Development of a catalytic fluid bed steam reformer for production of hydrogen from biomass

J. Abedi*[a], Y. D. Yeboah[a], J. Howard[b], and K. B. Bota[c]
[a]Clark Atlanta University, Department of Engineering, 223 James Brawley Dr., Atlanta, GA 30314
Tel: 404-880-6938; Fax: 404-880-6720; jabedi@cau.edu
[b]Scientific Carbons Inc., 253 North bay, Blakely, GA 31723
[c]Clark Atlanta University, Chemistry Department, 223 James Brawley Dr., Atlanta, GA 30314

Biomass as a product of photosynthesis is a renewable resource that can be used for sustainable production of hydrogen. However, direct production of hydrogen from biomass by gasification/water-gas shift technology is unfavorable economically, except for very low cost feedstocks and very large plants. Our approach proposes an alternative strategy with potentially better economics resulting from combined production of hydrogen with valuable co-products. The concept is based on a two-stage process: slow pyrolysis of biomass to generate activated carbon and bio-oil, and catalytic steam reforming of the oil or its fractions to produce hydrogen. This paper focuses on the use of agricultural residues such as peanut shells to produce hydrogen for urban transportation. Specifically, a side stream of the pyrolysis products of a process for making activated carbon from densified peanut shells at Scientific Carbons Inc. in Southwest Georgia will be used to test the concept. The primary focus of this work was to undertake process development studies in the use of the large quantities of peanut shells produced in Georgia as feedstock for the pyrolysis-steam reforming process described above. Scientific Carbons Inc is currently operating a pilot facility in Blakely, GA to convert 24 tons/day of pelletized peanut shells to activated carbon. Scientific Carbons' facility will be used to perform a scaled up demonstration of a steam reforming process to convert the off-gas of the peanut-shell carbonization process to hydrogen.

The catalytic fluid bed reformer was designed and constructed with the basic engineering design based on past results with the bench-scale, fluid-bed reactor. The reactor can process 10-20 kg/h of pyrolysis vapor. The maximum allowable operating temperature and pressure are 900 ^{o}C and 140 kPa, respectively. The reformer is equipped with fluid bed reactor, vapor and liquid injection, steam (and O_2) injection, internal and external cyclones for disengaging catalyst particles, heat exchanger to recover heat and condense the water vapor, instrumentation, data acquisition, and safety features (alarms, etc.). The product collection line includes a cyclone that captures fine catalyst particles and possibly, char generated in the process and two heat exchangers to condense excess steam. The inconel reactor with a porous distribution plate is placed inside a three zone electric furnace. The catalyst is fluidized using superheated steam, which is also a reactant in the reforming process. The status of the engineering development of the pyrolysis–steam reforming process that includes reactor development and long term catalyst testing; hydrogen storage and utilization; and analytical testing will be presented.