

Hydrogen FC Vehicle – Combined of Electrolysis and Chemical Reaction

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Abstract

In day-to-day lives of human automobiles plays an vital role in world, Particularly in india. Nowadays fuels are the major demand in india and the cost of fuels goes on increasing day by day. In result of this major demand and cost increases we uses a alternate fuels to equate the demands but it is also not economy now. So we uses a hydrogen as a fuel. Hydrogen

can be extracted with the chemical reaction and electrolysis method with this combinations of two methods more amount of hydrogen can be extracted and this can lead us to increase the performance of engine and also the efficiency of the engine. These methods can used as an alternate for the petrol usages. This leads to decrease the major demand of fuels.

I.INTRODUCTION

In individual process of electrolysis and chemical reaction, we can produce minimum amount of hydrogen, its not sufficient to run an engine. So we combine two processes for extracting maximum amount of Hydrogen. It leads to run an engine or increases the mileage. It is Ecofriendly.

A. Properties: Atomic Structure - Hydrogen

Hydrogen is by far the most plentiful element in the uni-verse, making up 75% of the mass of all visible matter in stars and galaxies. Hydrogen is the simplest of all elements. You can visualize a hydrogen atom as a dense central nucleus with a single orbiting electron, much like a single planet in orbit around the sun. Scientists prefer to describe the electron as occupy-ing a “probability cloud” that surrounds the nucleus some-what like a fuzzy, spherical shell.

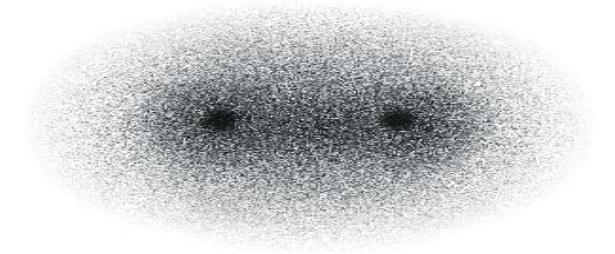


Figure 1.1: Atomic Structure of a Hydrogen Molecule

In most hydrogen atoms, the nucleus consists of a single proton, although a rare form (or “isotope”) of hydrogen con-tains both a proton and a neutron. This form of hydrogen is called deuterium or heavy hydrogen. Other isotopes of hy-drogen also exist, such as tritium with two neutrons and one proton, but these isotopes are unstable and decay radioac-tively.

Most of the mass of a hydrogen atom is concentrated in its nucleus. In fact, the proton is more than 1800 times more massive than the electron. Neutrons have almost the same mass as protons. However, the radius of the electron’s orbit, which defines the size of the atom, is approximately 100,000 times as large as the radius of the nucleus! Clearly, hydro-gen atoms consist largely of empty space. Atoms of all ele-ments consist largely of empty space, although all others are heavier and have more electrons.

A proton has a positive electrical charge, and an electron has a negative electrical charge. Neutrons do not carry a charge. Together, the charges associated with the proton and elec-tron of each hydrogen atom cancel each other out, so that individual hydrogen atoms are electrically neutral. Chemically, the atomic arrangement of a single electron orbiting a nucleus is highly reactive. For this reason, hydro-gen atoms naturally combine into molecular pairs (H_2 in-stead of H). To further complicate things, each proton in a hydrogen pair has a field associated with it that can be visu-alized and described mathematically as a “spin”. Molecules in which both protons have the same spin are known as “ortho-hydrogen”.

Molecules in which the protons have oppo-site spins are known as “para-hydrogen”. Over 75% of normal hydrogen at room temperature is ortho-hydrogen. This difference becomes important at very low temperatures since ortho-hydrogen becomes unstable and changes to the more stable para-hydrogen arrangement, releasing heat in the process. This heat can complicate low temperature hydrogen processes, particularly liquefaction.

