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EXTRACTION OF HYDROGEN FROM SEA WATER USING SPLITTING PROCESS FOR HYDROGEN FUEL CELL HYBRID VEHICLES

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Abstract - This document shows the required format and appearance of a manuscript prepared for SPIE e-journals. The abstract should consist of a single paragraph containing no more than 200 words. It should be a summary of the paper and not an introduction. Because the abstract may be used in abstracting and indexing databases, it should be self-contained (i.e., no numerical references) and substantive in nature, presenting concisely the objectives, methodology used, results obtained, and their significance. A list of up to six keywords should immediately follow, with the keywords separated by commas and ending with a period.

***Key Words*:** optics, photonics, light, lasers, templates, journals

1.INTRODUCTION *(Size 11, Times New roman)*

Nicolas Otto's invention of the internal combustion engine, it revolutionized the automotive industry. Later, petrol and diesel became the main fuel source for these vehicles. This technology makes Human Efforts very easy and commercialized in the market, when this technology went through the 20th century there had been many technological advancements that made it efficient and cost-effective. Thanks to this, this has become a commercial success and increasing usage in everyday life. With the help of this people can travel 1000 kilometre /mile within hours with this technology. But we know that for everything there are benefits and drawbacks. They are the high emissions of carbon monoxide and carbon dioxide, the emission rate reached extremely dangerous at the begging of the 21st century and caused the negative effect, the reason for Global Warming, Health related issues, etc. This forced Scientists, Researchers and Policymakers to focus or made them start thinking about Green Technology or the technology which can stop the adverse effect happening on Nature. Hence, the 21st Century will become the Century for Evolution in various technologies with the main focus on Automobile Sector. The new advanced technologies that emerged in the automobile industry are "**Hybrid electric vehicles**", "**Hybrid solar power automobiles**", "**Hydrogen fuel cell vehicles**", etc

1.1. What are Hydrogen fuel cell vehicles, and how it works?

A hydrogen fuel cell vehicle is a vehicle that uses hydrogen fuel for motive power. They are more efficient than conventional internal combustion engine vehicles and produce no tailpipe emissions—they only emit water vapour and warm air. FCEVs and the hydrogen infrastructure to fuel them are in the early stages of implementation. The U.S. Department of Energy leads research efforts to make hydrogen-powered vehicles an affordable, environmentally friendly, and safe transportation option. Fuel cell cars are powered by compressed hydrogen gas that feeds into an onboard fuel cell "stack" that doesn't burn the gas, but instead transforms the fuel's chemical energy into electrical energy. This electricity then powers the car's electric motors. Tailpipe emissions are zero, and the only waste produced is pure water.

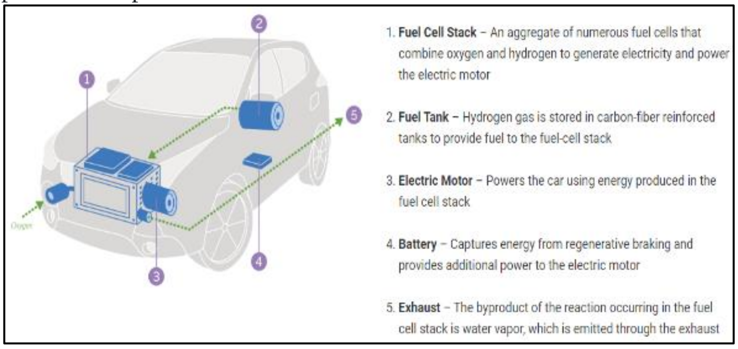

Figure 1.1 Hydrogen fuel cell vehicle

1.2. Hydrogen can be produced from a variety of domestic sources, including

- Natural gas,
- Nuclear energy,
- Biomass,
- Solar energy
- wind energy
- Fossil fuels
- Coal
- Aquatic
- Chemical reactions.
- Electrolysis

1.3. There are different types of hydrogen fuel production methods based on which domestic source we are using

- Black hydrogen
- Gray hydrogen
- Red hydrogen
- Brown hydrogen
- Turquoise hydrogen
- Blue hydrogen
- Green hydrogen
- Yellow hydrogen
- Pink hydrogen

