International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 6 (2015) pp. 15611-15620

http://www.ripublication.com

Production of Hydroxyl Gas By Electrolysis Process Using Different Catalyst

Rajasekaran T.[1], Duraiswamy K.[2], Santhosh M.[1] and Pooventhan S.[1]
[1]*Department of Mechatronics Engineering, K.S.Rangasamy College of Technology, Tiruchengode, India*
[2]*Department of Computer Science and Engineering, K.S. Rangasamy College of Technology, Tiruchengode, India*

Abstract

Clearly fossil fuel reserves are finite, continues use of fossil fuel in such a rate will lead to an energy crisis. Hydrogen is an alternate green fuel. Hydrogen storage is a tedious process. Electrolysis is an environmental friendly production method for hydrogen. Our experimental setup offers a comprehensive overview of hydroxyl gas, which produced by the water electrolysis process using different kind of electrodes and catalyst gives a better production rate. The Hydroxyl gas was used as a supplementary fuel in the engine. By using this hydroxyl gas the emission of Hydrocarbon and Nitrogen Oxide are reduced. Engine torque is also increased and the specific fuel consumption rate is reduced to maintain the greenhouse effect.

Key words: Hydroxyl gas, Water electrolysis, Electrode, Catalyst.

Introduction

Fossil fuel prices have never been volatile, influenced economic acceleration in worldwide and subsequently by economic recession. The difficulty of controlling prices and the uncertain reserves is strong incentives for pursuing energy security. Global warming and local pollution hotspots associated with fossil fuel usage are further significant, environmental and social problems. Throughout the world, every year consumption rate is approximately 11 billion tonnes of oil in fossil fuels. The use of hydrogen as a fuel in internal combustion engines has been studied by a number of research groups, in response to increasing governmental Pressure and consumer demand for more environmentally friendly fuel chains. A number of manufacturers are now leasing, demonstration vehicles to consumers using, hydrogen as a fuel. Compared with conventional, fossil hydrocarbon fuels, hydrogen offers practically an elimination of pollutants such as carbon monoxide and un-burnt hydrocarbons, known to pose health risks in densely populated areas. The only nontrivial pollutant from hydrogen engines is nitrogen oxides. However the characteristics of hydrogen fuel, such as a high flame speed and extensive lean burn operation possibilities, allow significant reductions in Nitrogen oxide compared using conventional fuels. In the future, hydrogen may be used in one of three ways to power Vehicles, to Produce electricity in a fuel cell, as a replacement and supplement for gasoline or diesel fuel in an internal combustion engine.

Water As A Motor Fuel

Water molecules are electrically neutral. The separation of hydrogen from water can be used as a fuel. Since the water molecule has a stable structure at ambient temperature. The positive as well as negative charges are concentrated at the hydrogen and oxygen molecules. The hydrogen bond of positively charged hydrogen molecules is partially attracted by the negatively charged oxygen molecules. To break the bonding between hydrogen and oxygen molecules in water require a minimum voltage of 1.23V. This voltage is also known as equilibrium voltage of water. By passing, the voltage above equilibrium level through Hofmann's voltmeter gaseous oxygen forms at anode end and gaseous hydrogen forms at cathode end. The formed gaseous hydrogen at cathode end is used as fuel to the motor.

Electrolysis of Water

Electrolysis is driving on a non-spontaneous chemical reaction by passing a direct electric current through an electrolyte. During Electrolysis the electrode should have a high conductivity of the material, resistance to corrosion and erosion. This reaction occurs depending on electron transfer at the electrodes is oxidation and reduction reaction. Since it's a have the ability to accept and donate the electrons at any condition.

At anode, water decomposes into oxygen and hydrogen ions.

$$2H_2O\ (l) \rightarrow O_2\ (g) + 4H^+\ (aq) + 4e^-$$

At the cathode, water decomposes into hydrogen and hydroxide ion.

$$2H_2O\ (l) + 2e^- \rightarrow H_2\ (g) + 2OH^-\ (aq)$$

And the overall reaction is,

$$2H_2O\ (l) \rightarrow 2H_2\ (g) + O_2\ (g)$$

Pure water conducts electricity very poorly, so water soluble electrolyte has to be added to close the circuit. This electrolyte dissociates into cations and anions, it carry the charge through the liquid. The electrolyte with the aqueous boundary layer subject to concentrated and electrical potential gradient with the presence of generating gaseous nano-bubbles and micro-bubbles.

