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A Review on Production of H_2 and O_2 gas by Electrolysis Process using Artificial Photosynthesis Method

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Abstract

The purpose of Artificial Photosynthesis process is to make other methods of the photosynthesis process in a manual way, handled and operated by humans [19]. The sole objective of this process is to feed oxygen gas and also to reduce carbon pollution from the environment and surrounding where we live [9]. In order to achieve this, many researchers have worked in recent times and certain fruitful information is available using different methods. The most common method is splitting of water molecules using electrolysis process which mimic the original natural process [2]. This method adopts different electrodes like Platinum [2], Aluminium, Titanium, and electrolytes like salt, chlorophyll powder, grapheme etc. In recent time NASA developed another method for producing Hydrogen Gas and Oxygen Gas is by using Solid Oxide cell (SOEC) [5]. But it's quite costly due to electrodes price. Considering and comparing all methods, in the present research we adopted prototype which may replicate the first process of Photosynthesis. In this method we use simple electrolysis process for the production of Hydrogen and Oxygen where chlorophyll is going to be used as an electrolyte. An experimental analysis showed number of oxygen present within the 100 ml of solution was 5.5 mg per litre and amount of hydrogen obtained was approximately 550 ppm/s. In present work IC engine is also used to run and perform, using oxygen produced with water splitting method.

Keywords

Carbon Reduction, Artificial Photosynthesis Process, Water Splitting Process, Diesel Engine

Review Analysis of various methods

An exhaustive literature review of different published research papers is made using various parameters and that has been compared to work out some amicable solution with method adopted by present researchers. This analysis gives insight of different objective and methodology adopted by different researchers. It also summarises their observations and specific conclusions based on their methodologies. This has helped the present research to simply his work and make it more qualitative in terms of the output expected and finally drawn.

Here in table 1.1. Review of various published researches is being made for their objectives, parameters chosen and methodologies adopted mainly.

Table 1.1 Review Analyses of Objectives, Parameters and Methodology Selected

Sr.No	Title	Journal	Objectives	Parameters	Methodology
LR#1	Apparatus and Method for Enhancing Engine Performance and Cleaning the same [10]	World Intellectual Property Organization International Bureau	To enhance performance of IC engine by supplying oxygen and hydrogen as fuel instead of fossil fuels	Efficiency, Reliability, pollution control	Electrolysis process is used for splitting of atoms of water so that Hydrogen and Oxygen is obtained in gaseous form.
LR#2	Artificial Photosynthesis: Solar Splitting of Water to Hydrogen and	American Chemical Society	To convert sunlight, water and carbon dioxide into oxygen and reduced species that can be used as	Fuel production rate, Cost effectiveness, Thermal	water splitting process using solar energy Photo - electrochemical method use for water treatment, destroying organic wastes and removing

	Oxygen [19]		food and fuel and to produce more fuel	reactions, Amount of energy obtained	metal particles
LR#3	Artificial Inorganic Leaves for Efficient Photochemical Hydrogen Production Inspired by Natural Photosynthesis [14]	Advanced Materials	Generation of hydrogen fuel through water splitting using sunlight. To control carbon-based gases from the surroundings	Light harvesting efficiency Charge separation Photochemical hydrogen production	To construct an artificial leaf by mimicking the complex structure of natural leaf which can replace the natural photosynthetic pigments with artificial catalysts and construct efficient light-harvesting and photochemical hydrogen production
LR#4	Development of Sunlight Driven Water Splitting Devices towards Future Artificial Photosynthetic Industry [9]	Chem-Engineering	To develop Photo-electrochemical water splitting device using sunlight which make H_2/O_2 gas separation	Solar energy, Light absorbing photo-catalyst panels, Gas separating device	Direct solar energy incident on water molecules which gives $H_2 + ½ O_2$. Method of Separation of H2 & O2 gases. Synthesized carbon atoms combined with hydrogen atom and hence hydrogen fuel can be produced
LR#5	Solar fuels and Artificial Photosynthesis [6]	Royal Society of Chemistry	To introduce methods of Artificial Photosynthesis to raise awareness of the concept of solar fuels and show their potential to long-term energy independency.	Cost effectiveness, Efficiency, Reliability and Durability	Fischer-Tropsch process in which hydrogen combines with carbon dioxide and hydrocarbon products are obtained which can be used as fuel.

