

Hydrogen Production Types

Steam Reforming of Natural Gas or Propane

Hydrogen production from natural gas or propane commonly employs a process known as steam reforming. Steam reforming of natural gas involves two steps. The initial phase involves rendering the natural gas into hydrogen, carbon dioxide and carbon monoxide. This breakdown of the natural gas is accomplished by exposing the natural gas to high temperature steam. The second phase of steam reforming consists of creating additional hydrogen and carbon dioxide by utilizing the carbon monoxide created in the first phase. The carbon monoxide is treated with high temperature steam and the resulting hydrogen and carbon dioxide is sequestered and stored in tanks. Most of the hydrogen utilized by the chemical and petroleum industries is generated with steam reforming. Steam reforming reaches efficiencies of 70% - 90%. The reformer component on a complete fuel cell system is usually a smaller variation of the process described above. Component reformers operate under varying operating conditions and the chemical path that the hydrogen generation follows will vary from manufacturer to manufacturer, but the resulting hydrogen reformat is essentially the same.

Fossil Fuel Based Hydrogen Production

A closer look at the chemical formula for any fossil fuel reveals that hydrogen is present in all of the formulas. The trick is to remove the hydrogen safely, efficiently and without any of the other elements present in the original compound. Hydrogen has been produced from coal, gasoline, methanol, natural gas and any other fossil fuel currently available. Some fossil fuels have a high hydrogen to oxygen ratio making them better candidates for the reforming process. The more hydrogen present and the fewer extraneous compounds make the reforming process simpler and more efficient. The fossil fuel that has the best hydrogen to carbon ratio is natural gas or methane(CH₄).

Water Based Hydrogen Production Electrolysis

Electrolysis is the technical name for using electricity to split water into its constituent elements, hydrogen and oxygen. The splitting of water is accomplished by passing an electric current through water. The electricity enters the water at the cathode, a negatively charged terminal, passes through the water and exists via the anode, the positively charged terminal. The hydrogen is collected at the cathode and the oxygen is collected at the anode. Electrolysis produces very pure hydrogen for use in the electronics, pharmaceutical and food industries.

Relative to steam reforming, electrolysis is very expensive. The electrical inputs required to split the water into hydrogen and oxygen account for about 80% of the cost of hydrogen generation. Potentially, electrolysis, when coupled with a renewable energy source, can provide a completely clean and renewable source of energy. In other circumstances, electrolysis can couple with hydroelectric or off-peak electricity to reduce the cost of electrolysis.

Photo electrolysis

Photo electrolysis, known as the hydrogen holy grail in some circles, is the direct conversion of sunlight into electricity. Photovoltaic, semiconductors and an electrolyzer are combined to create a device that generates hydrogen. The photo electrolyze is placed in water and when exposed to sunlight begins to generate hydrogen. The photovoltaic and the semiconductor combine to generate enough electricity from the sunlight to power the electrolyzer. The hydrogen is then collected and stored. Much of the research in this field takes place in Golden, Colorado at the National Renewable Energy Laboratory.

Photo biological

Photo biological production of hydrogen involves using sunlight, a biological component, catalysts and an engineered system. Specific organisms, algae and bacteria, produce hydrogen as a byproduct of their metabolic processes. These organisms generally live in water and therefore are biologically splitting the water into its component elements. Currently, this technology is still in the research and development stage and the theoretical sunlight conversion efficiencies have been estimated up to 24%. Over 400 strains of primitive plants capable of producing hydrogen have been identified, with 25 impressively achieving carbon monoxide to hydrogen conversion efficiencies of 100%.

In one example, researchers have discovered that the alga, *Chlamydomonas Reinhardt*, possesses an enzyme called hydrogenise that is capable of splitting water into its component parts of hydrogen and oxygen. The researchers have determined the mechanism for starting and stopping this process, which could lead to an almost limitless method for producing clean, renewable hydrogen. The algae need sulfur to grow and photosynthesize. Scientists found that when they starved the algae of sulfur, in an oxygen-free environment, the algae reverted to a hydrogenise-utilizing mode. This mechanism was developed over millions of years of evolution for survival in oxygen-rich and oxygen-free environments. Once in this cycle, the algae released hydrogen, not oxygen. Further research is necessary to improve the efficiencies of the engineered plant systems, collection methods and the costs of hydrogen generation.

Biomass Gasification and Pyrolysis

Biomass can be utilized to produce hydrogen. The biomass is first converted into a gas through high-temperature

gasifying, which produces a vapor. The hydrogen rich vapor is condensed in pyrolysis oils and then can be steam reformed to generate hydrogen. This process has resulted in hydrogen yields of 12% - 17% hydrogen by weight of the dry biomass. The feedstock for this method can consist of wood chips, plant material, agricultural and municipal wastes, etc… When biological waste material is used as a feedstock, this method of hydrogen production becomes a completely renewable, sustainable method of hydrogen generation.