IV.D.2 A Novel Slurry-Based Biomass Reforming Process

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Subcontractors:
Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND

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Objectives

- Develop an initial reactor and system design, with cost projections, for a biomass slurry hydrolysis and reforming process for H_2 production
- Develop a cost-effective catalyst for liquid-phase reforming of biomass hydrolysis-derived oxygenates
- Perform a proof-of-concept demonstration of a micro-scale pilot system based on liquid-phase reforming of biomass hydrolysis-derived oxygenates
- Demonstrate that the proposed H_2 production system will meet the 2010 efficiency and cost targets of 50% lower heating value (LHV) and $1.75/kg H_2

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:

- V. Feedstock Cost and Availability
- W. Capital Cost and Efficiency of Biomass Gasification/Pyrolysis Technology

Technical Targets

This project consists of three key elements: plant and system design, catalyst research, and a proof-of-concept demonstration. The information obtained from all three efforts will be used to demonstrate that the proposed H_2 production system will meet the DOE's 2010 Biomass Gasification/Pyrolysis Hydrogen Production energy efficiency and total hydrogen cost targets of 50% (based on feedstock LHV) and $1.75/kg H_2.

Approach

The basic concept for this project is shown in Figure 1. The initial feed is assumed to be poplar wood which is ground up and made into an approximately 10% slurry in dilute acid. This slurry will be hydrolyzed to produce a reformable mixture. Catalysts will be developed to reform this mixture. If the advanced catalysts from this project are unable to reach the hydrogen production goals, then an optional hydrogenation step will be used to make the mixture of sugars, lignins, and cellulose fragments more reformable. With either path, the reformable mixture will be reacted in the liquid phase over a mixed metal Pt metal-based (Pt-MM), mixed metal oxide supported catalyst to convert the hydrolyzed biomass to hydrogen. A palladium alloy membrane will be used to remove the pure hydrogen, while the retentate will be used as fuel gas for the proposed plant.

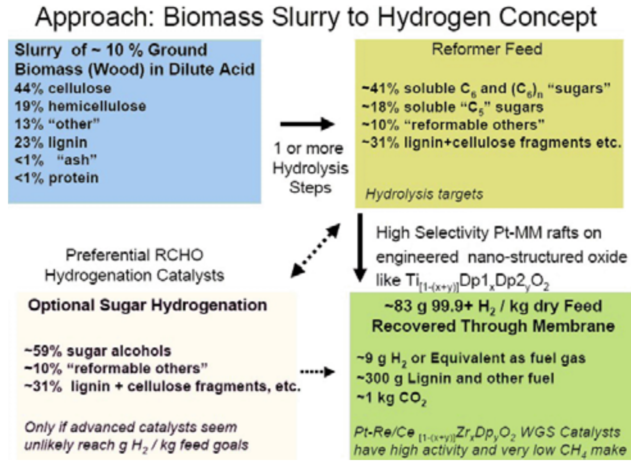

Figure 1. The UTRC Approach to Biomass Slurry Reforming

The catalyst development approach is based on a paradigm used successfully in the past at United Technologies Research Center (UTRC) to produce a high-activity precious metal-based water gas shift (WGS) catalyst that had a very low alkane (methane) production rate. This approach, shown in Figure 2, combines catalyst conceptual design, quantum mechanical atomistic modeling, and advanced catalyst synthesis techniques to determine the best catalyst formulations to focus the synthesis effort prior to experimentation. Initially, a theoretical catalyst design is proposed to maximize high catalytic activity and selectivity and minimize less desired attributes such as diffusion limitations. Using atomistic modeling tools such as the Vienna Ab Initio Simulation Package (VASP), variations in catalyst formulations can be explored to define the best compositions and structures on which to focus the synthesis effort. Then, special synthesis techniques can be employed to make only the materials that show the greatest promise. These materials are then characterized and tested under reaction conditions to feed back information to the design and modeling efforts in an iterative effort that will produce the optimal catalyst for a given process.

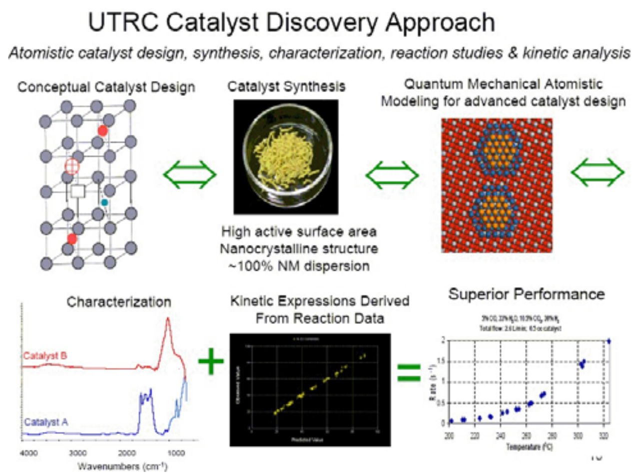

Figure 2. The UTRC Catalyst Discovery Approach