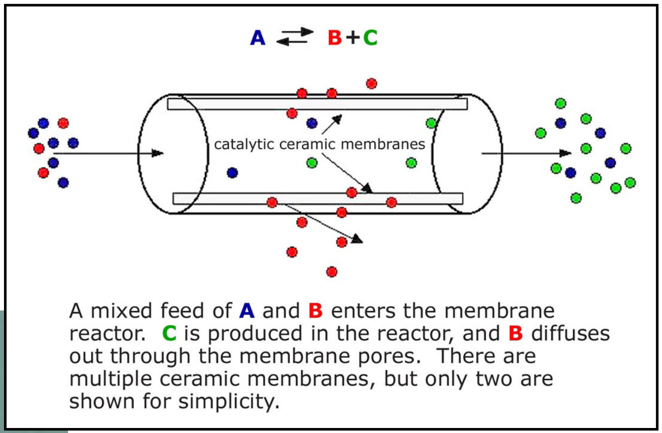
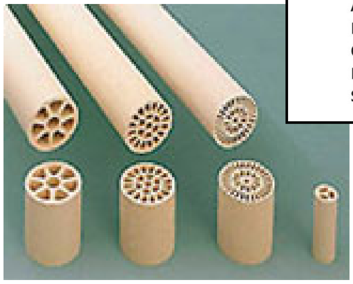


Diagram of a membrane reactor



Ceramic membranes showing various pore structures

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Primary Project Goal

The goal of this research is to develop hybrid membranes capable of selective CO_2 removal in reducing environments, such as in IGCC power plants. Organic polymer membranes have superior selectivity, while inorganic membranes have superior permeability and stability. The incorporation of organic groups onto inorganic templates has the potential to result in a hybrid with the advantages of both types of membranes. Silation of inorganic membranes is a simple preparation procedure that can result in the attachment of virtually any organic function to the surface of an inorganic membrane via an intermediate Si atom. The preferred inorganic support material is g-alumina, and chlorosilanes are the most useful silating agents. The silation of alumina membranes is especially interesting because of the exceptionally high degree of structural control it offers.

Objectives

This research examines the development of hybrid membranes based on surface diffusion, which is a significant challenge itself because surface diffusion is among the most difficult types of transport to optimize. The objective is to develop a method that produces a hybrid membrane capable of achieving high permeability and selectivity in a reducing environment. Membranes must also operate for extended periods at high temperatures and in the presence of trace contaminants, such as hydrogen sulfide. The method developed in this research will modify a previously fabricated inorganic membrane with organic groups. NETL researchers have conducted a thorough literature review and will conduct future testing on various combinations of gases, as well as tests of membranes with CO_2-selective functional groups. Project partners will be sought to assist with the development of hybrid membranes over the life of this project.

Achievements

While still in its early stages, the project has already reached some significant milestones:

- Membranes have been fabricated by silation of alumnia with monolayer coverage of silane over the active surface.
- A screening system has been constructed to quickly and economically test membrane samples in-house.
- A study of membranes prepared from silanes of different chain lengths has been completed.

Benefits

The successful development of a commercially viable membrane would have several benefits. Industry would gain a simplified separation technique for CO_2/H_2 mixtures leading to enhanced water/gas shift capacity. The method used to produce this membrane can then be reproduced to create membranes applicable to other important separation problems, such as the removal of CO_2 from crude natural gas. A systems analysis has shown that membranes of this type could possibly remove the required amount of CO_2 from an IGCC plant for as little as 15 percent parasitic power, an improvement of 45 percent over Selexol, the best currently available technology.