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Artificial Photosynthesis Future of Green Energy

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Abstract – The natural photosynthesis process is one of the most essential for life cycle to continue on Earth. This Bio-Chemical reaction is the backbone of life on the planet. During the photosynthesis process the sunlight is been absorbed in the cell chlorophyll and this is converted to chemical energy. The reaction includes photolysis of water from carbon-di-oxide and liberates Oxygen as byproduct in air; however the plant is not able to store any solar energy not even 1% of it [1].

This last point motivates us to mimic this reaction spuriously (artificially). These we can use from various alternative energy sources as coal/diesel are limited (which we found out till date) in nature. [2] In this paper we are discussing various methods by which we can mimic the photosynthesis process domination process by alternative technologies so the kingdom of alternate technology in energy generation increases.

Key Words – photosynthesis, kingdom, domination, alternative, energy, energy management, chlorophyll, carbon-di-oxide, water, nascent hydrogen, mimic

Introduction – The first idea of artificial photosynthesis process is been given in late 1900 century by an Italian Chemist Giacomo Ciamician and because of this research he is been awarded Legion of Honor award. His work in photochemistry is to develop a device to capture solar radiation so that solar fuel can be used for later and stored. Accidently in the process he discovered artificial photosynthesis, but this idea in 1890 is not given any attention. After some years when scientist Honda try to split water by Titanium Oxide using an ultra violet ray excitation process this discovery came out again.

These are greatest discoveries of mankind but do not get any wattage by scientists as the solar radiation is considered unlimited on Earth in early 1900. [3] The earth has a lot of greenery that time and plentiful of vacant spaces as till that discovery time no industrialization takes place. [4] Till the arrival of 1980's we realize the harm done by us to the nature. [5] This idea is been adopted by a Indian-U.S. collaboration and a thin film amorphous silicon sheet was manufactured in the presence of Titanium Oxide, which can split water to Hydrogen and Oxygen and also can transfer protons so they named it artificial Leaf. This was in history considered first and most successful attempt of making leaf from low cost silicon multi junction cells. This leaf can perform photosynthesis both in natural and artificial environment.

Fig. 01 – Artificial Leaf, Source – [11]

The figure 2 described the potential differences between photosynthesis – Artificial photosynthesis – Photo-de-pollution. Elaborating the three firstly in the natural photosynthesis process the leaf chlorophyll reacts with Water, Carbon-di-oxide and sunlight giving starch

(glucose) to the plant and liberates Oxygen to the atmosphere. Where as in"b" i.e. artificial photosynthesis the catalyst is been used which uses Water, Carbon-di-oxide and sunlight and liberates Carbon-Mono-Oxide, Hydrogen, Oxygen and complex of C_xH_y to the atmosphere. In the photo-de-pollution process the various organic compounds complex of C_xH_y are been degraded by water and Carbon-di-oxide. This process combined with the above two i.e. natural photosynthesis – Artificial photosynthesis and make a system loop of o discharge waste to environment.

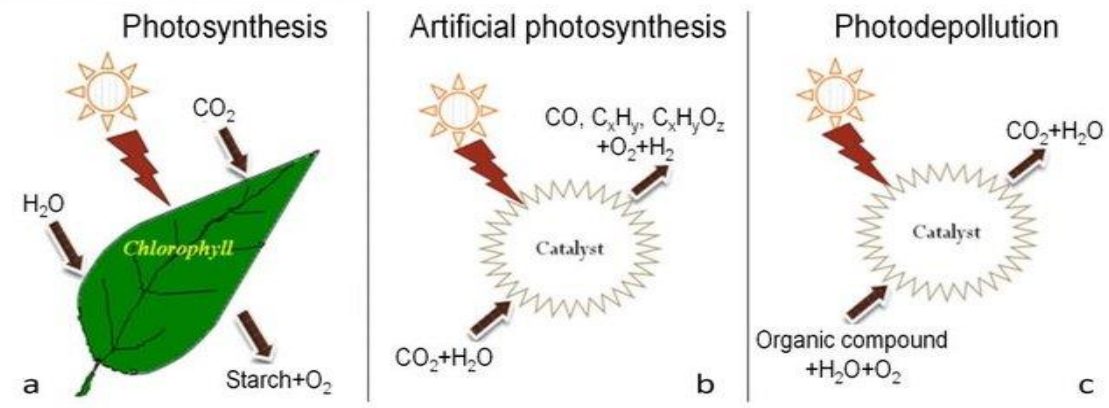

Fig. 02 –Comparison of photosynthesis, Source – [12]

Material and Methods – Lack of land and need of urging new technologies increases the demand of renewable energy resources, this lead us to open the gates of artificial photosynthesis too. This paper presented by Dr. Dalal reports significant advancements in the current scenario and also opens the gates of the future technologies to run.

The artificial photosynthesis uses solar cells for energy in place of chlorophyll to absorb sunlight. To split water into hydrogen and oxygen this uses organic catalysts. This process produces a large amount of energy and in the by-product we get Hydrogen fuel which is used now days to run mobility vehicles especially cars. [6] In Figure 3 the natural and artificial photosynthesis process are been described and if the energy in photo catalyst is been taken we get about 237KJ/mol energy which is good and can be used easily by converting it from chemical to electrical or mechanical. Also in the process two best by-products are been formed i.e. Oxygen and Hydrogen which can be separated easily and hydrogen can be stored and used as fuel afterwards.

