BCHES12/22

GREEN FUELS

Introduction:

Green energy is any energy type that is generated from natural resources, such as sunlight, wind or water. Green energy is important for the environment as it replaces the negative effects of fossil fuels with more environmentally-friendly alternatives. The **six most common forms** are as follows: solar power, wind power, hydropower, geothermal, biomass and biofuel.

Mainly the energy sources are divided into 2 types based on sources

1. Conventional energy sources: Conventional energy sources are provided by nature but are present only in restricted quantities. Example coal, petroleum etc.
2. Non- conventional energy sources: These are non-polluting and present in abundance within the earth's atmosphere. Example sun, wind, geothermal etc.

Past and future perspective of green fuels

Green fuels are fuels produced from biomass sources through a variety of biological, thermal, and chemical processes. These products are chemically identical to petroleum gasoline, diesel, or jet fuel. The shift from use of conventional fossil fuels to green fuel is mainly because they are clean, safe and obtained from renewable sources. They release lower levels of carbon dioxide and other emissions when burnt compared to standard diesel. Green fuel production increases the demand for suitable biofuel crops, providing a boost to the agriculture industry.

Definition: Green fuels also called green hydrocarbons, biofuels, are fuel produced from biomass sources through a variety of biological and thermochemical processes.

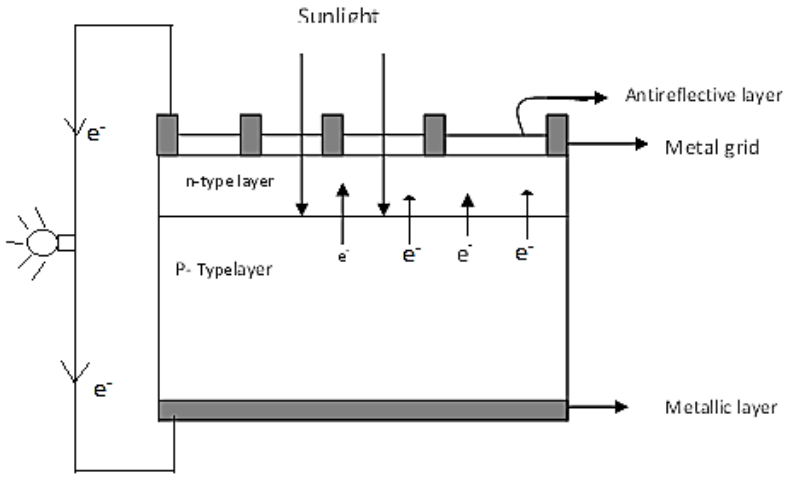
Photovoltaic Cells:

Photovoltaic cells are semiconductor device which convert solar energy into electrical energy.

(Photovoltaic cell is based on the principle of photoelectric effect).

Construction of Photovoltaic Cell:

- A typical silicon **PV cell** is composed of a n-type silicon on top of p-type silicon.
- Hence a p-n junction is formed between the two.
- **A metallic grid** forms one of the electrical contacts of the PV cell, over n-type semiconductor and coated with an **antireflective layer** (TiO_2) between the grid lines increase the amount of light transmitted to the semiconductor (prevent reflection of solar radiation).
- The other electrical contact is formed by **a layer of noble metal** (like silver) on the back of p-type semiconductor



Working of PV cell:

Electromagnetic radiation consists of particles called **photons**. The photons carry a certain amount of energy given by the Planck quantum equation,

Planck relation:

$$E = h\nu = \frac{hc}{\lambda}$$

where:

E = energy
h = Plank constant
v = frequency
c = speed of light
λ = wavelength

- **When electromagnetic radiation (sunlight) is incident to the plane of solar cell, the photons are absorbed (which possess energy sufficient to overcome the barrier potential). That results in drifting of electrons.** Thus electron-hole pairs are generated. The drifted electron will move from p- type semiconductor towards n-type through p-n junction to recombine with holes).

- Since p-n junction allows only one way movement of electrons, these electrons must flow through the external circuit to **recombine with holes**. This movement of electrons through the external circuit generates an electric current.

