IV.A.5 Hydrogen Generation from Biomass-Derived Carbohydrates via the Aqueous-Phase Reforming (APR) Process

Dr. Randy D. Cortright
Virent Energy Systems, INC.
3571 Anderson St.
Madison, WI 53704
Phone: (608) 663-0228, Ext. 211; Fax: (608) 663-1630; E-mail: Randy_Cortright@virent.com

DOE Technology Development Manager: Mark Paster
Phone: (202) 586-2821; Fax: (202) 586-9811; E-mail: Mark.Paster@ee.doe.gov

DOE Project Officer: Carolyn Elam
Phone: (303) 275-4953; Fax: (303) 275-4788; E-mail: Carolyn.Elam@go.doe.gov

Contract Number: DE-FG36-05GO15046

Subcontractors:
University of Wisconsin, Madison, WI
Archer Daniels Midland Company, Decatur, IL
Universal Oil Products LLC, Des Plaines, IL

Start Date: September 1, 2005
Projected End Date: September 30, 2008

Objectives

This project will combine the expertise of Virent Energy Systems (Virent), Universal Oil Products LLC, Archer Daniels Midland Company (ADM), and the University of Wisconsin to demonstrate the feasibility of generating high yields of hydrogen from corn-derived glucose. This proposed concept takes advantage of the fact that corn contains large amounts of starch which can be extracted and converted to glucose. The resulting aqueous solutions of glucose can be fed to Virent's novel aqueous-phase reforming (APR) process that generates hydrogen in a single reactor. The effluent gas from the APR process can then be efficiently purified to produce high purity hydrogen utilizing pressure swing adsorption.

The objectives of the first year of this project are as follows:

- Identify candidate sugar streams (glucose), document plant integration requirements and associated economic factors.
- Develop catalyst and reactor based on the APR process suitable for converting candidate sugar streams to hydrogen.
- Design a baseline hydrogen generation system utilizing the APR process.
- Calculate the thermal efficiency and economics of the baseline APR system.
- Assess the baseline APR system with respect to Hydrogen Program goals and make a go/no go decision to proceed with further development of a demonstration system.

The objectives of the second and third years of this project are as follows:

- Develop the detail design of the demonstration APR hydrogen generator system (50 kg/day).
- Fabrication of the integrated hydrogen generator system.

- Install and operate the APR hydrogen generator system at a sugar facility owned by ADM.
- Assess APR hydrogen generator system performance with respect to Hydrogen Program goals.

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:

- A. Fuel Processor Capital Costs
- D. Feedstock Issues
- E. Carbon Dioxide Emissions

Technical Targets

It is believed that using corn as a feedstock, converting this corn to glucose with cost effective and established technologies, and developing the APR process will provide a cost effective and energy efficient method to generate hydrogen from biomass. If successful, this proposed method of hydrogen generation would achieve a production energy efficiency of greater than 70%, a feedstock cost of less than $1.80/gge, a production equipment capitol cost contribution of $0.50/gge, and a hydrogen cost of $3.60/gge.

Approach

The conversion of corn to glucose via either wet or dry milling is well known and optimized. ADM is the leading producer of sweeteners from corn utilizing such processes. Virent's APR process reacts water with carbohydrate-type compounds (glycerol, sugars, and sugar alcohols) and has the following advantages over conventional vapor-phase steam reforming processes: (1) generates hydrogen and/or alkanes without the need to volatilize water, which represents a major energy saving; (2) occurs at temperatures and pressures where the water-gas shift reaction is favorable, making it possible to generate hydrogen with low amounts of CO in a single chemical reactor; and (3) takes place at low temperatures that minimize undesirable decomposition reactions typically encountered when carbohydrates are heated to elevated temperatures. While proven in the laboratory, the APR technology must be shown viable on a larger scale. This project will result in the design, construction, and operation of a 50 kg H_2/day prototype reactor system. Such a system will provide the necessary scale-up information for the generation of hydrogen from glucose derived from corn.

Accomplishments

This project is newly awarded and work has yet to be initiated.