1.4. What is Hydrogen: Hydrogen (H2) is tasteless, colourless and odourless, highly flammable and non-toxic gas at atmospheric pressure and temperature. Although it is the most abundant element in the universe, it is almost absent in the atmosphere in the form of individual molecules. Still abundant on Earth, but present as part of water-like compounds. Hydrogen burns in the air with an almost invisible bluish flame. Hydrogen is the lightest known element, about 1/15th the weight of air. Hydrogen is flammable and generates explosive gas (oxyhydrogen). Hydrogen has the lowest boiling point of all elements except helium. When hydrogen is cooled to its boiling point, it becomes an odourless, clear liquid that is 1/14th the weight of water. Liquid hydrogen is not corrosive or reactive when going from liquid to gas hydrogen expands about 840 times. Liquid hydrogen spills due to the low boiling point and low density of hydrogen. Hydrogen (H2) is the ultimate sustainable and safe energy option due to its excellent energy density of 142.351 MJ kg–1 and zero pollutant emissions.

1.5. PROPERTIES OF HYDROGEN: Hydrogen burns in the air with a pale bluish, almost invisible flame. Hydrogen is the lightest of all elements known, approximately fifteen times lighter than air. Hydrogen ignites easily and emits an explosive gas (oxy-hydrogen). Hydrogen has the lowest boiling point of any other element except helium. When cooled to its boiling point, -252.76oC (-422.93oF), hydrogen turns into a transparent, odourless liquid that is only fourteen times lighter than water. Liquid hydrogen is not corrosive or reactive. When converted from liquid to gas, hydrogen expands approximately 840 times. The low boiling point and low density of hydrogen result in liquid hydrogen spills dispersing rapidly.

Chemical Formula	H_2
Molecular Weight	2.016
Boiling Point @ 1 atm	−423.2°F (−252.9°C)
Freezing Point @ 1 atm	−434.8°F (−259.3°C)
Critical Temperature	−400.4°F (−240.2°C)
Critical Pressure	186 psia (12.7 atm)
Density, Liquid @ B.P., 1 atm	4.42 lb./cu.ft. (70.8 kg/cubic meter)
Density, Gas @ 68°F (20°C), 1 atm	0.005229 lb./cu.ft. (0.0838 kg/cubic meter)
Specific Gravity, Gas (air=1) @ 68°F (20°C), 1 atm	0.0696
Specific Gravity, Liquid @ B.P., [water=1 @ 68°F (20°C)]	0.0710
Specific Volume @ 68°F (20°C), 1 atm	191 cu. ft./lb.
Latent Heat of Vaporization	389 Btu/lb. mole
Flammable Limits @ 1 atm in air	4.00%–74.2% (by Volume)
Flammable Limits @ 1 atm in oxygen	3.90%–95.8% (by Volume)
Detonable Limits @ 1 atm in air	18.2%–58.9% (by Volume)
Detonable Limits @ 1 atm in oxygen	15%–90% (by Volume)
Autoignition Temperature @ 1 atm	1,060°F (571°C)
Expansion Ratio, Liquid to Gas, B.P. to 68°F (20°C)	1 to 845

Figure 1.2 properties of hydrogen table

1.6. APPLICATIONS OF HYDROGEN FUEL:

Hydrogen fuel is been in used for many years and many new applications have been introducedsome of them are.

- Rocket fuel
- Fuel cell vehicles
- Ships
- Aerospace industries
- Energy producing industries
- Weapons etc

2. LITRETURE SURVE:

2.1. Design for On-Site Hydrogen Production for Hydrogen Fuel Cell Vehicles at the University of Birmingham U.K. (2012):

In April 2008, the first-ever hydrogen refuelling station was inaugurated by the University of Birmingham. This refuelling station enabled Hydrogen Hybrid Fuel Cell Vehicles (HHFCV) to refill their tanks with hydrogen fuel. The hydrogen at this refuel station was of ultra-high purity and was called "Green" hydrogen. This "Green" hydrogen was provided by a third-party contractor from off-site. The major purpose of this refuelling station was to maintain low emissions of carbon dioxide and other pollutants and dangerous gases. This refuelling station aims to produce on-site hydrogen so the expenses of buying the hydrogen from a third party may be cut off completely. The process that produces ultra-high pure hydrogen commercially is water electrolysis because the hydrogen produced by this process does not need to be further purified, unlike other industrial processes. High Pressure Alternating Current (HPac) electrolyzer commonly known as the electrolytic cell is used to produce hydrogen industrially. An alkaline fuel cell uses an alkaline solution i.e., KOH solution to be used as an electrolyte in the fuel cell

