Hydrogen Production through Biomass Gasification

Hydrogen is **Green & Sustainable** fuel that has highest energy content (**142kj/g**) that can be produced through few number of methods, e.g, Natural Gas Reforming, Biomass Gasification, Coal Gasification, Electrolysis (sun light, wind, high temperature), Photo Biological, Photo-catalytic water splitting, Microbial Biomass Conversion, Bio Derived Liquid etc. Hydrogen Energy laboratory, Chattogram, Bangladesh focuses biomass gasification, Pho-catalytic water splitting to produce/generate hydrogen.

Hydrogen production from Biomass Gasification

Biomass gasification is a matured technology, not combustion, involves high temperature, controlled oxygen and steam to convert biomass to hydrogen along with other value added products. To reduce the net carbonaceous emissions, Biomass Gasification is assembled with carbon capture, utilization and long term storage

Biomass

Biomass is a renewable organic resource which includes agriculture crop residues (such as rice straw, wheat straw or corn stover), forest residues, special crops grown specifically for energy use, animal wastes, and organic municipal solid waste. Hydrogen along with other value added by products can be produced from this renewable resource via gasification. Renewability, abundance, carbon neutral and cost efficiency is the main features considered to use Biomass for hydrogen production by Gasification.

Gasification technology

Gasification or Biomass gasification in which solid fuels is undergone to high temperature (>700^0C) with controlled oxygen/steam ratio to produce high efficient hydrogen rich gaseous fuel or producer gas. The main composition of this yield gas is steam (H_2O), carbon dioxide (CO_2), carbon mono oxide (CO) and Hydrogen (H_2). The reaction between CO and steam increases the hydrogen content in the mixture. High quality membrane or adsorbers are used to obtain pure hydrogen.

General reaction-

$C_6H_{12}O_6$*(*)*+ O_2 + H_2O → CO + CO_2 + H_2 + other species ; *a surrogate of cellulose.

Commonly Water Gas Shift (WGS) reaction, Scrubbing, membrane or Pressure Swing Adsorption (PSA) is followed to remove the contaminations from producer gas to get pure hydrogen.

Water Gas Shift reaction

In this reaction, CO is reacted with steam to produce hydrogen by reducing the CO content as following reaction.

$$CO + H_2O \rightarrow CO_2 + H_2 \text{ (+ small amount of heat, } \Delta H = 41{:}1 \text{ kJ mol}^{-1})$$

Generally, temperature 600^0C-1000^0C with various catalysts is frequently used to optimize the process. A significant performance in converting CO into hydrogen is noticed from different authors.

Scrubbing

Different scrubbing agents such as water, RME, glycol are used to remove Tar, NH3, steam and other particulates at various temperature and pressure. Improved tar cleaning is noticed by combining cyclone, ceramic filter, air cooler, water coolers venturi scrubber and packed bed absorber consecutively. Activated carbon, biodiesel and char are also used as scrubbing agent. Sometimes, the removal of 99.70% ammonia, 98% tar, 70% sulfur is observed.

Membrane Separation

It provides a high purity of hydrogen in the gas mixture at low cost and effectively and 3 mm thick metallic membrane with Zeolitic-imidazolate framework-8 at temperature 200 C modest performance on hydrogen separation from biomass derived gas. Different catalyst based membrane is developed to optimize the membrane performance. Pd based catalysts are an excellent choice but its cost is very high and that's why different Pd alloy is being developed to compensate the cost without compromising performance. Producer gas is passed through the membrane at different conditions. Selective gas can pass through the membrane to allowed side driven by chemical potential.

Pressure Swing Adsorption (PSA)

After reforming and CO processing, the hydrogen content in syngas increase significantly. The present syngas is rich in hydrogen but further purification is necessary as CO causes the deactivation of the catalyst of the proton exchange membrane fuel cell (PEMFC) electrode. Different pressure swing adsorption systems on the basis of adsorption size, velocity, regeneration, and choice of the adsorbent material are designed for better performance. Activated carbon and activated carbon-Zeolite or only zeolites act as good adsorbets.

Challenges and Research Concentration

Costs related to skilled manpower, Infrastructure and Biomass feedstock is the main challenges for hydrogen production from Biomass Gasification.

Research Concentration-Skilled Manpower

- Frequent training and workshop on related technology at home and abroad

Research Concentration-*Infrastructure*

- Emerging new membrane technologies
- Reducing steps
- Optimizing the related steps by developing high efficient catalysts

Research Concentration -*Biomass feedstock*

- Emphasizing agricultural activities
- Biomass Feedstock collection plan
- Combining a unit to collect Value added products during hydrogen production.