Electrodes Used

Basically five types of electrodes have been used. They are Copper, Zinc, Aluminium, Silver, Stainless steel (S16). Electrode selected should not corrode easily. The Ohmic resistance between these electrodes in a vertical position will be reduced. Pure copper is soft and malleable. It is used as a good conductor of heat and electricity. Copper is a ductile metal with very high thermal and electrical conductivity. It is basically a hygienic metal that slow-down the growth of germs such as E-coil and Legionella. Zinc is a metallic chemical element. Zinc is most commonly used as an anti-corrosion agent. It easily dissolves in strong basic and acidic solutions. The component is rare and requires bulky ligands to stabilize the low oxidation state.

Aluminium metal is chemically reactive. It is relatively soft, durable, lightweight, and malleable metal with appearance ranging from silvery to dull grey depending on the surface roughness. Aluminium is oxidized by water to produce hydrogen and heat. Silver metal in its pure state has a brilliant white metallic luster that can take a high degree of polish. It has the highest electrical and heat conductivity of all metals and the lowest contact resistance. Silver is soluble in nitric acid and in hot Sulphuric acid. Silver is most reflective metal on earth with highest electrical conductivity of all metals. Stainless steel has a unique self-healing property. Its parts offers higher strength and corrosion resistance. The stainless steel also retains strength and shock resistance even at high temperature. Excellent fatigue and impact resistance products made with the metal generally last a long period of time.

Catalyst Used

Catalysis is the increase in the rate of a chemical reaction of one or more reactants due to participation of additional substances. Catalyst used to Potassium Hydroxide, Titanium Oxide, Sodium Bicarbonate, Dilute Sulphuric Acid, and Dilute Hydrochloric Acid.

Rutile, Anatase and Brookite are the minerals, primarily composed of titanium oxide. It is mainly sourced by the Ilamenite ore. When incorporated into a plastic formulation, its efficiency in scattering of visible light and imparting brightness, high opacity are high. It has resistance to discoloration under ultra violet light in exposed application. Sodium chloride is the responsible for the salinity of the ocean. The process of electrolysis is carried out electric current is passed through the solution of sodium chloride to prepare the element chlorines. The physical form of sodium chloride is transparent to translucent cubic crystal.

Hydrochloric acids are naturally found in the gastric acids. It is a clear, colorless, highly pungent solution of hydrochloric acid in water that is a highly corrosive, strong mineral acid with many industrial uses. It is basic in nature as it solutions turn red litmus in to blue. Sulphuric acid is a colorless viscous corrosive oily liquid. It is also a powerful dehydrating agent and is used to remove a molecule of water from many organic compounds. Sulphuric acid is miscible with any amount of water with an exothermic reaction.

Experimental Setup

The Hoffman's Voltmeter is a set of 3 vertical glass tubes that are joined so that a fluid filling the longer center limb will completely fill the other two shorter limbs. The shorter limbs are graduated to 50ml and each is fitted with a glass tap at the highest point. The bottom of each limb is open so an electrode mounted in a rubber stopper can be sealed into the limb with the special material pointing upwards inside the limb and the electrical connection pointing downwards. The normal use of the Hoffman's voltmeter is to electrolyze water into the gases Hydrogen and Oxygen. Using electrodes and electrolyte the Hydrogen gases can be obtained. Carefully pour the electrolyte into the glassware using the center limb. To eliminate all air bubbles while filling through the center limb, open the taps slightly to let the air escape and close them when water begins to flow out of them. Be sure the two electrodes are fitted securely into the side limbs and that all the joints are leak tight. Take a DC power supply or a sturdy battery and connect the electrodes to 10V.DC. It can be either a full wave (unsmoothed) or smoothed DC.

A small current flows through the water and bubbles can be seen forming around the electrodes. These bubbles break free from the electrodes and rise up the side limbs to form a gas column under each tap. Notice the volumes of gas formed. Notice that one volume is close to double the other volume. Since water is H2O, it is likely that there would be double the volume of Hydrogen. To determine which gas is which, invert a test tube over one of the taps and slightly open the tap until the water rises to the tap. The gas escapes into the test tube, but while withdrawing the test tube, place your thumb over the mouth of the test tube to hold the gas in. Test for Hydrogen: If ignited as it flows into the air, it will softly 'pop' as a slight explosion occurs.

