ARTIFICIAL PHOTOSYNTHESIS FOR PRODUCTION OF HYDROGEN FOR FUEL AND ITS POSSIBLITIES IN FUTURE

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ABSTRACT

Purpose: The objective of this paper is to present the artificial photosynthesis for the production of hydrogen for fuel and by this way promote the renewable energy as the major hope of energy for the future.

Methodology/approach: Artificial photosynthesis for production of hydrogen as the fuel is actually the process in which we split the water molecules into hydrogen and oxygen. We will use silicon plate as an artificial leaf, which is one sided coated with phosphorous and cobalt which produced oxygen another side coated with zinc, nickel which produced hydrogen.

Findings: For the future purpose fuel is the major thinkable and talking point. As per seeing the limitation of fossil fuel it is very necessary to find it's alternate. Renewable energy is the very much possible and major alternate source of energy for the future . The proposed paper shows the future in renewable energy and gives us the another option of renewable energy which is hydrogen as the fuel.

Practical Implications: The proposed thesis attempts to use the silicon plate as the artificial leaf. By the photolysis process we will split the water into oxygen and hydrogen. Also it will mimic the carbon di oxide gas. This will further increasethe reliability of the renewable energy and also help in the management of the welfare of environment management.

Key Words*: Photosynthesis, Solar energy, Renewable energy, Silicon Plate, Hydrogen gas production.*

1. INTRODUCTION

Renewable power is power derived from herbal resources, together with renewable sunlight, wind, rain, tides, and geothermal power.hgg The universe is largely powered by hydrogen gas as fuel. The Solar System gets its energy from hydrogen combustion in the Sun. This makes hydrogen a long term dependable source of energy that can meet any conceivable large scale demand. Currently the world population is increasing at a fast rate and so is the demand for energy. Indeed, it is predicated that the world population is expected to reach 11 billion people in the year 2100 . The current population is just above 7.7 billion people. This will lead to high demand for energy among other resources. The developing countries are already facing enormous problems to produce enough energy due to climate change and rising environmental concern on the use of fossil fuels. Clean cheap energy sources are not easy to find. Any country's energy production has a direct impact on its economic development. The world is currently heavily reliant on fossil fuels such as coal, natural gas and oil. These fossil energy sources have been directly associated with global warming, air pollution and many respiratory diseases. Furthermore, oil and gas are localized energy sources; hence their availability is heavily dependent on local political situation.

The greatest challenge the whole world is facing is to produce cheap renewable energy that can be stored easily without causing any adverse environmental effects. Of course the most abundant cheap, clean, renewable energy source is sunlight. Plants, since time memorial have harvested this energy to produce their own food and as well as food for animals. Mimicking the processes that plants use to produce food, it is possible to use the same sunlight energy to produce abundant environmentally friendly renewable energy that can easily be stored.

Photosynthesis is a photo-chemical process by which photons and charges in semiconductors such as chlorophyll *a* and chlorophyll *b* interact to split water to produce oxygen and hydrogen. The hydrogen will normally combine with carbon from carbon dioxide to form sugars. Photolysis is the splitting of water into hydrogen and hydrogen protons by light. Photosynthesis occurs in nature in green plants, algae and cyano bacteria. Artificial photosynthesis mimics the natural process of photosynthesis and also seeks to extend the natural process.

Sunlight is part of electromagnetic radiation, which is emitted by the sun. The amount of sunlight reaching the earth's surface can be calculated from the eccentricity of the Earth's elliptic orbit and the attenuation by the Earth's atmosphere. The carrier of sunlight energy is the photons. To efficiently utilize sunlight energy to produce renewable energy, it is very important that these high energy photons are directed to light absorbers that can then create a charge separation between excited electrons and holes. Separation of electrons and holes from exactions is used in photovoltaic cells to generate voltage and current, hence electricity. Although it is possible to generate electricity in this way, large scale storage and hence portability of this energy is a challenge. Because of this problem, people are still turning to fossil fuels. Instead of using the photons to directly produce electricity, the harvested solar energy can be converted to chemical energy, such as hydrogen. This stored chemical energy can later be used to produce electricity. This will help overcome the current challenge.

Many researchers have managed to split water into hydrogen and oxygen by electrolysis using high voltage electricity of the order of 3 x 1024 V/mole to break the bond energy (493 kJ/mole) of water molecules at very high cost, generally unsustainable for large scale production of hydrogen. This study proposes the use of cheap mode of hydrogen gas production such as the use of cheap organic polymers such as Polyaniline in the place of chlorophyll. Chlorophyll is generally unstable polymer when used in vitro hence the use of other polymers. Polyaniline has high environmental stability, easy polymerization and low cost of monomers. The advantages of using sunlight are that it is free and abundant. It is readily available in most parts of the world. Water is also abundant in oceans. One of the objectives of this study is to suggest affordable and effective photo catalysts. This will in turn lower the cost of harvesting hydrogen gas from water and hence be viable for large scale production. In this paper a novel way of harvesting hydrogen gas by using

sunlight to split water (H2O) into hydrogen gas and oxygen gas with the help of two photo catalysts is proposed.

