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# Study on splitting of water for production of hydrogen gas using solar energy.

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**Abstract**

Hydrogen is a coveted gas: industry uses it for everything from removing sulfur from crude oil to manufacturing vitamins. Since its combustion does not emit carbon dioxide into the atmosphere, there is some belief that it could even fuel a potential "hydrogen economy"-an energy-delivery system based entirely on this one gas. In space, it is the fuel which drives the energy output of stars. But since there is no abundant supply of hydrogen gas that can be simply tapped into, this lighter-than-air gas has to be mass-produced. The choice of water as a raw material to produce hydrogen using sun light gives the impression of an ideal novel approach to supply clean energy. The design of efficient systems for splitting water into hydrogen and oxygen, driven by sunlight is among the most important challenges facing science today, underpinning the long term potential of hydrogen as a clean, sustainable fuel.

**Keywords:** Hydrogen fuel, solar energy, Sustainable fuel.

## INTRODUCTION

Hydrogen fuel is a zero-emission fuel which uses electrochemical cells, or combustion in internal engines, to power vehicles and electric devices. It is also used in the propulsion of spacecraft and can potentially be mass produced and commercialized for passenger vehicles and aircraft Hydrogen fuel can be produce through various method . it can be done by electrolysis ,thermolysis,photolysis of water. Water splitting, in which water is decomposed into its component protons, electrons, and oxygen, occurs in the light reactions in all photosynthetic organisms. Some such organisms—including the alga *Chlamydomonas reinhardtii* and cyanobacteria—have evolved a second step in the dark reactions in which protons and electrons are reduced to form $H_2$ gas by specialized hydrogenases in the chloroplast. Efforts have been undertaken to genetically modify cyanobacterial hydrogenases to efficiently synthesize $H_2$ gas even in the presence of oxygen. Efforts have also been undertaken with genetically modified alga in a bioreactor to produce hydrogen by process of photosynthesis in absence of sulphur.

## METHODS

### Water splitting routes using solar energy

The choice of water as a raw material to produce hydrogen using sun light gives the impression of an ideal novel approach to supply clean energy. A variety of approaches have been studied to achieve this important goal including indirect or direct approach. There are four basic pathways for producing hydrogen by water splitting using solar energy:

### Electrochemical

This is a method of hydrogen production by electrolyzing water using D.C. electricity. This method uses an electrolysis cell to produce hydrogen and oxygen from water. The cell consists of two electrodes immersed in an electrolyte (water plus a dissolved conducting chemical) and connected to a direct current power supply. When sufficient potential (1.23 V plus over voltage) is applied between the electrodes to cause a flow of current, oxygen is liberated at the anode and hydrogen at the cathode. The net, overall effect is to decompose water into its elemental components, hydrogen and oxygen. The electrochemical reaction taking place can be described as follows:

$$\text{Cathode:} \quad 4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$$
$$\text{Anode:} \quad 4OH^- \rightarrow 2H_2O + O_2 + 4e^-$$

In this method the solar energy is first converted to D.C. electric power by different means and then to hydrogen through electrolysis.

### Thermochemical

Thermochemical approach is based on the use of concentrated solar radiation as high-temperature process heat for driving an endothermic chemical transformation. There are five thermochemical routes for solar hydrogen production as depicted in figure 1. Water is used as raw material for the solar thermolysis and the solar thermochemical cycles. Fossil fuels are used for the solar cracking, and a combination of fossil fuels and H2O is used for the solar reforming and solar gasification. All of these routes involve endothermic reactions that make use of concentrated solar radiation energy as the source for required high-temperature process heat.

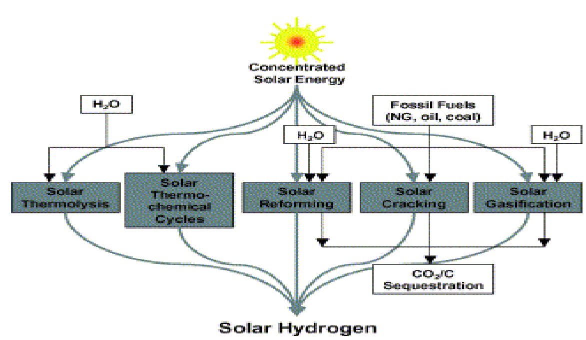


Fig 1. Five Thermochemical routes for the production of solar hydrogen

Although conceptually simple, the above pathways has been impeded by the need of a high-temperature heat source at a temperature above 2500 K for achieving a reasonable degree of dissociation, and also needs an effective technique for separating $H_2$ and $O_2$ to avoid explosions.