B. Composition of Other Fuels

It is natural for us to compare hydrogen to other hydrocar-bon fuels with which we are more familiar. All hydrocarbon fuels are molecular combinations of

carbon and hydrogen atoms. There are thousands of types of hydrocarbon compounds, each with a specific combination of carbon and hydrogen atoms in a unique geometry. The simplest of all hydrocarbons is methane, which is the principal constituent of natural gas. (Other components of natural gas include ethane, propane, butane and pentane as well as impurities.)

Methane has the chemical formula CH_4 , which means that each molecule has four hydrogen atoms and one carbon atom. Other common hydrocarbons are ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). These are all considered light hydrocarbons since they contain less than five carbon atoms per molecule and therefore have low molecular weight (a carbon atom is almost 12 times as heavy as a hydrogen atom).

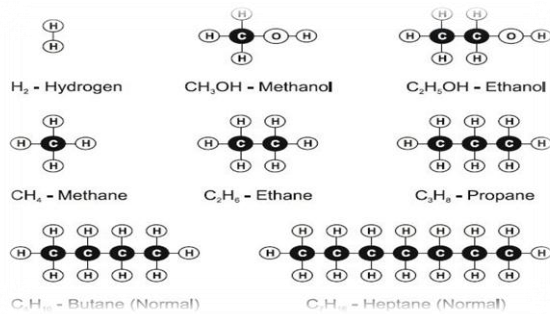


Figure 1.2: Chemical Structure of Common Fuels
Gasoline is composed of a mixture of many different hydrocarbons, but an important constituent is heptane (C_7H_{16}). Gasoline, diesel, kerosene, and compounds found in asphalt, heavy oils and waxes, are considered heavy hydrocarbons as they contain many carbon atoms per molecule, and therefore have high molecular weight. The lightest hydrocarbons are gases at normal atmospheric pressure and temperature.

Heavier hydrocarbons, with 5 to 18 carbon atoms per compound, are liquid at ambient conditions and have increasing viscosity with molecular weight. Other chemical fuels include alcohols whose molecules combine an oxygen/hydrogen atom pair (OH) with one or more hydrocarbon groups. Common alcohol fuels are methanol (CH_3OH) and ethanol (C_2H_5OH). These may be blended with hydrocarbons for use in internal combustion engines

II. PROPERTIES

A. Physical Properties

1. State

All substances exist on earth as either a gas, liquid or solid. Most substances will change from one of these states to another depending on the temperature and pressure of their surroundings. In general, a gas can be changed into a liquid by reducing its temperature, and a liquid to a solid by reducing its temperature further. To some extent, an increase in pressure will cause a

substance to liquefy and solidify at higher temperature than would otherwise be required. The transition from liquid to gas is known as boiling and the transition from liquid to solid as freezing. Accordingly, each substance has a characteristic boiling temperature and freezing temperature (at a given pressure).

The opposite transitions, from gas to liquid and solid to liquid, are known as condensation and melting respectively. The condensation temperature is the same as the boiling temperature and the melting temperature is the same as the freezing temperature. The process of condensation is also known as liquefaction and the process of freezing is also known as solidification. Boiling and freezing temperatures are most meaningfully compared relative to “absolute zero”. Absolute zero (0 °R; 0 K; -459.69 °F; -273.15 °C) is the lowest temperature in the universe at which all molecular motion stops.

Hydrogen has the second lowest boiling point and melting points of all substances, second only to helium. Hydrogen is a liquid below its boiling point of 20 K (-423 °F; -253 °C) and a solid below its melting point of 14 K (-434 °F; -259 °C) and atmospheric pressure. Obviously, these temperatures are extremely low. Temperatures below -100 °F (200 K; -73 °C) are collectively known as cryogenic temperatures, and liquids at these temperatures are known as cryogenic liquids.

The boiling point of a fuel is a critical parameter since it defines the temperature to which it must be cooled in order to store and use it as a liquid. Liquid fuels take up less storage space than gaseous fuels, and are generally easier to transport and handle. For this reason, fuels that are liquid at atmospheric conditions (such as gasoline, diesel, methanol and ethanol) are particularly convenient. Conversely, fuels that are gases at atmospheric conditions (such as hydrogen and natural gas) are less convenient as they must be stored as a pressurized gas or as a cryogenic liquid.

