

## **IV.B.2 Robust Low-Cost Water-Gas-Shift Membrane Reactor for High-Purity Hydrogen Production from Coal-Derived Syngas**

*Zhijang (John) Li, Ph.D.*

*Aspen Products Group Inc.*

*184 Cedar Hill Street*

*Marlborough, MA 01752*

*Phone: (508) 481-5058; Fax: (508) 480-0328; E-mail: zli@aspensystems.com*

*DOE Technology Development Manager: John Winslow*

*Phone: (412) 386-6072; Fax: (412) 386-4822; E-mail: John.Winslow@netl.doe.gov*

*DOE Project Officer: Arun Bose*

*Phone: (412) 386-4467; Fax: (412) 386-4604; E-mail: Arun.Bose@netl.doe.gov*

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*Projected End Date: May 31, 2007*

### **Objectives**

- Develop a lower cost, robust water-gas-shift (WGS) membrane reactor that can be used to process coal-derived syngas for the production of high-purity hydrogen
- Develop and demonstrate a contaminant-tolerant, highly active WGS catalyst
- Develop and demonstrate a highly-selective hydrogen membrane with improved durability
- Construct and demonstrate a bench-scale WGS membrane reactor
- Demonstrate the scalability of the technology by constructing a 500 L hydrogen/hr production capacity unit
- Perform a study on the economic feasibility of the WGS membrane reactor

### **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
- O. Selectivity
- Q. Flux
- S. Cost

The project also addresses one or more of the barriers described in Section 5.1.5.1., *Technical Barriers – Central Production Pathway* in the Hydrogen from Coal – Research, Development, and Demonstration Plan, which was issued by the DOE Office of Fossil Energy.

## Technical Targets

This project is conducting studies to develop a low-cost, robust WGS membrane reactor that can be used to process coal-derived syngas for the production of high-purity hydrogen. Insights gained from these studies will be applied toward the design, construction, and operation of a 500 L hydrogen/hr production unit that can meet the DOE's 2010 and 2015 hydrogen separation targets, particularly with respect to membrane/module cost, durability, operating pressure, hydrogen recovery, and hydrogen quality.

Tables 1 and 2 list the targets that the project will attempt to meet during its implementation.

**Table 1.** Technical Targets: Ion Transfer Membranes for Hydrogen Separation and Purification.<sup>a</sup>

Performance Criteria	Units	2003 Status	2005 Target	2010 Target	2015 Target
Flux Rate	scfh/ft <sup>2</sup>	60	100	200	300 <sup>b</sup>
Cost	\$/ ft <sup>2</sup>	2,000	1,500	1,000	<\$500
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	>99.9	>99.9	>99.95	99.99

<sup>a</sup> Targets are derived from Table 3.1.5. from the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan, March 2005.

<sup>b</sup> Flux upper limit for ion transport membranes.

**Table 2.** Technical Targets for the Water Gas Shift Reaction<sup>a</sup>

Performance Criteria	Units	Current Status	2005 Target	2010 Target	2015 Target
Reactor Type	–	Multiple fixed beds	To be determined		
Catalyst Form	–	Pellets	To be determined		
Active Metal	–	Cu/Zn or Fe/Cr or Co/Mo	To be determined		
Temperature	°C	200-550	300-450	300-500	200-600
Pressure	psia	450-1150	450	750	>1,000
Approach to Equilibrium	°C	8-10	10	6	>4
Min Steam/CO Ratio	Molar	2.6	3.0	2.5	<2
Sulfur Tolerance	–	Varies	Low	Moderate	High
Chloride Tolerance	–	Varies	Low	Moderate	High
Water Tolerance	–	Varies	Low	Moderate	High
Stability/Durability	Years	3-7	3	7	>10
Reactor Cost Reduction	%	–	–	>15%	>30%

<sup>a</sup> Targets are derived from Table 6 of the Hydrogen from Coal RD&D Plan, June 10, 2004.

## **Approach**

- Prepare, test, and demonstrate the operation of a contaminant-tolerant, highly active WGS catalyst.
- Prepare, test, and identify a highly-selective hydrogen membrane with improved durability for development and demonstration.
- Using data from tests conducted in steps (1) and (2), construct and demonstrate a bench-scale WGS membrane reactor.
- Show that WGS membrane reactor technology is scalable by constructing a 500 L hydrogen/hr system and performing an economic feasibility study of the WGS membrane reactor.

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## **Introduction**

There exists a need to develop a lower cost, robust WGS membrane reactor that can be used to process coal-derived syngas for the production of high-purity hydrogen. The required characteristics of this WGS membrane reactor are a contaminant-tolerant, highly active WGS catalyst and a highly-selective membrane with improved durability. Such a membrane reactor should be constructed and demonstrated at bench-scale to demonstrate the scalability of the technology, preferably at 500 L hydrogen/hr production capacity unit. The demonstration should be completed with a study on the economic feasibility of the WGS membrane reactor.

## **Approach**

The first step is to prepare, test, and demonstrate the operation of a contaminant-tolerant, highly active WGS catalyst. A highly-selective hydrogen membrane with improved durability will then be identified for development and demonstration. Using data from these tests, a bench-scale WGS membrane reactor will then be constructed and demonstrated. Finally, to show that the WGS membrane reactor technology is scalable, a 500 L hydrogen/hr system will be built and an economic feasibility study of the WGS membrane reactor will then be performed.

## **Accomplishments**

This project is newly initiated and no there are no accomplishments to report to date.