

IV.C.4 Scale-up of Microporous Inorganic Hydrogen-Separation Membrane

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Commercial Partner:

Pall Corporation

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Projected End Date: December 2007

Objectives

- Scale up already proven, nanoporous membrane technology to separate hydrogen from raw or shifted synthesis gas.
- Design membrane system to optimize the balance between hydrogen purity and flux.
- Ensure 90% carbon capture.
- Demonstrate this system at Southern Company's Power Systems Development Facility (PSDF) and Eastman Chemicals Kingsport facility during the summer of 2007.
- Explore the potential to separate hydrogen from shifted syngas prior to syngas clean-up.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Production section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- L. Durability
- M. Impurities
- N. Defects
- O. Selectivity
- P. Operating Temperature
- Q. Flux
- S. Cost

The project also addresses Section 5.1.5.1., Technical Barriers – Central Production Pathway in the Hydrogen from Coal – Research, Development, and Demonstration Plan of the DOE Office of Fossil Energy. This includes water-gas-shift reaction barriers and hydrogen separation barriers.

Technical Targets

Table 1 lists the targets that the project will attempt to meet during its implementation.

Table 1. Technical Targets: Micro Porous Membranes for Hydrogen Separation and Purification

Performance Criteria	Units	2003 Status	2005 Target	2010 ^a Target	2015 ^a Target
Flux Rate	scfh/ft ²	100	100	200	300
Membrane Material and All Module Costs	\$/ft ² of Membrane	\$450-\$600	\$400	\$200	<\$100
Durability	Hours	<8,760	8,760	26,280	>43,800
ΔP Operating Capability	psi	100	200	400	400-1000
Hydrogen Recovery	% of total gas	60	>70	>80	>90
Hydrogen Purity	% of total (dry) gas	>90%	95%	99.5%	99.99%

^a Assumes a two-stage membrane system or a membrane + pressure swing adsorption

Approach

- Design an optimal system configuration using Oak Ridge National Laboratory's (ORNL's) experimental data and National Energy Technology Laboratory (NETL) system analysis capabilities.
- Pilot-scale tests will be on clean shifted syngas derived in the demonstration.
- Lab-scale tests will show the feasibility of separating hydrogen from raw shifted syngas (prior to syngas clean-up).
- Materials compatibility and flow tests will be conducted on selected membranes using simulated shifted syngas, at conditions specified by program goals and the system analysis.
- Flow tests using simulated raw shifted syngas will be performed.
- Demonstrate the system at Southern Company's PSDF and Eastman Chemicals Kingsport facility during the summer of 2007.

Accomplishments

- Initiated planning discussions with Tennessee Eastman and Southern Company on hydrogen separation membrane testing.
- Conducted pilot-scale fabrication tests for one-meter-long hydrogen membrane elements.
- Incorporated Materials Program results into refinement of processing parameters for pore size and pore-size distribution control.

Future Directions

- Initiate membrane fabrication for test modules.

Introduction

Part of the vision of a hydrogen economy is the production of hydrogen from coal via gasification, due to its low cost and abundance in the U.S. A critical part of this process is to separate the hydrogen from carbon dioxide in the synthesis gas, resulting in a pure, clean fuel (hydrogen) stream and a separate carbon dioxide stream amenable to sequestration. The ORNL nanoporous membrane technology has already been proven to separate hydrogen from CO₂ in lab-scale tests, at a flux and purity expected to be commercially competitive. This project will scale up the technology and refine the membrane choices to suit DOE program objectives.

Approach

The project approach is to (1) design an optimized system based on ORNL's experimental data and NETL system analysis; (2) perform compatibility tests on a variety of membrane materials for the operating conditions at the Southern Company's PSDF and Eastman Chemicals Kingsport facilities; (3) fabricate commercial-scale membrane

tubes; and (4) demonstrate this system at the Southern Company's PSDF and Eastman Chemicals Kingsport facilities during the summer of 2007. The demonstration will be done using clean shifted syngas; however, lab tests will be performed on raw shifted syngas to show the feasibility of this approach. Flow tests using simulated raw shifted syngas are expected to be performed at NETL, where equipment to perform these tests already exists. If possible, pilot-scale tests on raw syngas will also be performed. Pall Corporation will be ORNL's commercial partner in this project and will have increasing input as the membranes approach commercial readiness.

Summary

Lab-scale tests have been conducted on one-meter-long hydrogen membrane elements. The results from these tests are being used to further refine process parameters, pore size, and pore-size distribution control for these elements. Initial discussions have been held with Tennessee Eastman and PSDF to further test and evaluate these hydrogen separation membranes.