The boiling point of a pure substance increases with applied pressure—up to a point. Propane, with a boiling point of -44 °F (-42 °C), can be stored as a liquid under moderate pressure, although it is a gas at atmospheric pressure. (At temperatures of 70 °F (21 °C) a minimum pressure of 111 psi (7.7 bar) is required for liquefaction). Unfortunately, hydrogen’s boiling point can only be increased to a maximum of -400 °F (-240 °C) through the application of approximately 195 psi (13 bar), beyond which additional pressure has no beneficial effect. Hydrogen as a vehicle fuel can be stored either as a high-pressure gas or as a cryogenic liquid (Section 2.2).

2. Characteristics

Pure hydrogen is odorless, colorless and tasteless. A stream of hydrogen from a leak is almost invisible in daylight. Compounds such as mercaptans and thiophanes that are used to scent natural gas may not be added to hydrogen for fuel cell use as they contain sulfur that would poison the fuel cells. Hydrogen that derives from reforming other fossil fuels (Section 2.1.2) is typically accompanied by nitrogen, carbon dioxide, carbon monoxide and other trace gases. In general, all of these gases are also odorless, colorless and tasteless.

3. Toxicity

Hydrogen is non-toxic but can act as a simple asphyxiate by displacing the oxygen in the air.

4. Asphyxiation

Oxygen levels below 19.5% are biologically inactive for humans. Effects of oxygen deficiency may include rapid breathing, diminished mental alertness, impaired muscular coordination, faulty judgment, depression of all sensations, emotional instability and fatigue. As asphyxiation progresses, dizziness, nausea, vomiting, prostration and loss of consciousness may result, eventually leading to convulsions, coma and death. At concentrations below 12%, immediate unconsciousness may occur with no prior warning symptoms.

In an enclosed area, small leaks pose little danger of asphyxiation whereas large leaks can be a serious problem since the hydrogen diffuses quickly to fill the volume. The potential for asphyxiation in unconfined areas is almost negligible due to the high buoyancy and diffusivity of hydrogen. A mixture of carbon monoxide and air is potentially flammable and explosive, and can be ignited by a spark or hot surface! Expansion Ratio The difference in volume between liquid and gaseous hydrogen can easily be appreciated by considering its expansion ratio.

Expansion ratio is the ratio of the volume at which a gas or liquid is stored compared to the volume of the gas or liquid at atmospheric pressure and temperature. When hydrogen is stored as a liquid, it vaporizes upon expansion to atmospheric conditions with a corresponding increase in volume. Hydrogen's expansion ratio of 1:848 means that hydrogen in its gaseous state at atmospheric conditions occupies 848 times more volume than it does in its liquid state.

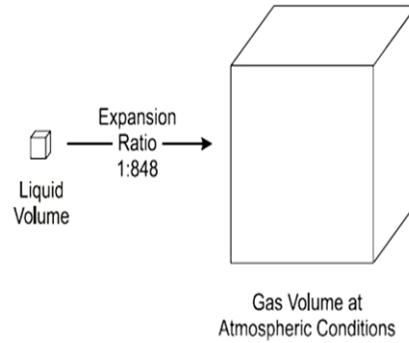


Figure 1.3: Hydrogen Liquid to Gas Expansion Ratio

When hydrogen is stored as a high-pressure gas at 3600 psig (250 barg) and atmospheric temperature, its expansion ratio to atmospheric pressure is 1:240. While a higher storage pressure increases the expansion ratio somewhat, gaseous hydrogen under any conditions cannot approach the expansion ratio of liquid hydrogen. Hydrogen Content Even as a liquid, hydrogen is not very dense. Ironically, every cubic meter of water (made up of hydrogen and oxygen) contains 111 kg of hydrogen whereas a cubic meter of liquid hydrogen contains only 71 kg of hydrogen. Thus, water packs more mass of hydrogen per unit volume, because of its tight molecular structure, than hydrogen itself. This is true of most other liquid hydrogen-containing compounds as well; a cubic meter of methanol contains 100 kg of hydrogen and a cubic meter of heptane contains 113 kg. Hydrocarbons are compact hydrogen carriers with the added advantage of having higher energy density than pure hydrogen (Section 1.3.1.2).