Applications of Photovoltaic Cells

The photovoltaic systems can be used to supply electricity for:

- telecommunication repeater stations
- water pumps
- navigational aids
- laptop computers
- cottages and remote residences
- parks in remote regions
- supplying occasional power

Advantages:

- Fuel source is vast and essentially infinite(renewable)
- No emissions, no combustion or radioactive residues for disposal.
- Environment friendly.
- Low operating cost (no fuel).
- No moving parts and so no wear and tear.
- They do not corrode
- They operate at ambient temperature.
- Can be integrated into new or existing building structures.

- High public acceptance and excellent record.

Disadvantages:

- High installation cost.
- It works only in presence of sunlight.
- Efficiency of solar cells depends on the seasonal variations, latitude and climate.
- Space required to generate unit power output is relatively more.
- Poor reliability of auxiliary elements including storage.
- Dust often accumulates on the panel thus reducing its efficiency.

Green hydrogen:

Carbon containing fuels are non-renewable and emit carbon dioxide which is the main greenhouse gas. Therefore, developing an alternative source of energy which is clean, continuous and renewable, is required to meet global energy demand. Hydrogen is the only promising alternative fuel to carbonaceous fuels.

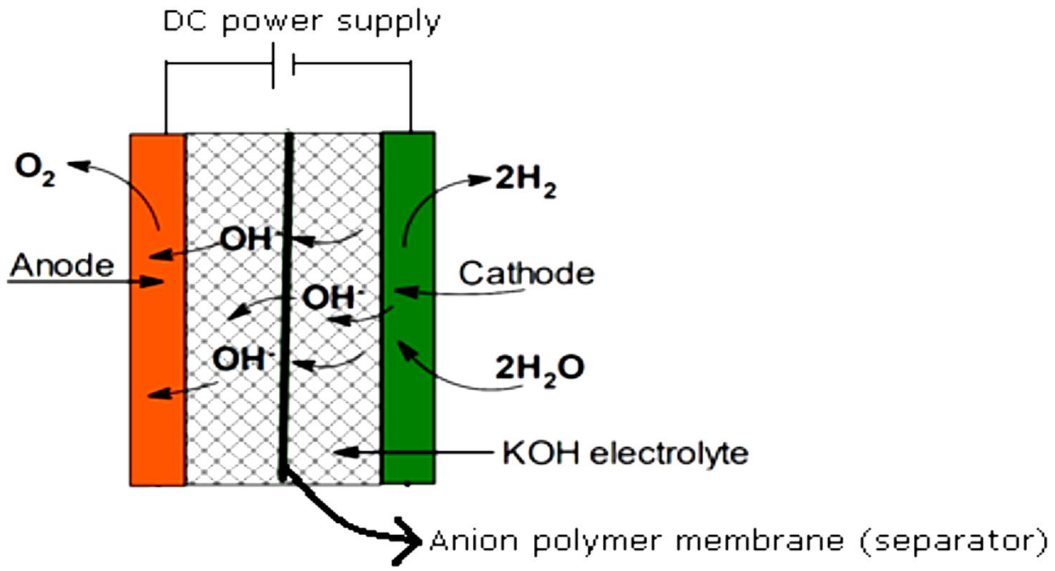
Properties of hydrogen fuel:

1. Hydrogen is an ideal, highly efficient, renewable, clean, and sustainable energy source.
2. It is abundant from various sustainable sources (biomass or water).
3. Energy content of hydrogen is 122 KJ/g, which is 2.75 times greater than hydrocarbon fuels like petrol and Diesel.
4. The combustion product is water, which is not a pollutant.
5. It can be used as fuel in Fuel cell for production of electric current.
6. It can be used as chemical fuel and burnt directly to produce heat energy.
7. It has high storage capability, thus considered as an ideal alternative source of energy for fossil fuels.

❖ **Green hydrogen by electrolysis of water (Alkaline water electrolysis)**

Construction

1. **Anode:** Nickel metal particles dispersed on porous carbon
2. **Cathode:** Nickel metal particles coated on porous carbon
3. **Electrolyte**: Aqueous solution of KOH
4. **Separator:** Porous dense anion exchange membrane. It is a good ionic conductor for hydroxide ions and bad electronic conductor. It prevents the spontaneous recombination of H_2 and O_2.