2.2. The Intensification Technologies to Water Electrolysis for Hydrogen Production (2014):

Electrolysis of water is a sustainable method due to high purity of the product and simplicity of the process. The electrolysis is carried out by renewable energy i.e., wind or solar energy. The major challenge, that is being confronted, is to decrease the energy consumption by the use of electricity in large scale applications. An important parameter in the use of electricity is the cell voltage. This cell voltage depends on reaction over potential (η), ohmic voltage drop (i*ΣR) and theoretical decomposition 1111 voltage (Uθ). During the electrolysis of water, bubble dispersion in electrolyte and bubble coverage on electrodes result in high reaction over potential and large drop in ohmic voltage. This bubble effect is the major parameter that increases the consumption of electricity. The latest intensification technologies have been categorized into the following three categories

1) New electrolyte composition

- 2) External field
- 3) New thermodynamic reaction system
- The drop in ohmic voltage and reaction over potential are improved kinetically new electrolyte composition and external field. The voltage required to split water into its components is also decreased by the use of Carbon Assisted Water Electrolysis (CAWE) and Solid Oxide Fuel Cell (SOFC).

2.3. Electrochemically Fabricated NiCu Alloy Catalysts for Hydrogen Production in Alkaline Water Electrolysis (2014):

The NiCu alloy catalysts used in alkaline electrolysis are produced by electrode deposition method by varying the composition of alloy. As the deposition potential in the formation of catalysts increases, the particle size and the copper content in the surface and the bulk both increases. It has been found by electrochemical techniques and spectroscopy that the surface coverage of catalysts is a function of deposition potential. The catalytic activities of the catalysts produced are investigated by using a 6.0 M KOH solution at 298 K with the help of cyclic voltammetry. The mass activities of the catalysts produced are being correlated with the surface and bulk contents of Cu.

2.4. Recent Progress in Alkaline Water Electrolysis for Hydrogen Production and Applications (2010):

The simplest and easiest method to produce 99.99% pure hydrogen is the alkaline electrolysis of water. The modern-day challenges in the production of hydrogen are the cost, maintenance and high energy consumption. When these problems get solved, the process will become more reliable, accurate, efficient, durable and safe. The resistances in the electrolysis circuit are categorized into following categories

- 1) Electrical resistance
- 2) Reaction resistance
- 3) Transport resistance.
- These resistances have been thoroughly investigated thermodynamically and kinetically in order to minimize them. As the resistances are minimized, the efficiency of the process increases. The thermodynamic analysis helps increasing efficiencies that are based on cell voltage and theoretical energy input. The kinetic analysis defines the reaction resistance on motion of ions, concentration of alkali and active site on the electrodes. The active site on the electrodes is determined by the composition of the electrode. A quantitative relationship has been developed between current density and cell voltage that relates all the resistances including bubble resistance. Since the invention of electrolysis, different electrolysis processes have been developed to excel the efficiency of one over another. This has been done by continuous improvement in thermodynamic and kinetic analyses. Along with the efforts to improve the efficiency and other major challenges that have been described above, there is a need to reduce the number of equipment used in this process besides cost and maintenance. The future study is being done on reducing bubble formation, electrolyte additives and electrode materials.

3. Problem statement and objective

3.1. Problem statement: The main reason for doing this project is to create an alternative fuel which can replace conventional fuel. As fossil fuels produce large amount of pollution when burned. This causes the atmosphere to heat up and leads to climate change due to global warming. And as time passes by, the availability of these fuels is getting depleted and future generations may face many problems.

3.2. Objectives: In future, water will replace fossil fuels as the primary resource of hydrogen. Hydrogen will be distributed via national networks of hydrogen transport pipelines and fuelling stations. Hydrogen energy and fuel cell power will be clean, abundant affordable, reliable and an integral part of all sectors of the economy in all regions. Owing to the decrease in fossil fuel availability, the production of liquid hydrogen for the electrolysis of water can prove to be a revolution in the fuel industry.

