Production of Hydrogen from Peanut Shells

The goal of this project is the production of renewable hydrogen from agricultural residues, in the near-term time frame (~three years) and at a comparable cost to existing methane reforming technologies. The hydrogen produced will be blended with CNG and used to power a bus in Albany, GA.

Our strategy is to produce hydrogen from biomass pyrolysis oils in conjunction with high value co-products. Activated carbon can be made from agricultural residues in a two-stage process: (1) slow pyrolysis of biomass to produce charcoal, and (2) high temperature processing to form activated carbon. The vapor by-products from the first step can be steam reformed into hydrogen. NREL has developed the technology for bio-oil to hydrogen via catalytic steam reforming and shift conversion. The process has been demonstrated at the bench scale and Phase 1 testing of the reformer began in FY2001. A preliminary economic analysis of the base case process assumes utilization of all of the pyrolysis vapors (225 kg/hr) at the current scale of the Scientific Carbons Inc. process. For an annual hydrogen production rate of 4.4 million Nm^3, the selling price of hydrogen is estimated to be $9.50/GJ.

The production of hydrogen from biomass, particularly agricultural residues, has been determined to make economic sense when combined with the production of additional value-added products, such as activated carbon. In cooperation with Clark Atlanta University, Scientific Carbons, Georgia Institute of Technology and Enviro-Tech, the National Renewable Energy Laboratory has demonstrated the production of hydrogen from biomass-derived pyrolysis vapors. Following shakedown tests at NREL, the reformer will be installed at Scientific Carbons' activated carbon production facility. Hydrogen produced at the facility will be used in transit applications, most likely buses, in the Albany (Georgia) metropolitan area in a future phase of the effort.

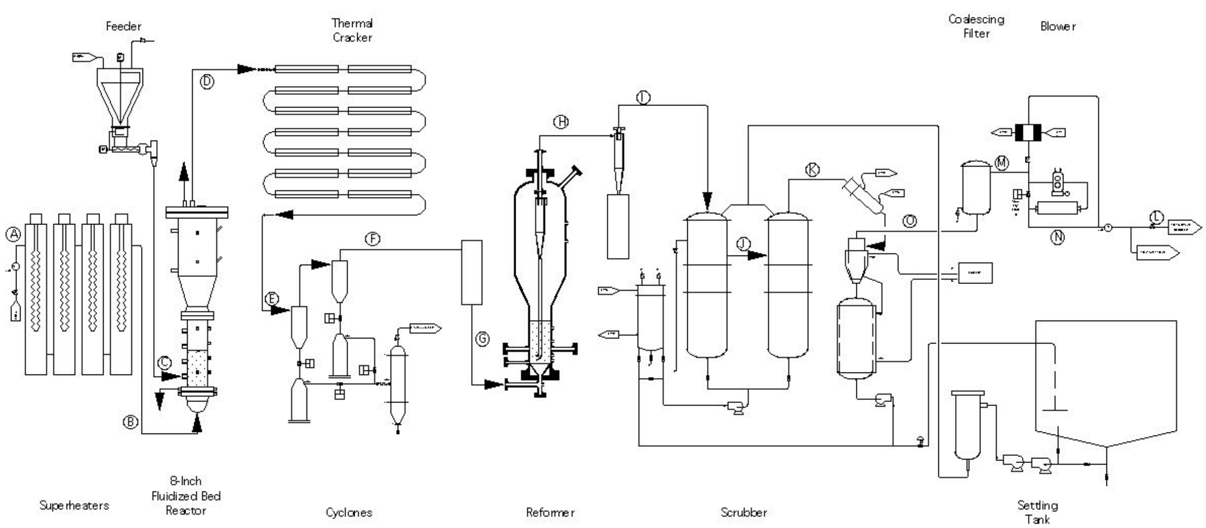

Figure 1: Schematic of the TCUF Biomass-to-Hydrogen system.

Hydrogen was produced at the NREL ThermoChemical User Facility (TCUF) using a pyrolysis/steam reforming system designed and constructed in conjunction with the project team. The pyrolyzer and reformer are fluidized bed reactors, designed to process 20 kg/hour biomass and 15 kg/hr pyrolysis vapors, respectively. A schematic of the system is shown in Figure 1. A photograph of the reformer is shown in Figure 2.

Pelletized peanut shells obtained from Birdsong (Blakely, GA) – the world's second largest peanut processing company – were fed to the pyrolysis reactor. Superheated steam at a flow ratio of 1.5:1 was used as a carrier gas and also as a reactant in the reformer.

