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Design of Photo Catalyst Induced Solar Photo Electrolysis Cell using Titanium Oxide as Catalyst and Zinc/Copper as Electrode

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Abstract:-- **Because of lower efficiency of solar photovoltaic cells, alternative means to harvest electric power from sunlight need to be explored. The idea is to use a photo catalyst to split water molecules into protons and hydroxyl ions and effectively separating the charges to produce usable electric power. A nafion membrane is used to separate the photons from the electrolyte. A zinc mesh is used to collect the protons effectively while copper plate situated outside the zinc mesh collects remaining electrons in the electrolyte. The protons generated are used to create a potential difference across the Copper(+) and Zinc(-) electrodes. Fine carbon particles are suspended within the electrolyte. Being effective black body, the carbon particles absorb maximum sunlight and transmit it to the electrolyte, thus improving the light absorption. To maintain constant supply of electrolyte, i.e., water, in the cell, it is fed by a water source separated by a RO membrane. Such a concept can also be used to harness solar energy when installed in bay area that have high amounts of incident Solar Irradiance, thus facilitating mass scale production of Solar Power and act as a major contributor in the overall electricity generation. Such a bay of cells provides high efficiency with negligible maintenance and low installation cost. It also has a very low requirement of surface availability, thus improving the effectiveness of the device. This project will be highly applicable in the Asian countries, especially the coastal areas.**

Index Terms— **Photo-catalyst, PEM Membrane, Titanium Oxide..**

I. INTRODUCTION

Photo-catalytic water splitting is an artificial photosynthesis process with photo-catalysis in a photo-electrochemical cell used for the dissociation of water into its constituent parts, hydrogen (H2) and oxygen (O2), using either artificial or natural light. Theoretically, only solar energy (photons), water, and a catalyst are needed. The minimum potential difference (voltage) needed to split water is 1.23V at 0 pH. [1] Since the minimum band gap for successful water splitting at pH=0 is 1.23 eV, corresponding to light of 1008 nm, the electrochemical requirements can theoretically reach down into infrared light, albeit with negligible catalytic activity. . Under normal conditions due to the transparency of water to visible light photolysis can only occur are with radiation of wavelength 180 nm or shorter. We see then that, assuming a perfect system, the minimum energy input is 6.893 eV.[2] Materials used in photo-catalytic water splitting fulfil the band requirements outlined previously and typically have dopants and/or co-catalysts added to optimize their performance. The conversion of solar energy to hydrogen by means of photo-catalysis is one of the most interesting ways to achieve clean and renewable energy systems. However, if this process is assisted by photo-catalysts suspended directly in water instead of using a photovoltaic and electrolytic system the reaction is in just one step, and can therefore be more efficient.

II. PROPOSED DESIGN

A. Structure of the cell

The following are the components of the cell-

- RO membrane
- Nafion membrane (PEM)
- Copper mess
- Zinc metal

The container is made of glass which has a opening containing RO membrane for constant supply of solutio Inside the container first section has number of Zinc electrode, second is the PEM membrane & finally we have the copper mess

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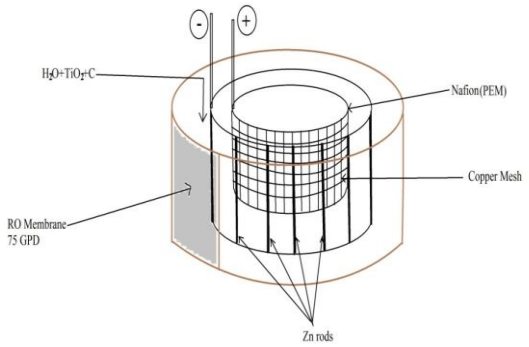


B. Working

Tio2 catalyst when exposed to sunlight absorbs energy & gets into excited state, this excited TiO2 catalyst when placed in water undergoes certain reaction enhancing the dissociation of H2O molecule.

The reaction is as follows:

- Ti_2O+hv----------→ $[Ti_2O]^*$
- $4H_2O$----------→ $4H^+ + 4OH^-$

(in presence of $[TiO_2]^*$)

Cathode-

$4H^+ + 4e^{-1}$----------→ $2H_2\uparrow$

Anode-

$4OH^-$----------→ $2H_2O + O_2\uparrow + 4e^-$

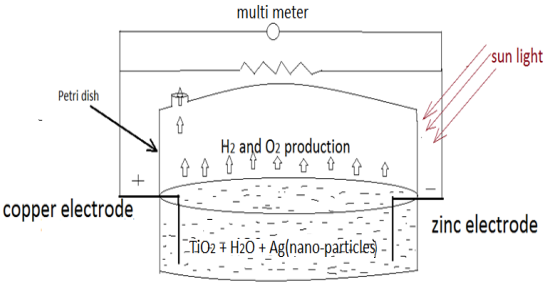
The energy received by TiO2 molecule from sunlight is not enough to overcome the band energy gap, also water when exposed to sunlight does not receive sufficient energy to overcome the energy gap. But mixing TiO2 with water together have enough energy to overcome the gap thus enhancing the chemical reaction.

The solution of TiO2 & water is passed through the RO membrane in the case containing the copper mess, zinc electrode, PEM membrane. The positive ions released after the chemical reaction is attracted towards the electronegative metal Zn & the negative ions are attracted towards cathode. PEM membrane placed just outside the copper sheet does not allow the negative ions to recombine with the positive ones. Thus we finally have H2+ ions & OH- separated giving us the required potential.

c) Probable Problems

- corrosion of electrode
- precipitation of TiO2
- Damage to the outer world by salt water.

III. ASSEMBLY & FABRICATION



This is our experimental setup for photo-electrolysis which we have observed during the sunlight. In this experiment, we have used two petri-dish as a container for solar photo-electrolysis and TiO2 as a photo catalyst and silver(Ag) nanoparticles as co-catalyst. We also used two different types of electrode i.e. zinc(cathode) and copper(anode) for collecting the charge which were partially merged into the TiO2 solution. After that we used a multimeter for measuring the output voltage and current.

III. DRAWBACKS & TROBLUSHOOTING

- ***Photosensitivity:*** The photosensitivity of this cell is very low that means it does not start generating electricity at the same time when it placed under sunlight, it takes 5-6 minute to start generating electricity and also it takes 5-6 minute to stop generation of electricity after stay away from sunlight to shadow place. To overcome of this problem in future we will test scintillation grade TiO2 solution instead of anatase TiO2 solution, though this form of TiO2 is costlier but very effective.

- ***Corrosion:*** Corrosion to the electrodes is a big drawbacks for its cell electrodes. To overcome of

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this heavy corrosion we will use treated Mg and Sn electrode instead of copper and zinc electrode to avoid corrosion.

- ***Precipitation of Ag nanoparticles:*** The silver nano-particles are precipitated under the solution which gives negative effect i.e. slow down the reaction of photo electrolytic cell. To overcome this problem we used good emulsifier to avoid precipitation of silver nano particles.

IV- RESULT & CONCLUSION

After implementation of this experimental setup we measure the voltage and current during the sunlight period which gives a voltage of 0.8 volt and current of 0.04 ampere for a small single cell. Besides the electrical output we also investigated the output hydrogen and oxygen gas, we have collected the product gas using an inverted beaker submerged in water, and tested it by directing the gas towards flame using a nozzle.

Though the product gas was very less in amount, it exhibited combustion, as the flame experienced turbulence, and produced a fade bluish flame which maintain the properties of hydrogen. So we can say that in that produced gas there is enough hydrogen. This hydrogen may be utilized in a fuel cell for generation of electricity then efficiency of this cell will be increased.

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