### Biological

In nature, only bacteria and algae have the capability of hydrogen production. Amongst these organisms, those currently selected for research are anaerobic bacteria, photosynthetic bacteria, cyanobacteria and green algae.

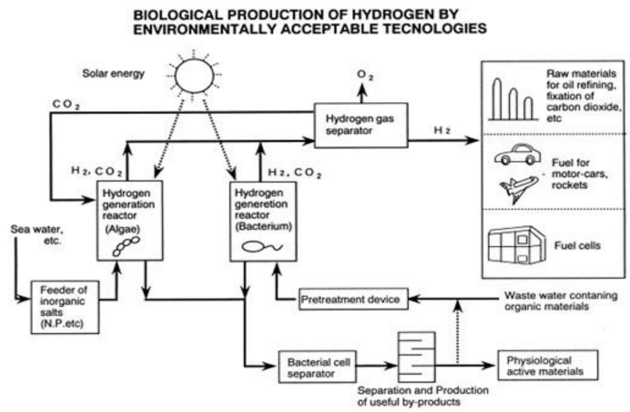


Fig 2. Concept of biological hydrogen production and utilization

Green algae and cyanobacteria directly decompose water to hydrogen and oxygen with light energy.

This is the process through which the earth obtained oxygen in the distant past. The reaction requires only water and sunlight and is very attractive from the viewpoint of environment protection. However, naturally born organisms that carry out this process showed rather low efficiency of hydrogen production due to the complicated reaction system, which remains to overcome the large free energy (+237 kJ/molH2). For the aspect of future applications, this methodology needs many improvements.

### Photochemical

Photons in solar radiation, having wavelengths shorter than a certain value in the ultraviolet range can be absorbed by water molecules under certain circumstances, and release hydrogen. This phenomenon, photolysis, could be used to produce hydrogen from the sun's rays or photons. Photons in the ultraviolet region of the radiation spectrum possess the energy needed for the direct photolysis of water. However, most of the ultraviolet radiation is absorbed in the upper atmosphere mainly by water vapor. Consequently, the intensity of the solar radiation reaching the earth is very low (about 5% of all the solar energy) in the ultraviolet region of the spectrum, but its high in the visible region. On the other hand, water is almost transparent to the visible light. Hence, photocatalysts must be used for the photolysis of water on earth. The function of such a catalyst is to absorb the solar radiation and then transmit the energy to water in order to decompose it. There are two photochemical techniques for direct water splitting using sunlight.

First technique is photoelectrochemical cell. The photoelectrochemical cell consists of two electrodes made of TiO2 and Pt, for example. These electrodes are immersed in an aqueous electrolyte and are separated by a porous membrane. Hydrogen and oxygen are evolved at Pt and TiO2 electrodes respectively and electric current flows in a circuit between these electrodes. A schematic illustration of the photoelectrochemical cell is presented in figure 3

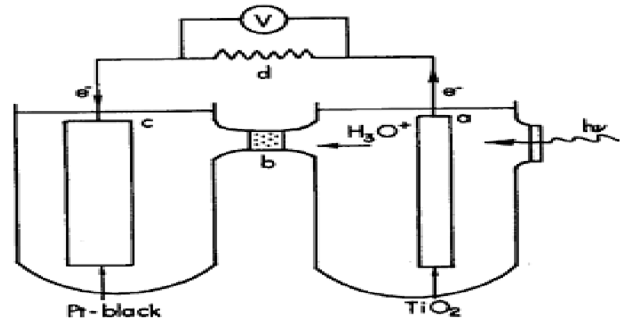


Fig 3. Schematic representation of photoelectrochemical cell

The reactions taking place in each of the electrodes are as follows:

**At the $TiO_2$- electrode:**

$$TiO_2 + \text{photon} = 2e + 2p \qquad \text{(i)}$$

$$2p + H_2O = 2H^+ + O_2 \qquad \text{(ii)}$$

**At the Pt- electrode:**

$$2H^+ + 2e = H_2 \qquad \text{(iii)}$$

In the above process, electrons (e) and positive holes (p) are produced at the TiO2-electrode. Then electrons and protons migrate to the other electrode via the circuit and electrolyte respectively. At the Pt-electrode, the reaction given by Equation (iii) takes place and hydrogen evolves.