Furthermore, the design of the model artificial photosynthesis device that can be used for large scale production has been described. The hydrogen gas can be used for many purposes including as fuel to power machines and drive economies of the world. The combustion of hydrogen in air as fuel is environmentally friendly as it produces water as a byproduct with no carbon dioxide. Currently there is a growing demand for hydrogen as a source of energy for automobiles such as cars, buses, scooters, aero plane, trams, trains, ships, rockets, trucks, and others.

2. METHODOLOGY

(a) Artificial Photosynthesis Process

Artificial photosynthesis starts with the process of absorption of photons that excite electrons in the semiconductor. The anode photo catalyst receives the excited electrons then interacts with the adsorbed water molecules. Two water molecules are split by the extraction of oxygen atoms by the anode as four hydrogen protons and four electrons are set free. The hydrogen protons are attracted to the cathode photo catalyst. The process involves redox reactions.

(b) Stages of Artificial Photosynthesis Process

Artificial Photosynthesis involves four stages in its process-

i. Light harvesting: the collection of light particles (photons) by antenna molecules and the concentration of the collected energy in a reaction centre.
ii. Charge separation: at the reaction centre, the collected sunlight is used to separate positive ('holes') and negative (electrons) charges from each other.
iii. Water splitting: positive charges are directly injected into catalytic centre's where they are used to split water into hydrogen ions (protons) and oxygen.
iv. Fuel production: electrons from step 2 are given more energy from new photons and subsequently combined with the hydrogen ions and possibly CO_2 to produce either hydrogen or a carbon-based fuel.

3.WORKING PROCEDURE

Artificial photosynthesis as a chemical process replicates natural photosynthesis to reduce anthropogenic carbon dioxide (CO_2), increase fuel security, and provide a sustainable global economy. Because of the development of some suitable technologies, we can develop artificial photosynthesis using artificial leaves for the efficient conversion of solar energy into H_2 and other fuels. This method may be a potential technology for H_2 production by mimicking natural photosynthesis by green leaves. Therefore, research has been carried out to harvest solar energy to produce H_2 by artificial photosynthesis. In artificial photosynthesis, the artificial leaf must be able to use sunlight and water to reduce CO_2 and water into H_2. Hence, artificial photosynthesis has created great interest owing to the employees photo electrochemical (PEC) to use sunlight to produce solar fuel. In practice, solar-driven electrochemical fuel generation needs the integration of light-absorbing and electrochemical components able to separate product fuels.

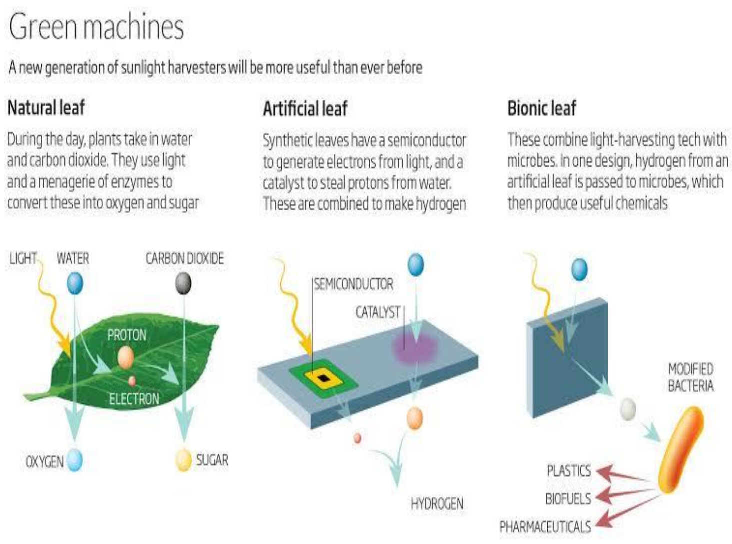

Fig.3.1:Comparison between Natural Leaf , Artificial Leaf and Bionic leaf

In artificial photosynthesis, model molecular systems, electron donor and acceptor assemblies, solar energy conversion by photo-induced charge separation, examination of photo electrochemical cells to convert solar energy into fuels, light-harvesting component, charge separation, and catalysis in photosynthesis have been compared with natural photosynthesis. The three key components for solar energy conversion in artificial photosynthesis are light harvesting, charge separation, and catalysis, a light-dependent reaction is required to mimic photosynthesis. Hence, artificial leaves were constructed by adding catalysts to a light-harvesting silicon-based semiconductor to split water. Those silicon