Figure 1: Hoffman's Experimental Setup

Test for Oxygen: If a glowing splinter is inserted into oxygen it will glow more brightly or will ignite. The Hydrogen gas is formed over the negative electrode (the Cathode) and Oxygen is formed over the positive electrode (the Anode). When compared to the other production process the cost of the experimental setup is comparatively low and hydrogen production rate is also up to the estimated limit.

Experimental Graph

In our experimental setup, different types of electrodes and catalysts have been employed for the producing hydrogen involves electrolysis. The weightiness of the electrode has been kept constant 3gm throughout the experiment. Other electrodes which have been messed up catalyst less production of hydrogen.

Table 1: Apparatus Requirement

Substance	Water (200ml)
Voltage	10v
Weight of electrodes	3gm
Weight of catalysts	20gm
Acid in ml	5ml
Area	10cm2

The graphical representation shows that the production of hydrogen using different catalyst with different electrode with respect to time. Whenever the time increases, amount of hydrogen production is also increased. This show that time is proportional to the production rate of hydrogen.

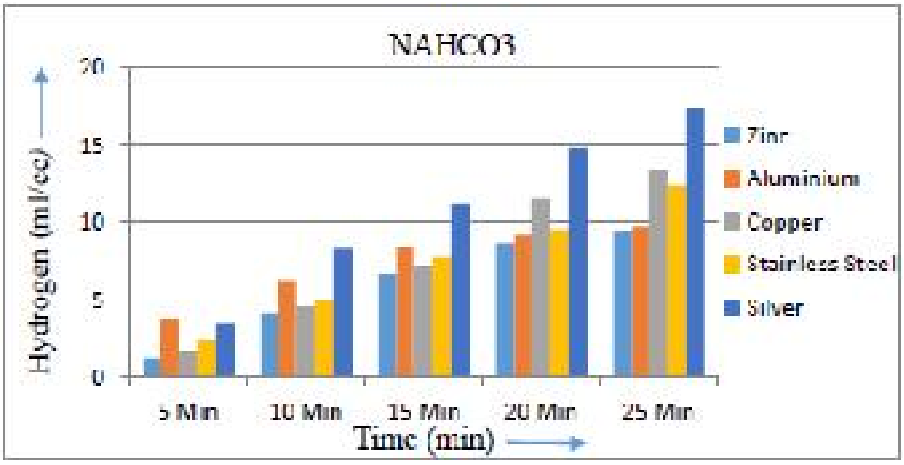

Figure 2: Sodium bi carbonate vs Hydrogen

The production of hydrogen along with sodium bi-carbonate catalyst using different electrodes. Here the production of hydrogen can be prominent at sliver of 17.3 ml and lower production rate at zinc of 9.4 ml. The Aluminium electrodes at 9.8 ml, copper electrodes at 13.4 ml, Stainless steel electrodes at 12.4 ml. In this silver and copper would produce a better hydrogen rate, compared to copper, silver produce better hydrogen.