The test proceeded very smoothly. Gas composition was monitored during the operation and is shown in Figures 3 and 4. The composition of the gas indicates that the yield of hydrogen from this agricultural residue feedstock is approximately 90% of maximum. Additional optimization of process conditions should result in somewhat higher yields (note that, in a commercial operation, the remaining CO would be converted to additional hydrogen using conventional water-gas shift processing). In these tests, the gas product stream was flared. Estimated hydrogen flows were 20 Nm^3. Following additional testing, the reformer will be installed and operated at Scientific Carbons.

Figure 2: Fluid bed reformer installed in NREL TCUF

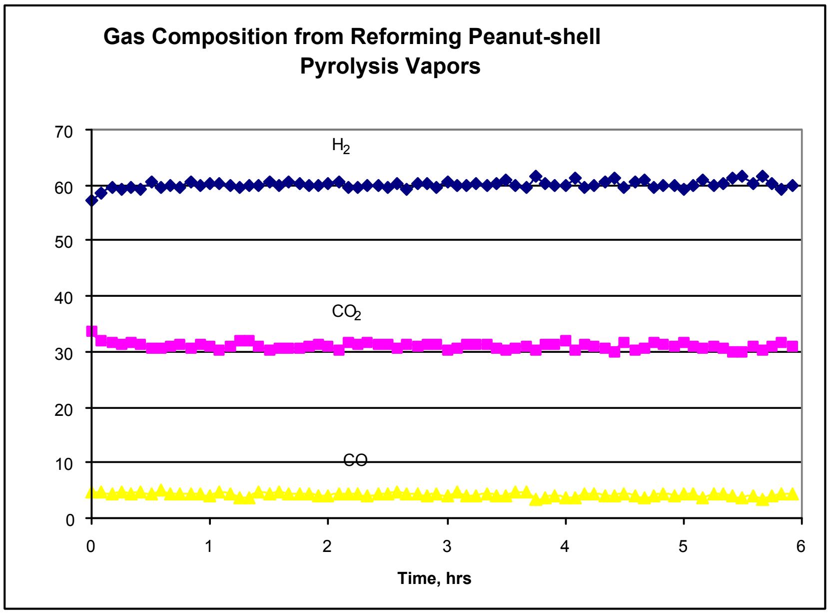

Figure 3: Gas composition data from test run.

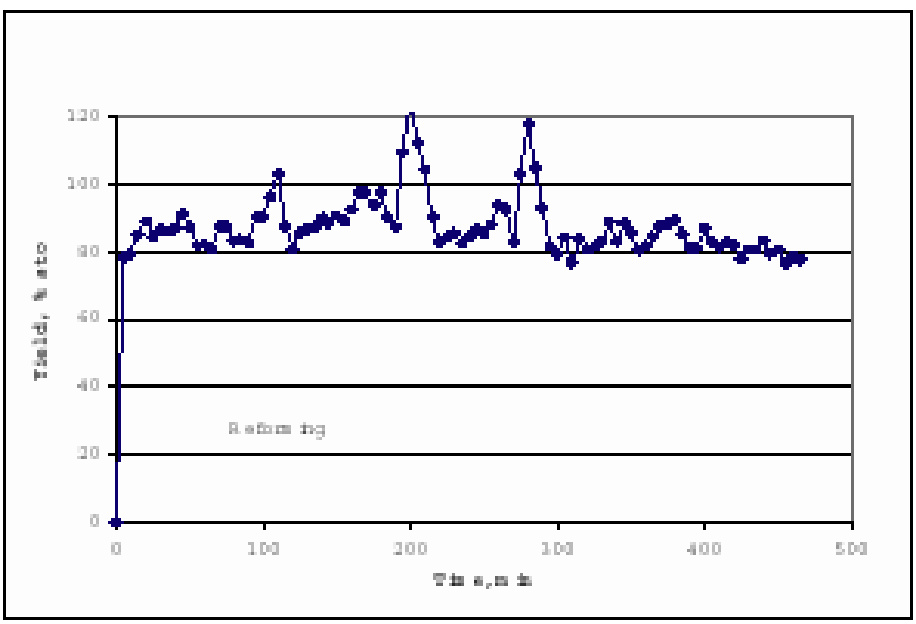

Figure 4. Yield of hydrogen obtained during reforming of peanut shell bio-oil carbohydrate-derived fraction at 850°C and S/C=9