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semiconductors in artificial leaves may be considered photosynthetic membranes in natural photosynthesis. The silicon junction harvests sunlight and converts it into a wireless current through Si. Then, Co-OEC is integrated with Si that functionalizes single-junction PEC. Several photochemical reactions that occur in this solar cell generate the photo voltage used for the water-splitting reaction to generate H_2. In addition, electro catalyst have been designed for a light-driven charge separation system for solar fuel production. Based on the current situation, the concept of an artificial leaf has been developed as a source of clean fuel. An artificial leaf can be developed using a silicon-coated sheet that splits water into hydrogen and oxygen. Silicon has become an attractive material with which to design an artificial leaf because silicone is cheap and abundant and such cells can capture and store energy. Although the development of an artificial leaf is still a scientific challenge, some concepts have been developed to overcome technical difficulties. To overcome those difficulties, some researchers have focused on artificial leaves for artificial photosynthesis to generate clean hydrogen. Hybrid strategy for solar water splitting based on dye-sensitized photoelectrosynthetic cells , by proposing natural to artificial photosynthesis with artificial photo catalyst, hybrid photo catalysts for water oxidation/proton reduction and hydrogen evolution, as well as construction of complete photo catalytic system for hydrogen and oxygen evolution from water, used a photovoltaic reactor for artificial photosynthesis, based on water electrolysis to produce high-energy hydrogen atom. An artificial photosynthetic system using TiO_2 was developed that has the features of photosynthesis to overcome the challenge of solar-driven water splitting and CO_2 reduction. In addition, the photo reduction of CO_2 into hydrocarbon fuels (CO and CH_4) has been demonstrated, which solves the architectural model of artificial photosynthesis to produce solar cells, fuel cells, or battery electrodes.

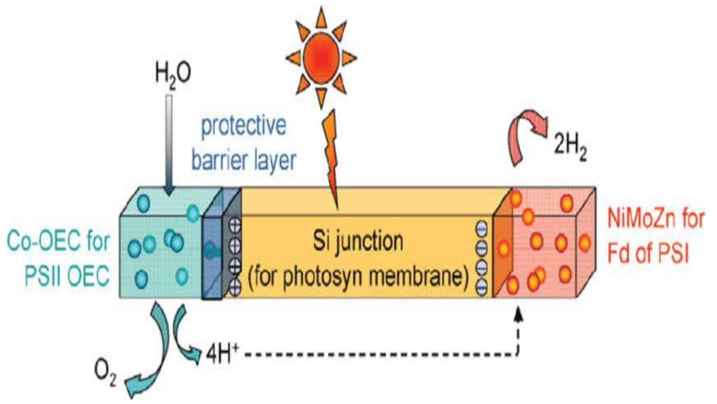

Fig.3.2:Construction of an artificial leaf. The photosynthetic membrane is replaced by an Si junction that performs light capture and conversion to a wireless current.

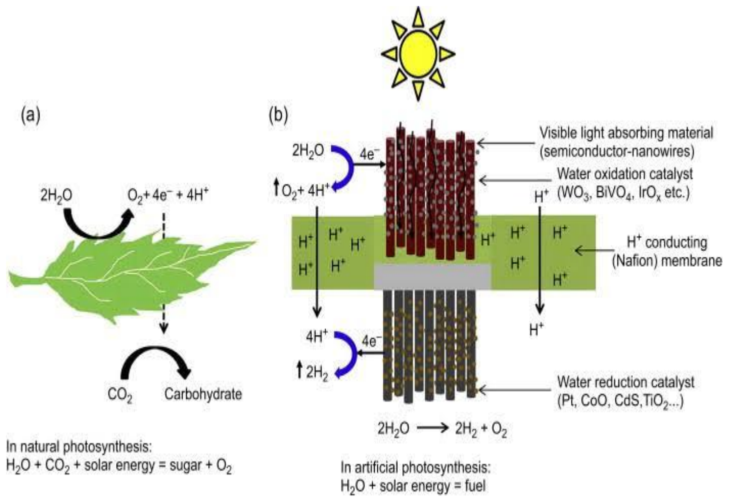

Fig.3.3: Schematic illustration of natural photosynthetic system (NPS) and artificial photosynthetic system (APS). (a) Basic process of photosynthesis in NPS. (b) Structural design of artificial photosynthesis in APS. In APS, electrons and are passed through a proton-conducting membrane, where protons are reduced to H_2.