When used as vehicle fuel, the low density of hydrogen necessitates that a large volume of hydrogen be carried to provide an adequate driving range.

5. Leakage

The molecules of hydrogen gas are smaller than all other gases, and it can diffuse through many materials considered airtight or impermeable to other gases. This property makes hydrogen more difficult to contain than other gases. Leaks of liquid hydrogen evaporate very quickly since the boiling point of liquid hydrogen is so extremely low. Hydrogen leaks are dangerous in that they pose a risk of fire where they mix with air (Section 1.3.1). However, the small molecule size that increases the likelihood of a leak also results in very high buoyancy and diffusivity, so leaked hydrogen rises and becomes diluted quickly, especially out-doors.

This results in a very localized region of flammability that disperses quickly. As the hydrogen dilutes with distance from the leakage site, the buoyancy declines and the tendency for the hydrogen to continue to rise decreases. Very cold hydrogen,

resulting from a liquid hydrogen leak, be-comes buoyant soon after is evaporates. In contrast, leaking gasoline or diesel spreads laterally and evaporates slowly resulting in a widespread, lingering fire hazard. Propane gas is denser than air so it accumulates in low spots and disperses slowly, resulting in a protracted fire or explosion hazard. Heavy vapors can also form vapor clouds or plumes that travel as they are pushed by breezes.

Methane gas is lighter than air, but not nearly as buoyant as hydrogen, so it disperses rapidly, but not as rapidly as hydrogen. For small hydrogen leaks, buoyancy and diffusion effects in air are often overshadowed by the presence of air currents from a slight ambient wind, very slow vehicle motion or the radiator fan. In general, these currents serve to disperse leaked hydrogen even more quickly with a further reduction of any associated fire hazard.

When used as vehicle fuel, the propensity for hydrogen to leak necessitates special care in the design of the fuel system to ensure that any leaks can disperse with minimum hindrance, and the use of dedicated leak detection equipment on the vehicle and within the maintenance facility. Hydrogen leaks pose a potential fire hazard.

6. over view

Hydrogen gas forms explosive mixtures with air in concentrations from 4-74%. The explosive reactions may be triggered by spark, heat or sunlight. The hydrogen auto ignition temperature of spontaneous ignition in air, is 500°C (932°F). Hydrogen has been touted as an environmentally friendly wonderful that can be used in vehicles and burns to produce only water as a byproduct.

III. ELECTROLYSIS OF WATER

A. Overview

During electrolysis, electrical energy is used to cause a no spontaneous chemical reaction to occur. Electrolysis is often used to obtain elements that are too chemically reactive to be found free in nature.

In this experiment electrolysis will be used to separate water into hydrogen gas and oxygen gas. During this experiment you will perform certain tests for the products of the decomposition reaction.

Our overall equation is:

$$\text{H}_2\text{O(l)} \rightarrow \text{H}_2 \text{ (g)} + \text{O}_2 \text{ (g)} \Rightarrow$$

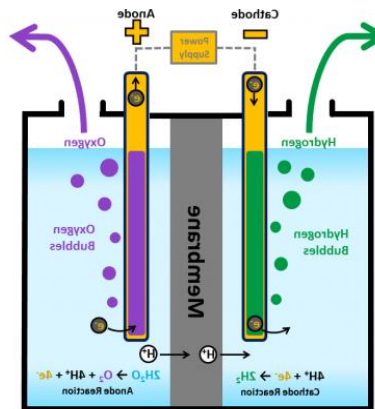


FIGURE 3.1: ELECTROLYSIS

We can tell how many moles of gas are collected because of a simple constant. 1mol of gas = 22.4L of volume. We will use this to determine our products and analyze whether or not we can use this as a tool to determine our ratio of hydrogen to oxygen.