LR – Literature Review Number

In table 1.2 comparative review of Research Process followed, Results received and Conclusion drawn were made of papers selected in table 1.1.

Table 1.2 Comparative Review of Research Process followed, Results received and Conclusion drawn

Sr.No	Title	Research Process Observed	Results	Conclusion
LR#1	Apparatus and Method for Enhancing Engine Performance and Cleaning the same [10]	Stage-I: Electrolysis process is used for splitting of atoms of water so that Hydrogen and Oxygen is obtained in gaseous form. Stage-II: These two gases are sent to I.C. engine and during its compression stroke the H_2 and O_2 gas atoms get heated and in power stroke when diesel is injected, they combine with each other and gets ignited engine gets operated.	Engine is operated on dual fuel due to which the emissions of NOx and COx gases reduce. Process consists of electrolysis process which consumes high amount energy in vehicle.	Efficiency of IC engine increases, use of fossil fuel reduces and pollution can also reduce.

LR#2	Artificial Photosynthesis: Solar Splitting of Water to Hydrogen and Oxygen [19]	Water itself cannot absorb maximum amount of radiation within the solar spectrum, one or more light-absorbing species must be used to transduce the radiant energy to chemical (or electrical) energy in the form of electron hole pairs, i.e., to the oxidizing and reducing potential needed to drive the reaction. An alternative system involves the semiconductor photovoltaic cell immersed directly in the aqueous system.	The oxidative trapping must occur faster than radiative or nonradiative relaxation of the sensitizer excited state. Each of the intermediate charge relays must be stable in both the oxidized and reduced states so that the sensitizing dye can be multiply recycled.	Turnover efficiency could be substantially improved by substituting a family of newly synthesized viologens that are resistant to catalytic hydrogenation and by replacing the hydrogen evolution catalyst with colloidal platinum.
LR#3	Artificial Inorganic Leaves for Efficient Photochemical Hydrogen Production Inspired by Natural Photosynthesis [14]	Complex structures bring out multiple scattering and light absorption within the leaves, resulting into enhanced light-harvesting. After light-harvesting process, charge separation takes place through which h^+& e^- ions separates and thus leading to photochemical hydrogen production.	The overall visible light absorbance intensities are improved and the band gap absorption starts at the edge of the UV and visible light.	The AIL1-TiO2 produces H2 at a rate of about 1.3 mmol h^{-1} in pure water.Whereas, with 20% aqueous methanol, rate of H2 produced is around 141.05 mmol h^{-1} which is 108 times higher than that produced by pure water.
LR#4	Development of Sunlight Driven Water Splitting Devices towards Future Artificial Photosynthetic Industry [9]	photocatalyst panels chained with pipes for water feed are kept under direct solar rays which results into products as 2H2 + O2 mixture. In transportation tubes connected to the gas separation plan, both the gases are separated using some gas separating device. Separated H2 gas is supplied to the synthetic plant, which is also fed with exhaust CO2. The tests were conducted with solar simulator 1 kWm,2 AM 1.5 G Irradiation.	For photocathode durability tests, the data were recorded at 0.6 V vs. RHE, which is the median potential of 0 V and 1.23 V vs. RHE, representing the practical operation crossover potential of the dual-electrode cell.	Experimental results indicates that, more stable & light absorbing photo-catalysts will be faster and accurate.
LR#5	Solar fuels and Artificial Photosynthesis [6]	Stage-I: capturing of sunlight and storing. Stage-II solar energy used to separate Hydrogen and Carbon dioxide and transferring them to separate unit. Stage-III Hydrogen is synthesized and transferred to Hydrogen station where it can be used as fuel and some of the Hydrogen is also sent to Power stations to generate electricity Stage-	As a result of the process the amount of Carbon dioxide can be reduced from the atmosphere gradually and significantly.	Usage of Hydrogen as fuel is one of the best alternatives to other gasoline products. Comparing to other methods it can be said that this process will have more efficiency with less

		IV: Rest of Hydrogen is combined with carbon dioxide to form Hydrocarbon products, again which can be used as fuel.		costing of production.