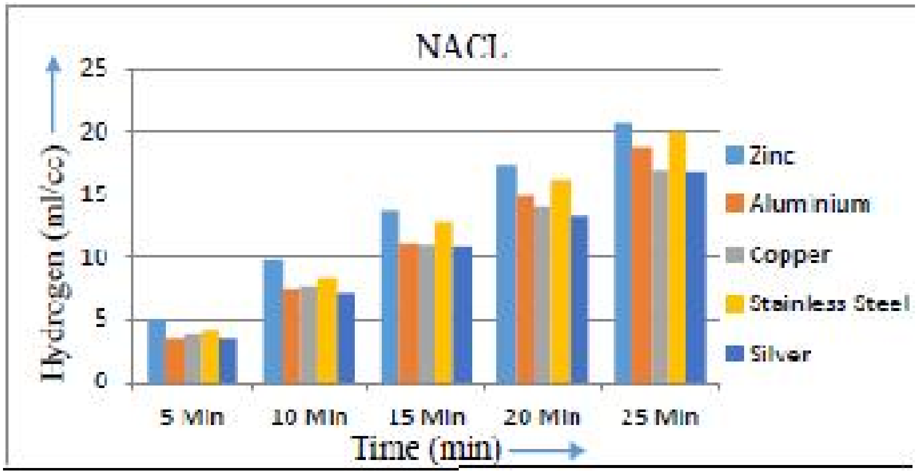

Figure 3: Sodium chloride vs. Hydrogen

By passing a current of electricity through a sodium chloride solution the salt is decomposed into chlorine at the anode and sodium at cathode. But the latter once decompose a molecule of water of the solution, forming caustic soda and setting free hydrogen. Here the hydrogen can be more prominent at zinc of 20.7 ml and lower production rate of copper and silver at 16.8 ml and 16.7 ml. The Aluminium electrodes at 18.7 ml, stainless steel electrodes at 20 ml. In this zinc and stainless steel would produce a better hydrogen rate, compared to stainless steel zinc produce better hydrogen.

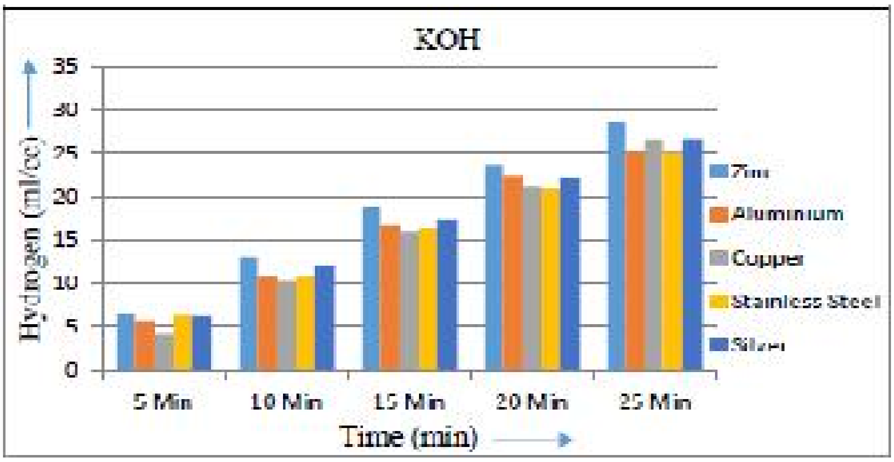

Figure 4: Potassium hydroxide vs. Hydrogen

Using different electrodes, the production of hydrogen along with potassium hydroxide catalyst can be higher at zinc of 28.6 ml. The Aluminium electrodes at 25.2 ml, copper electrodes at 26.6 ml, stainless steel electrodes at 25 ml, silver electrode at 26.7. In this catalyst, all electrodes would produce a better hydrogen, among that zinc can make yet more.

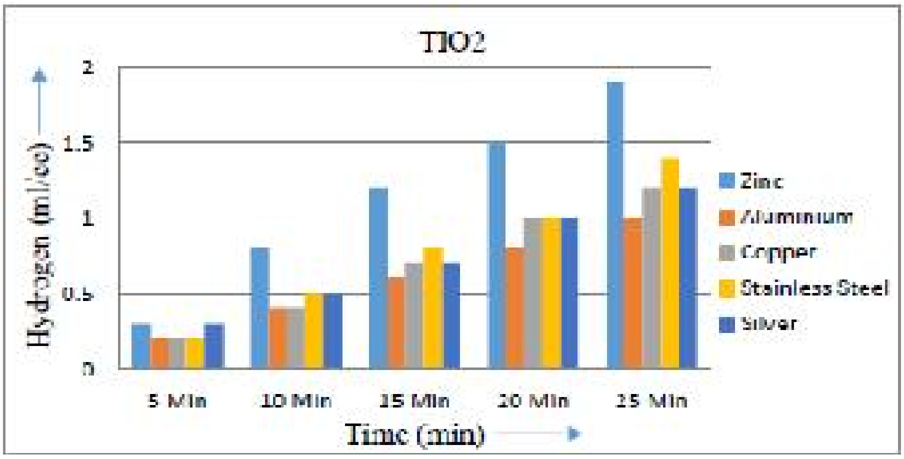

Figure 5: Titanium di oxide vs. Hydrogen

The hydrogen production rate obtained is low due to quick charge recombination, and inability to utilize visible light efficiently higher in zinc at 1.9 ml, to discoloration in exposed applications under ultraviolet illumination. It can be well solved in the photo-catalysis process. Salt can bring on hydrogen nearest acid value.