We will be creating our own Brownlee electrolysis apparatus. It is not difficult to assemble your own using common lab equipment. Using this method allows you to collect hydrogen and oxygen gases.

B. Purpose

To perform a decomposition reaction through the use of electrolysis to separate water into hydrogen and oxygen gas. To analyze the results of the reaction to see if it can be used to determine the composition of water quantitatively.

C. Safety

Small amounts of explosive hydrogen gas will be generated. Safety goggles should be worn when testing for the presence of hydrogen gas.

D. Procedure

1. Wash thoroughly your container so there are not any contaminants. Cut your plastic container in half or a third from the bottom depending on the size of the container, approximately 12 cm tall.

2. Insert tacks into the bottom of the plastic container as far apart without being at the walls of the container. Fill the container ½ full of water .Fill both test tubes completely with water. You may find the next step easier if you cover the open ends of the test tube with a small piece of paper. Invert the test tubes, placing the open tops under water in the large jar. Both test tubes should be completely full of water with no bubbles. Allow the paper you used to cover the test tubes to drop off under water. Add 1 gram of baking soda to the water (which will help conduct the electric current)..

3. Secure the inverted test tubes in place in for your Brownlee apparatus by using plastic wrap and a rubber band . The thumb tack electrodes will be inside the test tubes.

4. Carefully connect the wires to the thumb tacks and the power source to begin the electrolysis.

5. Record your observations. Continue the electrolysis until several cm of gas have been allowed to collect in each of the two test tubes. Note the relative amount of gas that collect in each tube. Be sure to indicate which test tube is attached to which post of the power source or battery. Mark your tubes negative and positive (Black wire negative, red wire positive)

6. Add a few drops of indicator solution to the beaker. Watch for any colour changes that occur near the mouths or inside the two test tubes. Record any changes you observe, making note of which test tube produced the change.

7. You will test the gas collected in each of the test tubes, one at a time. When testing the gas inside a test tube, carefully remove the tubes from the water, keeping the test tubes inverted so the gas doesn't escape. Use a test tube holder or clamp to hold the test tubes while performing the tests

8. Place the candle on a glass square or other suitable support and light it. a. Remove the test tube from the water and keep it inverted. Allow the water to drain out. Holding the test tube with a test tube holder, bring the open end of the tube over the lit candle. If a pale blue flame or a soft pop sound this indicates hydrogen is present. If the candle burns brighter or again bursts into flame, the gas is oxygen.

E Alternate test for oxygen:

a. Light a wood splint, then blow it out.

b. Place the smoldering splint inside the test tube. If the splint glows then oxygen is present

Electrolysis is a promising option for hydrogen production from renewable resources. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer. Electrolyzers can range in size from small, appliance-size equipment that is well-suited for small-scale distributed hydrogen production to large-scale, central production facilities that could be tied directly to renewable or other non-greenhouse-gas-emitting forms of electricity production

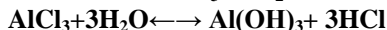
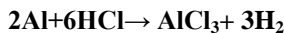
IV. CHEMICAL REACTION

A. ALUMINIUM FOIL + HCL

The hydrochloric acid gets through the Al₂O₃ layer, the reaction will begin. The lid will likely blow violently off, due to massive amount of hydrogen being produced. This reaction is normally very exothermic, but varies due to the concentrations of HCl.