Discussion of review papers cited and comparison with present work

The present review paper aim at the objective of using water splitting process as an artificial photosynthesis – an electrolysis process. Definitely it is a mimic of the natural photosynthesis process occurs in the nature widely. In the present work, we made prototype model for artificial photosynthesis process. Here electrolysis process is used for generation of hydrogen and oxygen molecules. The electrolyte powder used is chlorophyll. The generated gases later on used to run Diesel engine successfully. Definitely we use the gas sensors to collect the bottled gas mainly for hydrogen.

The parameters used were in line with the literature review made in above tables. The objectives were to collect gases in certain quantity and to run IC engine at par. The collected gases were measure in ppm unit and were sufficient in quantity run a Diesel IC engine for continuously for 45 minutes to 60 minutes.

Design and assembly were generated with exhaustive study of published data in the recent times. All care taken while making calculations for all the components at inlet and outlet section, for collecting of gas devices and monitoring of gas flow also, so that transmission losses can be reduced. Figure-1 indicates the general layout of experimental set-up for the production of hydrogen and oxygen gases.

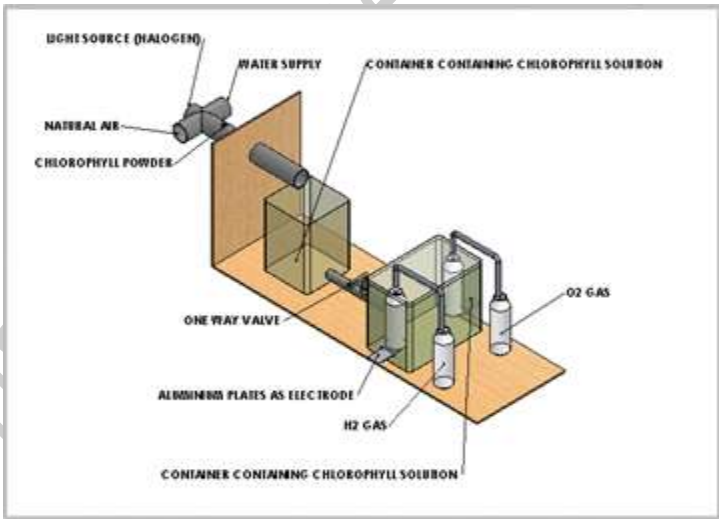

Figure-1 General Layout Experiment Set-up for Gas Production

Diesel Engine was run using the gases produced with this artificial photosynthesis process. The sole objective of this application was to establish the fact that with use of these gases, diesel engine emits less pollution and performs efficiently. All care has been taking to maintain temperature and amount of heat generation to have sufficient power generated.

Summary

The amount of oxygen produced in the 100 ml of solution was 5.5.mg/l and amount of hydrogen obtained is approximately 550 ppm/sec. It was observed that proportion of gas liberated increases, if temperature of powder, amount of water and temperature of water supplied increases. By considering the above given facts and data of review analysis, a diesel engine can be run easily

using Hydrogen and Oxygen Gases. It increases the efficiency of engine and reduces the exhaust gas emissions [10].

The whole process includes mimicry of natural photosynthesis, then after a simple electrolysis of chlorophyll solution (kind of water splitting process) used for separating hydrogen & oxygen gases from the solution containing chlorophyll as a catalyst. Its application as a dual fuel engine running on Diesel + H_2 gas + O_2 gas based on the principle of injecting diesel as primary fuel and H_2+O_2 gases as secondary fuel instead of air. This leads to reduction in exhaust gases and also increasing efficiency of the diesel engine by 5-10%.

Hence, it can be summarized from the experimental results and observations of various literature that artificial photosynthesis including electrolysis process can be an economic, efficient and clean energy process for the production of gases such as H_2 & O_2. These gases can be used as an alternative fuel in future with other applications as well [19].

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