H2SO4

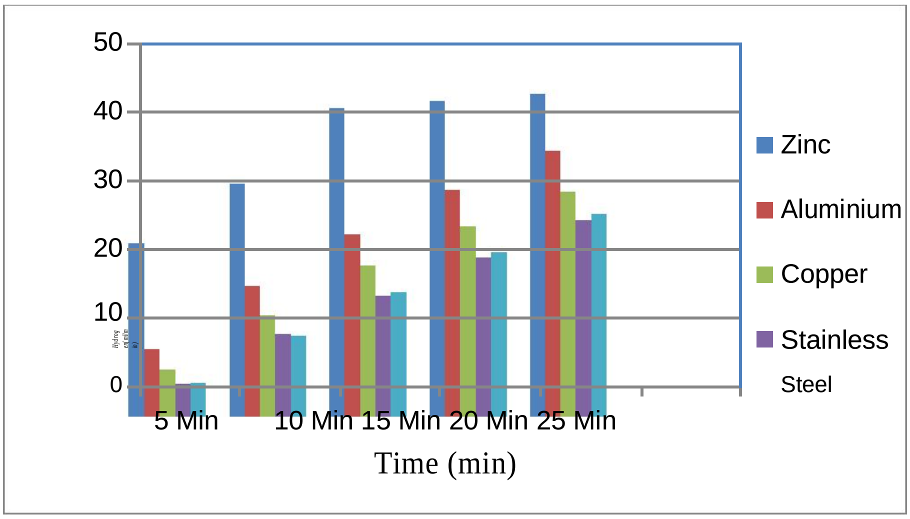

Figure 6: Sulphuric acid vs. Hydrogen

The strength of acids is determined by the degree to which they are ionized in aqueous solution. Here the production of hydrogen can be much more prominent of zinc at 45 ml in 15 min. And combination of other electrodes can give better hydrogen. Since it can be corrode easily. The Aluminium electrodes is 38.7 ml, copper electrodes is 32.8 ml, stainless steel electrodes is 28.6 ml. In this zinc would produce a better hydrogen rate, compared to stainless steel, zinc produce better hydrogen.

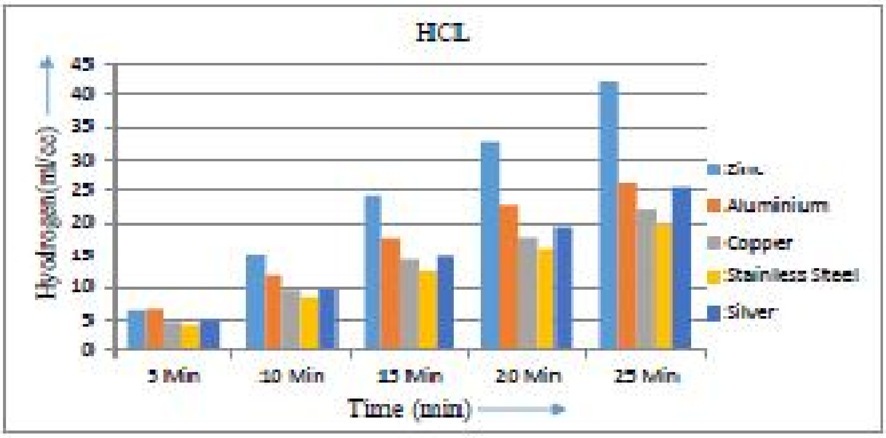

Figure 7: Hydrochloric acid vs. Hydrogen

Hydrogen can be higher at zinc at 41.9 ml and lower production rate of stainless steel of 20 ml. The Aluminium electrodes of 26.1 ml, copper electrodes of 22.1 ml, silver electrodes of 20 ml. In this zinc combine with hydrochloric acid forms a higher hydrogen production rate compare to other electrodes.