4. PRODUCTION OF HYDROGEN FUEL PROCESS BY ELECTROLYSIS PROCESS

4.1. CONSTRUCTION:

The experiment has a simple construction set up, and simple apparatus they are

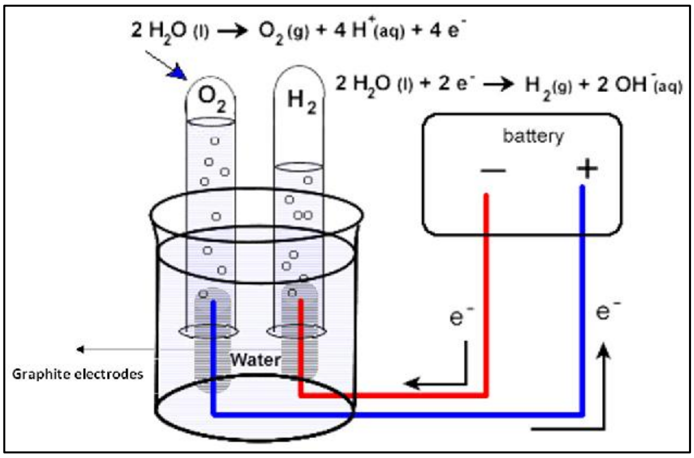

Figure 4.1 Electroless PROCESS

- **a. A plastic container**
- **b. Two 50 ml syringe**
- **c. Electric wire**
- **d. Volt meter**
- **e. DC converter**
- **f. Graphite rods**

g. **Sea water**

h. **Clear tube**

i. **Test tubes**

j. **Flame lighter for testing**

* Alkaline water splitting is one of the easiest methods for hydrogen production that has the advantage of simplicity. The major challenges in the water splitting are the reduce energy consumption, cost and maintenance and to increase reliability, durability and safety. In this regard, the electrolytic production of hydrogen is systematically studied by commercially available graphite electrodes at room temperature. The experimental results showed the rate of production of hydrogen gas was significantly affected when the reaction parameters such as effect of electrolyte concentration, temperature, applied voltage and reaction time are varied from the experimental results, it has been found that graphite is a good choice for the production of maximum hydrogen compared to various other electrodes.

4.2. Working Principle

A DC electrical power source is connected to two electrodes, or two plates (typically made from an inert metal such as graphite) which are placed in the water. Hydrogen will appear at the cathode (where electrons enter the water), and oxygen will appear at the anode. Assuming ideal faradaic efficiency, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions occur, resulting in different products and less than ideal faradaic efficiency. Splitting of pure water requires excess energy in the form of overpotential to overcome various activation barriers. Without the excess energy, the electrolysis of pure water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Pure water has an electrical conductivity about one-millionth that of seawater. Many electrolytic cells may also lack the requisite electrocatalysts. The efficiency of splitting is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electrocatalysts. Currently the splitting process is rarely used in industrial applications since hydrogen can currently be produced more affordably from fossil fuels.

In an acidic pH medium:

Anode: $2H2O = O2 + 4H+ + 4e-$ (1)

Cathode: $2H+ + 2e- = H2$ (2)

In an alkaline pH medium:

Anode: $4OH- = O2 + 2H2O + 4e-$ (3)

Cathode: $2H2O + 2e- = H2 + 2OH-$ (4)

4.3. Types of Electrodes used

There are two electrodes in an electrolysis solution: the positive and the negative electrode. The reaction that happens at each electrode is different. When the compound to be electrolyzed is in solution with the electrical current passing through it, the compound’s constituents become ionized (separate into positively and negatively charged ions). Positively charged ions (metals and hydrogen), are attracted to the negative electrode (the cathode), where they receive electrons (a process known as oxidation). Negatively charged ions are attracted towards the anode (the positively charged electrode), where they give up electrons (reduction).

4.4Material of Electrode Carbon Electrodes

Carbon electrodes are used in electrolysis due to their competence as a conductor and the number of free electrons they have available for transfer. Not only is carbon an efficient conduct, it also has a very high melting point. This means it can be used to facilitate a wide range of different reactions. Other advantages of using carbon include a relatively low cost, longevity and ease of procurement.

4.5. Working water conditions

PHYSICAL PARAMETERS

S.NO	PHYSICAL PARAMETERS	UNITS	RESULT	DESIRABLE PORTABLE LIMITS AS PER IS :10500
01	PH	—	6.85	6.50-8.50
02	ELECTRIC CONDUCTIVITY	µ.Mhos/cm	1417	-------

