Summary: SRI has developed Polymbenzimidazole (PBI) hollow-fiber membranes (HFMs) that can be chemically and physically optimized for various commercial gas separation applications. PBI is a commercially available polymer with excellent thermal/chemical stability and, PBI HFMs and the membrane modules assembled at SRI have been successfully demonstrated for CO₂ capture from syngas streams containing CO₂, H₂, CO, steam, and other trace-level gases. In the pre-combustion application, the membrane system will be situated downstream of the water gas shift reactors of the IGCC plant. The syngas stream will be operated above its dew point, and the membrane module will be used to separate H₂ and steam from the rest of the syngas stream. The permeate content, H₂, steam, and a few percent of acid gases along with the sweep gas N₂ will be sent to the turbine unit. The retentate that include CO₂ will be compressed to pipeline pressure for delivery/transportation after removal of trace gases in a high-pressure processing unit.

In this new project, we plan to perform parametric and steady-state testing of PBI-HFM gas separation skid to obtain excellent thermal/chemical stability and, PBI HFMs and the membrane modules assembled at SRI have been successfully demonstrated for CO₂ capture from syngas streams containing CO₂, H₂, CO, steam, and other trace-level gases. In the pre-combustion application, the membrane system will be situated downstream of the water gas shift reactors of the IGCC plant. The syngas stream will be operated above its dew point, and the membrane module will be used to separate H₂ and steam from the rest of the syngas stream. The permeate content, H₂, steam, and a few percent of acid gases along with the sweep gas N₂ will be sent to the turbine unit. The retentate that include CO₂ will be compressed to pipeline pressure for delivery/transportation after removal of trace gases in a high-pressure processing unit.

In the new project, we plan to perform parametric and steady-state testing of PBI-HFM gas separation skid to obtain system performance data covering full range of operating pressures and temperatures with actual coal-derived syngas stream from an oxygen-blown gasifier. Furthermore, we will perform component and system modeling and simulation, and techno-economic analysis of the commercial concept of PBI-HFM capture system integrated into a 550-MW (net) power plant.


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Concept of integration of a Hollow Fiber Membrane system in an IGCC plant

Characteristics of PBI Membranes
- PBI has an attractive combination of throughput and degree of separation
- Thermally stable up to ~300°C and sulfur tolerant
- Tested for 1000 hr at 225°C by SRI

Advantages of Membrane-Based Separation
- No need to cool syngas
- Reduced CO₂ compression costs
- Emission free, i.e., no solvents
- Decreased capital costs
- Low maintenance
- Modular

New Project - Testing with Syngas from Oxygen-Blown Gasifier.
In the new project, we will spin high performance GEN-2 fibers and fabricate 4-in modules. We plan to upgrade the 50 kWth skid with additional gas flow meters and newly designed vessels to use four 4-in modules. We will perform parametric and steady-state testing of PBI-HFM gas separation skid to obtain system performance data covering full range of operating pressures and temperatures with actual coal-derived syngas stream from an oxygen-blown gasifier at University of Kentucky- Center for Applied Energy Research. We will use the data to validate the system models, and prepare technology maturation plan and techno-economic analysis of the commercial concept of PBI-HFM capture system integrated into a 550-MW (net) power plant.

Test Results with Syngas from Air-Blown Gasifier.

Temperature effect: The membrane performance is greatly enhanced as the temperature increases; more than 90% CO₂ capture is possible with air-blown syngas at temperatures>180°C (Figure 1).

Pressure effect: Hydrogen permeance through the membrane increases rapidly with increase in pressure leading to increase in selectivity (Figure 2).

Figure 1. Observed CO₂ capture for GEN-1 membrane element with changing temperature when operating with syngas. Data for a stage cut at 40% are shown.

Figure 2. Measured H₂ and CO₂ permeances for GEN-1 (150 GPU) and GEN-2 (100 GPU) modules.

Figure 3. Comparison of measured H₂/CO₂ selectivity for GEN-1 (150 GPU) and GEN-2 (100 GPU) modules.

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