Hydrogen Production

Hydrogen (H2) is the most abundant element in the universe. It comprises 75% of all matter by mass and 90% by quantity of atoms. Hydrogen is an essential participant in the fusion reaction that forms and powers stars. On Earth, it is not easy to find because it combines readily with other elements and must be separated from them before it can be used as a fuel by itself. Fuels currently in daily use, such as gasoline, diesel, coal and natural gas are all hydrocarbons, meaning that they are combinations of Hydrogen and Carbon. Various amounts of many other elements, such as Sulfur and Nitrogen are usually found in these hydrocarbons, and are the source of much of the air pollution we are experiencing today.

There are many sources and ways of generating large quantities of Hydrogen:

Natural Gas

Most commercial Hydrogen is produced by steam reforming of Natural Gas. High temperature steam at 700 to 1100°C is used to react with methane (natural gas) to form syngas, a mixture of carbon monoxide and Hydrogen. Hydrogen can be recovered from syngas by using 130°C steam in the Water Gas Shift Reaction. The Oxygen atom is stripped from the steam and oxidizes the Carbon, liberating the Hydrogen. However, it also produces relatively large amounts of Carbon Dioxide, which is a greenhouse gas and should not be released into the atmosphere - it must be captured and sequestered or separated into carbon and Oxygen. An advantage of separation is that it produces pure carbon, which can be used as a raw material in many industrial processes such as the manufacture of carbon fiber or vehicle tires. New uses for Carbon are constantly being developed.

This process requires large amounts of steam, so locating those plants near geothermal sources or nuclear power plants is a wise idea because it would cost effectively provide the steam necessary without consuming fossil fuels.

Coal

The gasification process breaks coal into smaller molecules using steam and Oxygen at high pressure and temperature. The result is syngas, which can be further processed into Carbon Dioxide and Hydrogen as described above.

Coal liquefaction: Many processes for liquefying coal have been used, primarily in Germany. Generally, these operations involve the process of Hydrogenation. That is the addition, under high temperature and pressure, of Hydrogen and a catalyst, usually a metal, to a finely ground quantity of dry coal. This results in the production of oils and gasses of various molecular weights and viscosities. These can be further processed similar to petroleum refining to produce synthetic liquid fuel.

Water

Electrolysis is the process whereby water is separated into Hydrogen and Oxygen using an electrical current. Each gas can be captured, with the Hydrogen, which leaves the electrolyzer at high pressure, being stored and

made available as fuel. The Oxygen, also at pressure and very pure, has many uses such as for medical purposes, or it can merely be released back into the atmosphere.

The purity of the water used in the electrolyzer is not critical. In fact, distilled water, which is an ultra-pure form, does not perform well due to its high electrical resistance. Therefore, some impurities are beneficial, which is convenient, since impure water is far more common than pure water.

In addition to water, electrolysis also requires electricity for its operation. The ideal power sources are those that are renewable, such as solar and wind. It is preferred that these power sources be local rather than centralized. Thus the power is produced at the point of use, rather than having to be distributed by power lines. Hydrogen produced at home would be available for fueling the family car. If the electrolyzer is reversible, it can be operated as a fuel cell to produce electricity for the home using the excess Hydrogen. This latter process results in an added benefit – it produces pure water as a byproduct.

Nuclear submarines use electrolyzers to produce oxygen for their air supply during the long periods of submersion they routinely encounter. Hamilton Standard, a company that has made this equipment for the U.S. Navy, has also produced it in a much smaller version, about the size of a washing machine. This model would be ideal for home use if it could be produced cost effectively. It is reported that this unit could produce the equivalent of approximately six gallons of gasoline daily. This amount of Hydrogen would be sufficient for a large percentage of daily, local family travel.

The Hydrogen Challenger, Bremerhaven, Germany

The Hydrogen Challenger is the world's first wind-powered Hydrogen production ship. It is a 216-foot coastal tanker refitted in 2003 for mobile Hydrogen Production. Vertical axis wind turbines generate power to operate an electrolyzer using seawater to produce Hydrogen and Oxygen, which are stored and transported in onboard tanks. Hopefully, this ship, which is stationed near Bremerhaven, Germany will be the forerunner of a fleet of such mobile Hydrogen factories.

Solar-powered electrolyzers could allow existing gas and diesel service stations to add Hydrogen to their inventory without polluting the air or transporting the Hydrogen from a remote source. A water line, an electrolyzer, a solar panel (and/or a wind generator) and a high pressure storage tank with a fueling nozzle and meter are all that would be required to add Hydrogen to the available fuels at any service station. There are many Hydrogen fuel stations already in operation in the US and in Europe. One in Phoenix, Arizona has used a surplus navy electrolyzer to produce its Hydrogen. This fueling station run by Arizona Public Service, a local power utility,

until recently sold Hydrogen priced near the current cost of gasoline and diesel fuel and was capable of mixing any proportion of natural gas and Hydrogen desired by the customer.

Many automobile manufacturers are now producing cars and trucks that use Hydrogen for all or part of their fuel. Any internal combustion engine running on Natural Gas can utilize Hydrogen as part of its fuel. As the numbers of these vehicles grow, there will be more incentive to sell Hydrogen at your corner service station.

Biological Production

Hydrogen is produced naturally by several types of bacteria as they feed on vegetable matter. A number of companies are conducting research in genetic alteration of some of these bacteria species to increase the efficiency and output of the process. It is critical that this method make use of agricultural and other plant waste products to allow biofuels to be produced without reducing the world's food supply. See **"Biofuel Update - http://pfp100.us/bu.html"** on this website for more information.

The Future

Renewable Energy is the only way future generations can continue the prosperity that our generation has enjoyed. The world's dwindling supply of petroleum needs to be used for durable goods, not as an energy source. Each barrel of oil is worth far more when used to produce durable products and later recycled. When it is burned as fuel it is lost forever, not to mention the damage done to the atmosphere and to public health. One of the many ways of harnessing renewable energy is by production and use of Hydrogen as a source of power. But, in order to serve as a practical energy source, we must use renewable energy for generating the power or heat needed to produce the Hydrogen.

Remember – Hydrogen is a volatile substance and must be treated with care.

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