Table 1 PHYSICAL PARAMETERS OF WATER

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CHEMICAL PARAMETERS

S.NO	CHEMICAL PARAMETERS	UNITS	RESULT	DESIRABLE PORTABLE LIMITS AS PER IS :10500
01	DISSOLVED SOLIDS	mg/l	921	<500
02	TOTAL HARDNESS AS CaCO3	mg/l	436	<300
03	ALKALINITY TO PHENOLPHTHALEIN AS CaCO3	mg/l	Nil	Not specified
04	ALKALINITY TO METHYL ORANGE AS CaCO3	mg/l	248	<200
05	NON-CARBONATE HARDNESS AS CaCO3	mg/l	188	Not specified
06	CALCIUM AS CaCO3	mg/l	390	<187
07	MAGNESIUM AS CaCO3	mg/l	46	<123
08	SODIUM AS CaCO3	mg/l	268	Not specified
09	POTASSIUM AS CaCO3	mg/l	04	Not specified
10	CHOLRIDE AS CaCO3	mg/l	238	<352
11	SULPHATE AS CaCO3	mg/l	205	<208
12	NITRATE AS CaCO3	mg/l	16	<36
13	FLUORIDE AS CaCO3	mg/l	0.69	<1.00
14	TOTAL SILICA AS SIO2	mg/l	12.8	Not specified
15	IRON AS Fe	mg/l	0.03	<0.3
16	COLOUR	(Hazen)	Colour less	<0.5/colour less

Table 2. CHEMICAL PARAMETERS OF WATER

4.6. Material of Electrode

Carbon Electrodes

Carbon electrodes are used in electrolysis due to their competence as a conductor and the number of free electrons they have available for transfer. Not only is carbon an efficient conductor, but it also has a very high melting point.

4.7. What Happens to a Solution During Splitting When Carbon Electrodes is used

the process of electrolysis when carbon electrodes are used is similar to that achieved when other substances are used in electrodes. Positively charged ions flow towards the cathode, where they receive electrons. In contrast, negatively charged ions are attracted to the positively charged anode, where they lose electrons

4.8. Effect of weight loss on graphite

Effect of Weight Loss on Graphite Rod concerning electrolyte concentration: Reaction conditions: Dimensional of graphite rod: 80 × 20mm; Temperature: 303 K; Pressure: 1 atmf--------; Applied voltage: 12 V; Applied Current: 1.2 A; Medium: Distilled water; Reaction Time: 10 min and Distance between the electrodes: 2 cm

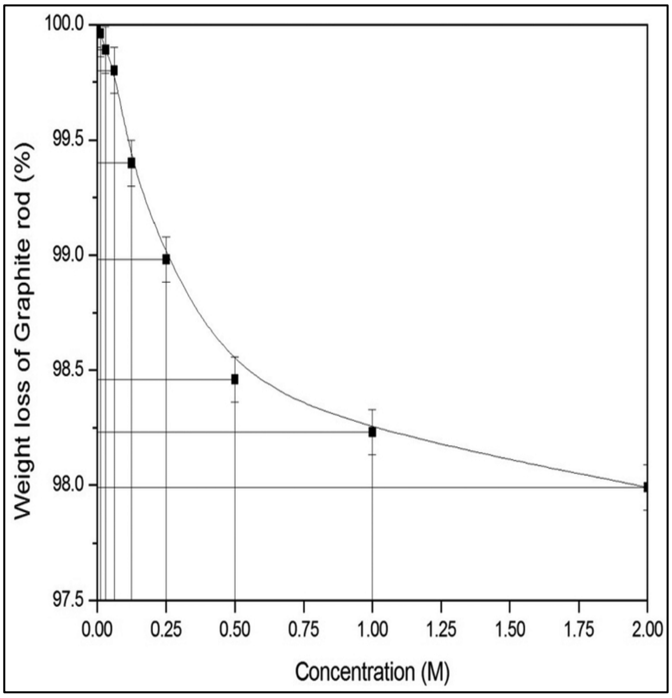

Figure 4.2 **weight loss on graphite graph**

4.9. What Will Happen If Graphite Used as Electrode

The experimental results showed the rate of production of hydrogen gas was significantly affected when the reaction parameters such as the effect of electrolyte concentration, temperature, applied voltage and reaction time are varied. From the experimental results, it has been found that graphite is a good choice for the production of maximum hydrogen compared to various other electrodes

5. ENVIRONMENTAL CONSIDERATIONS

5.1. Purpose:

In the years following World War II, environmental considerations gathered rapid importance due to some incidents involving inappropriate handling of waste material. These incidents include the Love Canal, Seveso and Bhopal tragedies which created mass awareness amongst the people about the environmental aspects. After these disasters, the focus shifted to the proper disposal of waste material and it was thought that only water resources were to be protected from pollutants. However, later it was realized that during the process of de-contamination of water, that pollutant might contaminate the air.