4. BENEFITS OF ARTIFICIAL PHOTOSYNTHESIS PROCESS

i. The main benefits of artificial photosynthesis is to produce the hydrogen fuel that will be energy efficient and carbon neutral. It will not add any green house gases into the atmosphere. On the other hand artificial photosynthesis may actually help to mop up large amounts of carbon dioxide from the air to produce liquid fuel.

ii. Mimicking photosynthesis to create fuel. Producing a fuel that is strong enough to power vehicles from natural CO2, water and sunlight

iii. The process of artificial photosynthesis makes carbon storage more economically efficient, as the carbon dioxide can be used to produce products available for purchase. Creating an endless, inexpensive supply of clean fuel gas has the potential to create more than one type on fuel.

5.BENEFITS OF HYDROGEN AS FUEL

Hydrogen can be produced from diverse domestic resources with the potential for near-zero greenhouse gas emissions. Once produced, hydrogen generates electrical power in fuel cell, emitting only water vapor and warm air. It holds promise for growth in both the stationary and transportation energy sectors.

- **Energy Security**
  Hydrogen can be produced domestically from the resources like natural gas, coal, solar energy, wind and biomass. When we used to power highly efficient fuel cell electric vehicles, hydrogen holds the promise to helping in conservation of petroleum and diversifying our transportation energy options. Actually hydrogen is becoming the new setup for the future fuel.

- **Public Health And Environment :-**
  About half of the U.S. population lives in areas where air pollutions level are high enough to negatively impact public health and the environment. Emissions from gasoline and diesel vehicles- such as nitrogen oxide, hydrocarbons and particulate matter are a major source of pollution. Hydrogen power full cell electric vehicles emit none of these harmful substance only water (H_2O) and warm air.

- **Fuel Storage**
  Hydrogen's energy content by volume is low. This makes storing hydrogen a challenge because it requires high pressure , low temperature , or chemical process to be stored compactly. Overcoming this challenge is important for light duty vehicles because they often have limited size and weight capacity for fuel storage.

- **Production Costs**
  To be competitive in the market place , the cost of fuel cells will have to decrease substantially without compromising performance. From at least one original equipment manufacturer , the predicted cost of mass produced fuel cell electric vehicle could be similar to the cost of there hybrid counterparts by 20-25 . Unlike a battery , where most of the cost comes from the row materials used to make it the most expensive part of a fuel cell is in manufacturing the fuel cell stake itself- not the materials to produce3 it . The cost to build and maintain hydrogen stations also needs to decrease from the market to be able to support a hydrogen economy.

6.CHALLENGES OF ARTIFICIAL PHOTOSYNTHESIS

Artificial photosynthesis uses sunlight to create high- value chemicals from abundant resources. It is seen as the most promising method for sustainable fuel and chemical production.

i. Splitting water into H_2 and O_2 involves integrated systems for light harvesting and catalytic conversion. The stability and performance of the photo anode material has to be improved.
ii. Optimized catalyst are needed for the conversion of CO_2 to products like CO, methane, or ethylene. It is challenging to find the right transition metal catalyst for each desired reaction, balancing activity, selectivity, and stability. Approaches to optimize the catalyst include nanostructuring and using bimetallic catalyst like Au- Cu systems.
iii. For the catalyst conversion of renewable H_2 to various species, it is crucial to efficiently couple the photosynthetic device with other fields in catalysis.

7.CONCLUSION

The outcome of the work is eliminates or reduce the drawbacks or losses occurs of flaws of this project. Also I tried to find out the best possibilities of this project in the India. I tried to sought out the limitations which comes in the way of the production of hydrogen in the minimal expenditure and also its easy setup. I was also looking to find all the possible ways to take this project from laboratory to the industrial level.

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9. REFERENCES

[1] Robin Purchase, Huib de Vriend and Huub de Groot. Editors: Paulien Harmsen and Harriette Bos : Artificial Photosynthesis (For the conversion of sunlight to fuel).
[2]Kalonga, RodrickS. Katete, Ededias Musonda, Richard Mwenya, Luke N.K.Zulu , University Of Zambia : Artificial Photosynthesis for Production of Hydrogen Gas for Fuel.
[3]Artificial photosynthesis for production of hydrogen peroxide and its fuel cells, Biochimica et Biophysica Acta (BBA) – Bioenergetics, Volume 1857, Issue 5, May 2016.
[4]Corey Baird : Artificial Photosynthesis : Submitted as coursework for PH240, Stanford University, Fall 2016, December 5, 2016.
[5]James Barber and Phonge : From natural to articificial photosynthesis journals, published : 06 April 2013 : The Royal Society Publishing.
[6] University Of Michigan : Harvesting clean hydrogen fuel through artificial photosynthesis :- Science News.
[7] L. Hammarstrom, "Artificial Photosynthesis and Solar Fuels." Acc. Chem. Res. 42, 1859(2009).