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

Zhijiang John Li
Aspen Group Inc.
184 Cedar Hill Street
Marlborough, MA 01752
Phone: (508) 481-5058; Fax: (508) 480-0328

DOE Technology Development Manager:
Dan Cicero
Phone: (412) 386-4826
E-mail: Daniel.Cicero@netl.doe.gov

DOE Project Officer: Arun Bose
Phone: (412) 386-4467; Fax: (412) 386-4604
E-mail: arun.bose@netl.doe.gov

Contract Number: DE-FC26-05NT42452

Start Date: May 20, 2005
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 selected Pd/Cu coated Ta 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.

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 selective Pd/Cu coated Ta 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. The demonstration should be completed with a study on the economic feasibility of the WGS membrane reactor.

Approach

The first step is to design, construct, and demonstrate the operation of a contaminant-tolerant, highly active WGS catalyst. A suitable Pd/Cu coated Ta membrane with improved durability will then be selected 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

- Completed preparation of 10-16 samples of both alumina-supported and unsupported nanosized Mo_2C and sulfided Mo, MoCo and CoCr catalysts and completed characterization of the catalysts by investigating the structural properties and determining their surface area, pore size, agglomerate size, composition, and crystallinity.
- Completed evaluation of the catalysts prepared in Q1 and compared with commercial high-temperature WGS catalysts for their WGS activity and stability in a high-pressure fixed-bed catalyst testing system. Identified and selected the most active and stable WGS catalysts and the best operating conditions.
- Completed the development of Pd/Cu-Coated Ta tubular H_2 membrane elements and studied the use of electroless plating method to fabricate Pd/Cu-coated Ta membrane tubes with different wall thicknesses.

Future Directions

- Complete characterization and testing for H_2 separation in order to identify and select the most stable and efficient membranes and associated membrane preparation parameters for building a WGS reactor and scale-up.