According to today's environmental safety regulations, it is made so that the solvent eliminated from water is absorbed by activated carbon and completely incinerated because merely shifting it from one medium to another is not enough. Environmental considerations are important in this age because of an increasing threat to the safety of the ecosystem. Increased attention of the people has made it almost impossible for the chemical industries to neglect the environmental aspects. Modern-day industries are designing processes according to the standards specified by a program known as Design for the Environment (DfE). The main goal of this program is to promote "green cleaning" and to use safer raw materials in industries. Clean water is a priceless resource which should be protected from pollutants so that it can be used in industries and also for domestic purposes. Production of fuel can also emit gases that pollute the air and this issue should also be addressed properly. The purpose of environmental consideration is to tackle the threats (acid rain, deforestation, global warming etc…) faced by the ecosystem and to properly dump the pollutants and waste products discharged from chemical plants to protect living beings and the environment.

5.2. Air Borne Emissions:

Hydrogen fuel is mainly produced from Steam-Methane reforming and also from the electrolysis of water. In the process of water electrolysis, hydrogen and oxygen gases are emitted into the air which has no such adverse effects on the environment. However, organic impurities from the evaporator blow-down which may include carbon dioxide must be dumped properly because it is a greenhouse gas.

5.3. Potential Environmental Impact of Hydrogen on the Stratosphere:

The widespread use of hydrogen fuel cells could have hitherto unknown environmental impacts due to unwanted emissions of molecular hydrogen, including an increase in the abundance of water vapour in the stratosphere (possibly by as much as ~1 part per million by volume). This would cause

- Stratospheric cooling
- Enhancement of the heterogeneous chemistry that destroys ozone
- An increase in noctilucent clouds
- Changes in tropospheric chemistry and atmosphere-biosphere interactions.

5.4. Water Borne Emissions:
Water, sanitation and hygiene have important impacts on both health and disease

Water-related diseases include:

- These are due to micro-organisms and chemicals in the water people drink.
- Diseases like schistosomiasis have part of their lifecycle in water.
- Diseases like malaria with water-related vectors.
- Drowning and some injuries.
- And others such as legionellosis carried by aerosols containing certain microorganisms.

6.0 RRESULT AND CONCLUSION

6.1. RESULT
We have conducted and experimented on the process by using a prototype setup, and we have done this experiment by using seawater (seawater sample parameters are given in the report) as our primary electrolyte. We have produced hydrogen gas as an output and tested it with the pop test. The produced gas is then compressed and converted into liquid hydrogen. Hydrogen fuel can be used in fuel cells and the latest hybrid vehicles, which use hydrogen. The above water parameters which were used in the project are attached below.

6.2. CONCLUSION
We will conclude our report by talking about the importance of liquid hydrogen as an alternative fuel source. Hydrogen is used in different walks of life. Some of the major areas of applications of hydrogen are aerospace and aircraft, refining, agriculture, chemical processing, construction (metal processing), electronics test, assembly and packaging, energy, welding and metal fabrication, flat panel displays, food, beverages, glass minerals, metals, pharmaceuticals, biotechnology, semi-conductors, automotive and transportation equipment etc. Hydrogen fuel has gained importance in the fuel and energy market in recent years. Hydrogen produced worldwide, as of 2005 valued at an astonishing figure of about $135 billion per year. The demand for liquid hydrogen is increasing with every passing day and as a result, alternate sources for the production of liquid hydrogen have gained massive importance. As of the year 2012, the cost of liquid hydrogen ranged between $1.00/pound to $1.40/pound. The process that we have selected for the production of hydrogen from the electrolysis of water is considered the most appropriate one. It is so because this process is the most efficient and produces a relatively pure product. As mentioned earlier, the efficiency has greatly increased from 58-72% to 85-90% in just one century. Moreover, this process is also very environmentally friendly because there are minimal greenhouse gas emissions from this method. Liquid hydrogen production from the electrolysis of water can be made more feasible if the storage techniques are improved.

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7. REFERENCE

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[6]A step closer to sustainable energy from seawater

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[8] EXAMPLES OF ELECTROLYSIS WITH DIFFERENT SUBSTANCES

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[10]https://aquarius.oceansciences.org/cgi/ed_act.htm?id=47

[11] Electrolysis extended content [GCSE Chemistry only]

[12] Electrolysis of Water
The biological electrolysis of water through photosynthetic organisms is the breakdown of water to oxygen and hydrogen.