OPPORTUNITIES FOR MEMBRANE SEPARATION PROCESSES IN COAL GASIFICATION

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The separation of hydrogen from synthesis gas is a major cost element in the manufacture of hydrogen from coal. Separation of these gases by membranes is an alternative technique that is still largely unexplored and that could offer substantial cost savings. We have been developing membranes for this application at Membrane Technology and Research, Inc. Most of this work has been supported by the U.S. Department of Energy.

There are three opportunities for membrane separation in the production of hydrogen from coal:

(1) The separation of hydrogen from carbon monoxide before the shift reactor.

(2) The separation of hydrogen from carbon dioxide and hydrogen sulfide after the shift reactor.

(3) The separation of hydrogen from nitrogen after the acid gas removal in an air-blown gasification process.

After reviewing polymer permeability data available in the literature or obtained at MTR, two polymers were selected for membrane development work:

(1) Poly(etherimide) for the separation of hydrogen from nitrogen and from carbon monoxide.

(2) Poly(ether-ester-amide) for the separation of hydrogen sulfide and carbon dioxide from hydrogen.

After characterizing the membrane properties of relatively thick (20-50 μm) films, we concentrated on fabricating asymmetric and composite ultrathin high-performance membranes. Asymmetric or composite ultrathin membranes in which the permselective layer is on the order of 0.5- to 1.0 μm-thick are required if usefully high membrane fluxes are to be obtained. The membranes were then tested with pure gases and gas mixtures.

POLY(ETHERIMIDE) MEMBRANES

The properties of the poly(etherimide) membranes are summarized in Figure 1. As shown, these membranes are extremely permeable to hydrogen compared to nitrogen and carbon monoxide. Poly(etherimide) membranes would, therefore, be most suitable for these separations. Poly(etherimide) is a tough, high-melting polymer. We have shown that the membranes maintain their desirable selectivity properties at temperatures in excess of 90°C. Membrane selectivity for gas mixtures is also essentially independent of feed gas composition, as the results in Figure 1 show. The membranes have been fabricated into continuous rolls of flat-sheet membranes and into hollow fibers.

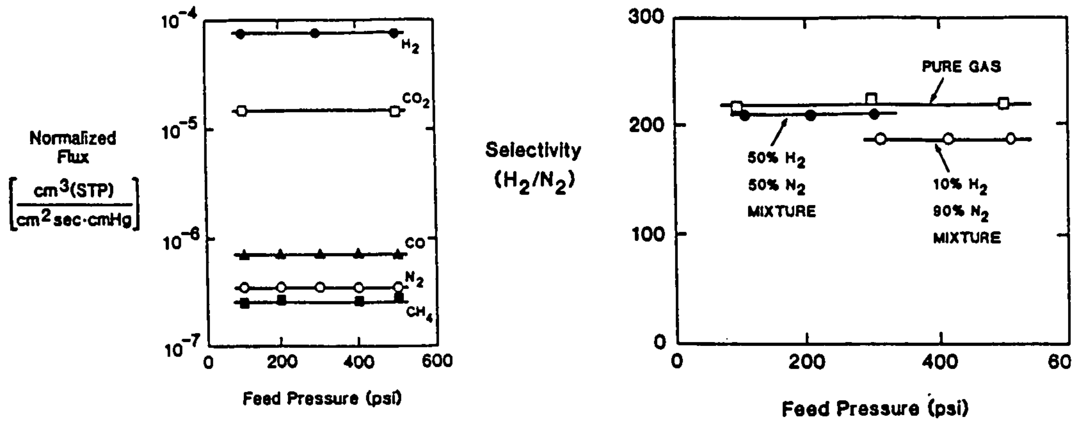

Figure 1. Normalized fluxes and selectivities of poly-(etherimide)/poly(dimethylsiloxane) composite membranes as a function of feed pressure. Temperature: 25°C.

POLY(ETHER-ESTER-AMIDE) MEMBRANES

Poly(ether-ester-amide) membranes are extremely selective for carbon dioxide, compared to other gases, as the data in Figure 2 show. Thus, these membranes are most suited to the separation of carbon dioxide from hydrogen/methane/nitrogen mixtures. Based on data from pure gases, a carbon dioxide/hydrogen selectivity greater than 10 would be expected. With gas mixtures, plasticization of the membrane by carbon dioxide lowers the selectivity to between 7 and 8. This mixed gas selectivity is lower than the pure gas selectivity, but still much higher than other polymeric membranes.

We have fabricated these poly(ether-ester-amide) membranes into spiral-wound membrane modules and tests with these modules are underway.

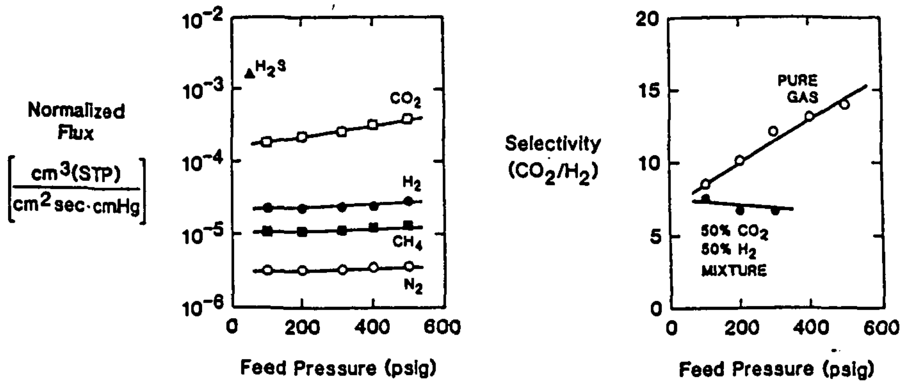

Figure 2. Normalized fluxes and selectivities of poly-(ether-ester-amide) composite membranes as a function of feed pressure. Temperature: 25°C.