II.E.1 One Step Biomass Gas Reforming-Shift Separation Membrane Reactor

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Subcontractors:
- Arizona State University, Tempe, AZ
- National Energy Technology Laboratory (NETL), Pittsburgh, PA
- Schott North America, Duryea, PA
- ATI Wah Chang, Albany, OR

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Objectives

- Reduce the cost of hydrogen from biomass to \$1.60/kg H_2 (without delivery).
- Develop an efficient membrane reactor that combines biomass gasification, reforming, shift reaction and H_2 separation in one step.
- Develop hydrogen–selective membrane materials compatible with the biomass gasification conditions.
- Demonstrate the feasibility of the concept in a bench-scale biomass gasifier.

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) Impurities

(N) Hydrogen Selectivity

(O) Operating Temperature

(P) Flux

Technical Targets

This project is directed at developing a membrane reactor that can survive the rigors of a gasification reactor environment while having a sufficiently high hydrogen flux to achieve a hydrogen production cost of \$1.60/kg (without delivery) per the DOE 2012 technical target.

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Approach

Our approach is shown in Figure 1 and shows a membrane inside the fluidized-bed gasifier to extract hydrogen directly from the gasifier using a high temperature H_2-selective membrane.

This approach will achieve a one-step biomass gas reforming, shift and hydrogen separation.

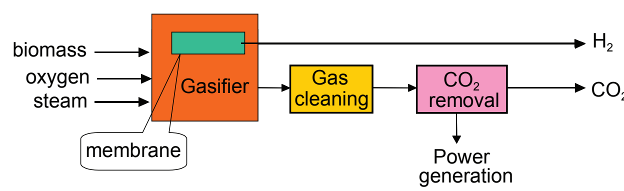

FIGURE 1. Integrated Approach to Hydrogen Production and Separation

Accomplishments

Hydrogen sulfide (H_2S) is a typical contaminant in the syngas generated from solid-fuel gasification systems. For biomass gasification systems, depending on the feedstocks, the H_2S content is generally below 1,000 ppm.

Hydrogen permeation tests in the presence of hydrogen sulfide were conducted for the PdCu membrane at several temperatures as shown in Figures 2 and 3. There was no apparent effect on the hydrogen permeation due to the H_2S for several hours.

Although this project was recently initiated, the work shown in Figures 2 and 3 was conducted through GTI's cost sharing activity.

Future Directions

- Improve proton and electronic conductivity and chemical stability of ceramic membrane (ASU).
- Develop synthesis methods to prepare thin membranes of modified ceramics.

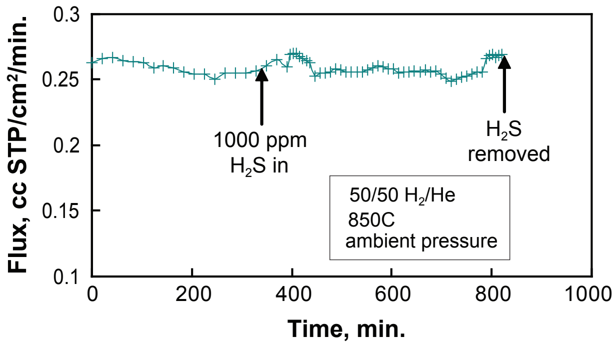

FIGURE 2. Effect of H_2S on $Pd_{80}Cu_{20}$ Alloy Membrane at 850°C

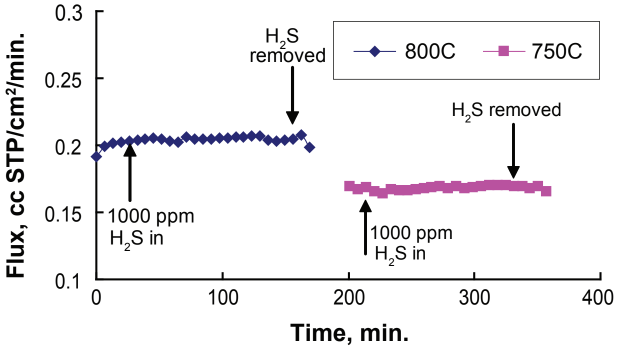

FIGURE 3. Effect of H_2S on $Pd_{80}Cu_{20}$ Alloy Membrane at 800 and 750°C

- Conduct oxidation and sulfidation corrosion analysis (NETL).
- Develop robust membrane materials to withstand gasifier conditions.
- Survey known glass-ceramic compositional families with respect to H_2 permeability (Schott North America).
- Evaluate using glass as a substrate to incorporate other hydrogen transport materials such as Pd or other metals.
- Evaluate conceptual design, tubular, planar, or monolithic.
- Sealing development assisted by ATI Wah Chang.
- Mechanical design of membrane.