Result and Disscussion

The production quantity of hydrogen can be varied by using different catalyst, among that silver electrode dipped in sodium bi-carbonate solution have higher production rate, when compared with other electrode- electrolyte combination, but Zinc electrodes, on the other hand gives double the quantity of hydrogen production in acids then salt. In terms of Sulphuric acid its production pace is higher at 45ml in 15min, such concentration can be exercised in case of Sulphuric acids.

In presence of hydrochloric acid, hydrogen involvement can be more at 41.9 ml in 25min, and then it can easily get rusted. All electrodes would manage to give better hydrogen production to one another.

Hydrogen production can be higher in Sulphuric acid was at last resolved, in a short period of time. When comparing to other electrodes like Aluminium, stainless steel, copper, silver. Zinc has the highest output rate of hydrogen.

Conclusion

Hydrogen is another gas that is capable of substituting the fossil fuels. But it is a gas and has the second lowest boiling point and melting point, which makes it inconvenient for storage. So, it is generally stored in cryogenic containers. The challenge is not about generating energy, but instead about using energy to create hydrogen which will later be reconverted into energy. For hydrogen production using a different catalyst and electrodes, gives a different rate of Hydrogen.

Mostly the required incipient hydrogen and fuel cell technologies are nonetheless in their infancy compared with the subsisting conventional energy infrastructure and major investments on both public and private, will be required to commercialize the engenderment of hydrogen for energy utilization.

The results include credits to the Zn electrodes producing a higher charge per unit of hydrogen in Sulphuric acid is 90% and lower rate at the titanium dioxide is 3.8%. Finally we concluded that Zn electrode produces more hydrogen when compare to other electrodes like Aluminum, copper, silver, stainless steel (S16) and corrode quickly when compare to other electrodes.

Reference

[1] Sebastian Verhelst A, Thomas Wallner B., 2009,"Hydrogen-fuelled internal combustion engines Progress in Energy and Combustion Science" 35 490–527.

[2] Maher A.R. Sadiq Al-Baghdadi., 2004, "Effect of compression ratio, equivalence ratio and engine speed on the performance and emission characteristics of a spark ignition engine using hydrogen as a fuel" 29 2245 – 2260.

[3] Nafiz Kahramana, Bilge C¸ S. Orhan Akansua, Kadir Aydinb., 2009,"Investigation of combustion characteristics and emissions in a spark-ignition engine fuelled with natural gas–hydrogen blends" 34 1026 – 1034.

[4] k. Chakrapani, Dr. P. Neelamegam. 2011, "Optimization of fuel consumption using HHO in HDL technique verified in FPGA" Vol. 31 no.2.

[5] Biswajit Mandal et al., 2012, "International Journal of Renewable Energy Research", Vol. 2, no. 1.

[6] Biswajit Mandal, A. Sirkar, Abhra Shau, P. de, P. Ray. Apply by AJ. 1994, "Effects of geometry of electrodes and pulsating DC input on water splitting for production of hydrogen" Fuel cell electrolytes: evolution properties and future prospects. J Power Sources, 15–34.

[7] Y.F.H.L. Hongqiang Hu, 2009, "Hydrogen Production in Single chamber Tubular Microbial Electrolysis Cells Using Non-Precious Metal Catalysts," International Journal of Hydrogen Energy, 34-20, 8535–8542.

[8] M.M. Rahman, Mohammed Kamil, Rosli A. Bakar., 2011, "Engine performance and optimum injection timing for 4-cylinder direct injection hydrogen fuelled engine" Simulation Modelling Practice and Theory 19, 34–751

[9] Nafiz Kahramana, Bilge C¸ epera, S. Orhan Akansua, Kadir Aydinb, 2009, "Investigation of combustion characteristics and emissions in a spark-

ignition engine fuelled with natural gas–hydrogen blends" 34, 1026 – 1034.

[10] [10] Priscilla A. Selembo, Matthew D. Merrill b, Bruce E. Logan b., 2010, "Hydrogen production with nickel powder cathode catalysts in microbial electrolysis cells" 35, 428 – 437.

[11] Akira Fujishima_, Tata N. Rao, Donald A. Tryk, 2000, "Titanium dioxide photo catalysis", Journal of Photochemistry and Photobiology C: Photochemistry 1–21.

[12] Wiley-VCH, Weinhein, 2002, Westphal, Gisbert, Sodium Chloride in Ullmann's Encyclopaedia of industrial chemistry.