Second technique is photocatalysis, where the attempts to drive the water splitting reaction by photo-induced molecular transformations or reactions take place at the surface of a catalyst. Depending on where the initial excitation occurs, photocatalysis can be generally divided into two classes of processes. When the initial photo-excitation occurs in an adsorbate molecule which then interacts with the ground state catalyst substrate, the process is referred to as a catalyzed photoreaction. When the initial photo excitation takes place in the catalyst substrate and the photo-excited catalyst then transfers an electron or energy into a ground state molecule, the process is referred to as a sensitized photoreaction. The initial excitation of the system is followed by subsequent electron transfer and/or energy transfer. It is the subsequent de-excitation process (via electron transfer or energy transfer) that leads to chemical reactions in the heterogeneous photocatalysis process.

Photocatalysis has the following interesting features that set it apart from the photochemical cell:

1. The electrolyte is not necessary.
2. Each particle functions independently as a microphotoelectrode.
3. They possess large surface areas which is advantageous for the surface reactions.
4. They possess novel photophysical properties which appear to depend on the size of the particles: the so called “quantum size effect”.
5. The particulate systems are very simple; their low cost and ease of fabrication make them attractive in some practical applications.

After looking into all the possible pathways of hydrogen production from water using solar energy, it can be said that photo catalysis surely do have a lot of potential in comparison with the other pathways considering the simplicity of operation.

## CONCLUSION

Hydrogen fuel is green and clean fuel , it does not produce any harmful emission during combustion and generation of energy .As It is a potential future fuel its production through economically viable and environmentally acceptable methods .using solar energy is best method for producing hydrogen fuel as per above consideration . Using existing conventional technology, "hydrogen requires at least twice as much energy as electricity twice the tonnage of coal, twice the number of nuclear plants, or twice the field of PV panels to perform an equivalent unit of work. Most of today's hydrogen is produced from natural gas, which is only an interim solution since it discards 30% of the energy in one valuable but depletable fuel (natural gas) to obtain 70% of another (hydrogen). The challenge is to develop more appropriate methods based on sustainable energy sources, methods that do not employ electricity as an intermediate step. An another method which can be used is One hydrogen collection method that does not involve the use of electricity is a process known as photolysis. This is a process where strains of blue green algae have been provided with proper temperature and light conditions so that the chlorophyll and enzymes within the algae can chemically split sea water into hydrogen and oxygen. Known as photobiological production, this is a very environmentally friendly process, with no need for external energy, other than perhaps maintaining the ambient temperature ranges necessary to promote the process. Thus these technique should be used for production of hydrogen fuel in India because India has a huge reservoir of fresh water which can be converted into hydrogen and oxygen in the presence of titanium dioxide a catalyst which accelerate the photolysis . using this technology we can generate a novel clean potential fuel to support all vehicles power plants and industries.

## REFERENCES

[1] Aldo Steinfeld, 2005.Splitting of water *Solar Energy.* 78:603–61

[2] Altork, L.N. & Busby, J. R 2010.Hydrogen fuel cells: part of the solution. Technology & Engineering Teacher, 70(2), 22-27.

[3] Staff 2003. "Hydrogen ($H_2$) Properties, Uses, Applications: Hydrogen Gas and Liquid Hydrogen". Universal Industrial Gases, Inc.. Rev( 2008-02-05).

[4] T. Ohta and T. N. Veziroglu, hydrogen energy progress *Int J Hydrogen Energy*, 1, 255-263

[5] A. Kogan, E. Spiegler and M. 2000.Wolfshtein solar hydrogen genration. *Int J Hydrogen Energy* 25,739.

[6] Amy L. Linsebigler, Guangquan Lu, and John T. Yates, 1995.Jr. *Chem*,735-758

[7] Tikhonov, Vladimir I.; Volkov, Alexander A. 2002. "Separation of Water into Its Ortho and Para Isomers". *Science* 296 (5577): 2363.