As the newly produced Aluminium Chloride forms, it will violently hydrolyze and form a black sludge of Al(OH)₃ and aluminium oxides at the bottom. If <10% concentrated HCl acid is used, you will feel the bottom heating up, the lid will likely expand and it might blow off. If >35% Concentrated HCl Acid is used, when the reaction kicks off, the bottom will get too hot to touch, a **MASSIVE CLOUD** of Hydrogen and Hydrogen chloride will expand outwards, and will likely blow your container apart. As the newly produced Aluminium Chloride forms, it will violently hydrolyze/VAPOURIZE due to its low boiling point and form a black sludge of Al(OH)₃ and aluminium oxides at the bottom, as well as more clouds of HCl vapors.

B. Reaction



Required items:

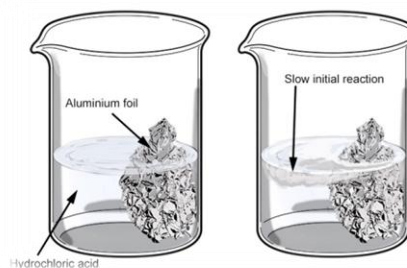


FIG 4.3. BEFORE REACTION

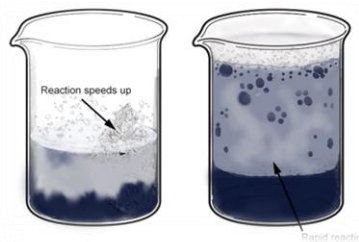
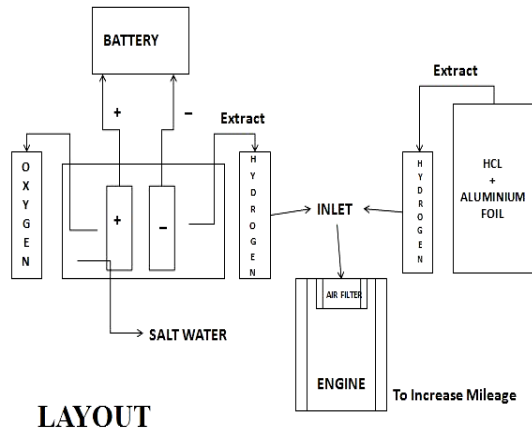


FIG 4.4. DURING REACTION

V.COMBINED OF ELECTROLYSIS AND CHEMICAL REACTION LAYOUT



A. Hydrogen pass to airfilter

The hydrogen produce from the electrolysis and chemical reaction process are then passed into the air filter. The hydrogen will mixed with the atmospheric air. The dust in the hydrogen are filtered. Then the fuel is mixed with the hydrogen and the spark produce more than the normal air moisture that are mixed with the engine.

B. Mileage increases

In a spark ignition engine the fuel is mixed with hydrogen and then induced into the cylinder during the intake process. After the piston compresses the fuel air mixture, the spark ignites it causing combustion. The expansion of the combustion gases pushes the piston during the power stroke. The continuous flow of hydrogen can increases the mileage of an vehicle. It also increases the performance of an engine. Compared with the normal air it also increase more spark produces in the engine.

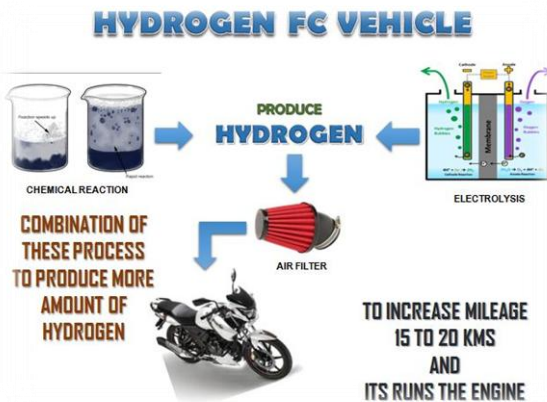


FIG7.1: COMBINATION OF TWO PROCESS REPRESENTATION

It will increase the mileage of the engine up-to **15 KMs**. The hydrogen extracted from the combination of electrolysis and chemical reaction process is up-to **35% to 40 %**. If, this combined process is much more efficiency by the large set-up. It extracts the hydrogen up-to**65% to 70%**. It can runs the engine without fuel.

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