Working

- Water electrolysis is a non-spontaneous chemical reaction. So, DC power supply is used.
- Anode is connected to positive end and cathode is connected to negative end.
- At the cathode, water molecules are reduced by electrons to hydrogen and negatively charged hydroxide ions. Hydroxide ions migrate through KOH and through separator to the anode.
- At the anode, hydroxide ions are oxidized to oxygen and water while releasing electrons.
- Overall, a water molecule splits in to hydrogen and oxygen in the ratio of 2:1.

$$\text{Anode: } 2OH^- \longrightarrow \frac{1}{2}O_2 + H_2O + 2e^-$$

$$\text{Cathode: } 2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$$

$$\text{Overall reaction: } H_2O \longrightarrow H_2 + \frac{1}{2}O_2$$

Advantages:

1. Alkaline water electrolysis is cheaper and simple method for hydrogen production.
2. Electrodes are made of cheaper nickel metal.
3. Pure carbon free hydrogen is obtained from this method.
4. Excess cheap current from renewable sources like solar power can be converted to hydrogen gas and stored as chemical energy.

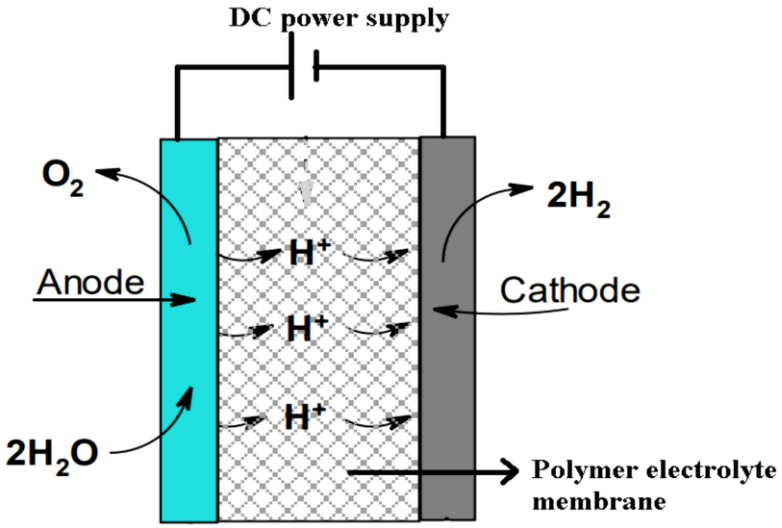
❖ Green hydrogen by electrolysis of water (Proton exchange membrane electrolysis)

Construction:

Anode: Iridium metal particles dispersed on porous carbon.

Cathode: Platinum particles coated on porous carbon.

Electrolyte/Separator: A porous solid polymer electrolyte made of chemically stable sulfonated tetrafluoroethylene-based fluoropolymer is used as an electrolyte as well as a separator. It is a good ionic conductor for protons and bad electronic conductor. It prevents the spontaneous recombination of H_2 and O_2.



Working:

- Water electrolysis is a non-spontaneous chemical reaction. So, DC power supply is used.
- Anode is connected to positive end and cathode is connected to negative end.
- Deionized water is circulated in the anodic chamber where it is oxidized liberating oxygen gas and hydrogen ions.
- Hydrogen ions migrate through the Solid Polymer Electrolyte membrane to the cathode, where they are reduced into molecular hydrogen.

Anode: $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

Cathode: $4H^+ + 4e^- \longrightarrow 2H_2$

Overall reaction: $2H_2O \longrightarrow 2H_2 + O_2$

Advantages

1. Use of polymer membrane avoids use of liquid acid electrolyte. Therefore, chance of electrolyte leakage is prevented.
2. Polymer membrane is chemically stable and non-corrosive.
3. Pure carbon free hydrogen is obtained from this method.
4. Excess cheap current from renewable sources like solar power can be converted to Hydrogen gas and stored as chemical energy.