the ENERGY lab

R&D FACTS

Carbon Sequestration

Novel Membranes for CO_2 Removal

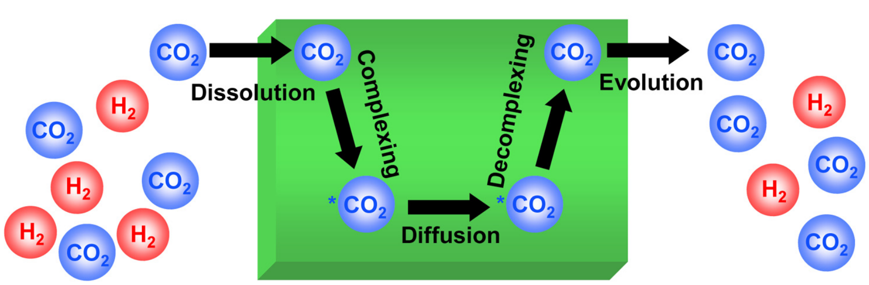
Background

As the stabilization of CO_2 concentrations in the atmosphere becomes increasingly important, the capture and sequestration of CO_2 emissions from advance power generation systems will become a necessity. In the current carbon sequestration concept, separation and capture represent the greatest expense in the overall capture and storage process. Improvements in capture and separation have the greatest potential to affect the cost of CO_2 mitigation, and membrane technology holds significant promise in this area.

Membranes have a number of innate advantages over other separation techniques, including simple design with no moving parts, limited maintenance, lower energy requirements due to lack of phase transitions, single-step separation, and exceptional reliability. These advantages have allowed membranes to make significant commercial advances in other CO_2 removal applications, such as natural gas sweetening. In fuel gas streams where pressures and CO_2 concentrations are high, membranes seem a natural choice for carbon capture.

Primary Project Goal

This research is aimed at developing robust membranes capable of selective CO_2 removal in reducing environments, such as those found in integrated gasification combined cycle (IGCC) power plant fuel gas streams or natural gas sweetening (NGS). Capture in gasification systems will most likely take place after the low-temperature water gas shift reaction. It is necessary that CO_2 technologies for the shifted fuel gas work at elevated temperatures approaching 260 °C to maximize the efficiency of the power generation process and also function well in the presence of fuel



In facilitated transport diffusion, the CO_2 dissolves into the membrane, reacts with the ionic liquid to form a complex, diffuses across the membrane, decomplexes, then desorbs into the gas phase.

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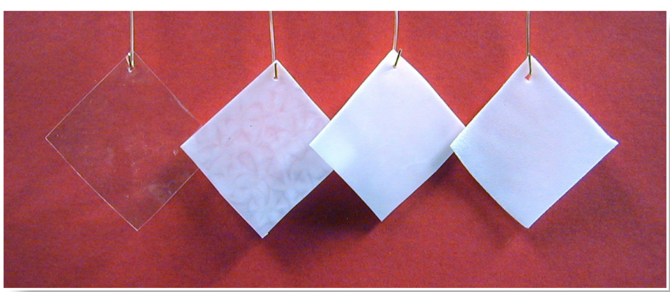
gas contaminants. Research has focused on a class of salts known as ionic liquids (ILs) which have high solubility for CO_2 compared to H_2 and other light gases. Supported liquid membranes (SLMs) have already demonstrated the capability to separate CO_2 in various applications and systems. SLMs can have higher diffusivities than polymeric membranes and be stable to temperatures above 300 °C. As the transport media in SLMs, the ionic liquids currently being examined have the ability to interact with CO_2 to form chemical complexes creating facilitated transport diffusion which increases membrane performance.

Objectives

The project examines the development of ionic liquids and techniques for the transformation of those ionic liquids into CO_2-selective membranes. Work has centered on optimization of ionic liquids and support materials by techniques including molecular modeling, synthesis, characterization and performance testing. Previously researchers incorporated ionic liquids into commercially available and fabricated polymer supports and examine the performance of the resulting membranes to determine whether or not particular liquid/support combinations met gas separation performance objectives. The scope of work has now expanded to include development of hollow fiber membranes. The membranes are expected to perform at high temperatures in the presence of trace contaminants, such as H_2S and water.

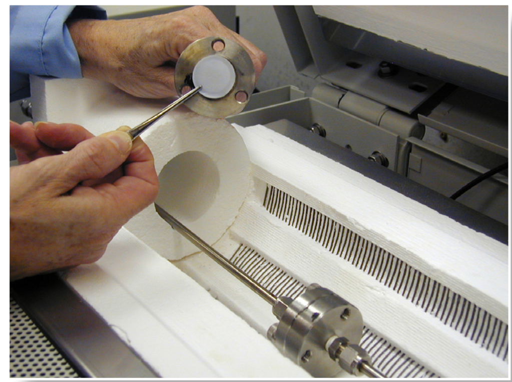


Series of polymeric films with increasing ionic liquid contents.

Accomplishments

Since its inception, the project has reached some very important milestones:

- Membranes have been prepared using both commercially available and fabricated polymer supports.
- Membranes have proven to be stable to temperatures above 300 °C.
- CO_2/H_2 selectivities as high as 15 have been measured with associated CO_2 permeabilities an order of magnitude greater than those observed for conventional polymers at 75 °C.
- Contaminants, such as H_2S and CO, have shown little to no effects on permeability.
- Molecular modeling has been able to accurately represent performance results.



Membrane and reactor assembly.

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 the way toward adoption of advanced power generation processes as part of an overall carbon abatement strategy. Membranes produced in this project may also have applicability to other separation problems, such as the removal of CO_2 from crude natural gas and the capture of CO_2 from conventional pulverized coal stack gas.

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