This energy generated in artificial photosynthesis can be converted, as in the current photovoltaic cells of solar panels uses same technology of converting chemical/solar energy to electrical energy. [7] The photovoltaic cells in solar panels cannot store energy and directly converts the solar chemical energy in electricity which depends on weather conditions, but in the photovoltaic cells they are been able to store the energy throw its semiconductors so that the energy can be used afterwards as needed.

The Process – In the artificial photosynthesis there are three main steps these are

i. Electron Transportation
ii. Water Splitting
iii. Carbon-di-oxide reduction

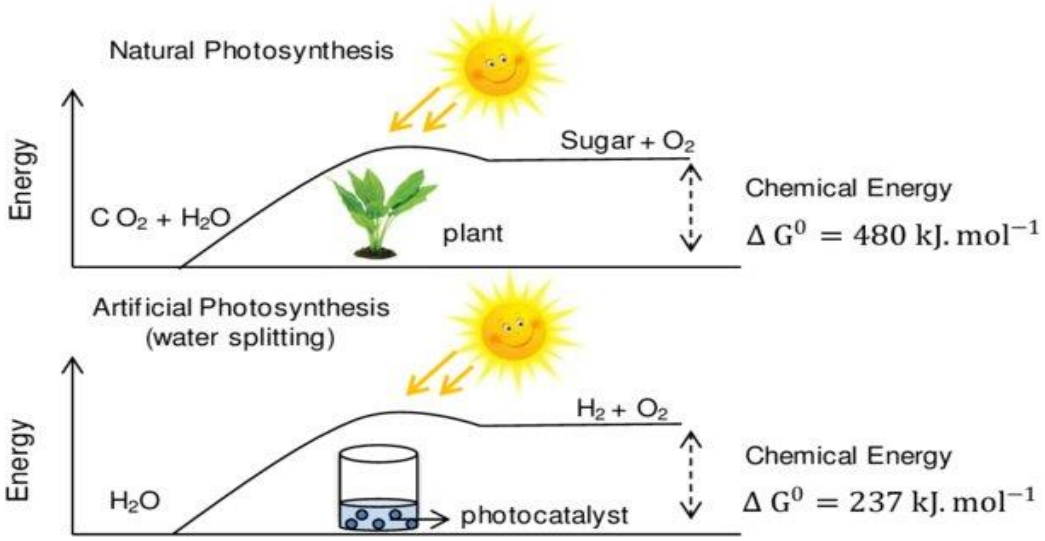

Fig. 03 – Comparison of Natural and artificial photosynthesis, Source – [13]

Elaborating the three processes –

In the electron transportation steps the photons with wavelength between 400 nm and 700 nm are been absorbed and this energy is stored for further process so this process is also known as Light harvesting step. In the second step i.e. the water splitting step the absorb light by semiconductors excites the electron they mitigates and move vigorously and partially completes the Hydrogen and Oxygen reaction. The last is the most important steps in the three and is for the environment management and service of the nature to reduce carbon-di-oxide and enhance fuel capacity. To achieve this goal we need the best material to be used in the reaction and also should have good calorific values with economic viability. We use inorganic semiconductors and photosensitive molecules both to store and harvest energy stored in form of electricity.

Now a day's enhance semiconductors are present which reduce the over potential of chemical reactions and this multi structural junction increases light absorption, this arrays couple in the P-N junction in which high energy photons are bombarded with some build in charge separators. This separator also separated the incompatible reduction and oxidation reactions resulting in the maximum efficiency of the system.

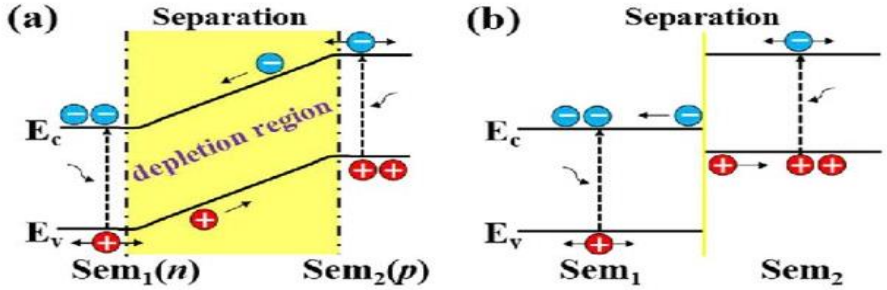

Fig. 04 – Separation process, Source – [14]

The figure 4 depicts about the SEM 1 and SEM 2 gets separated in the water splitting and carbon reduction steps. While the depletion region is non-uniform in light absorption this increases its efficiency.

The Proposal – The above knowledge is very important and can be used to build solar cell using different materials. However till date silicon cells are proved to be the best and superior to all others. We also can increase the efficiency of bio catalyst used for artificial photosynthesis, our goal should be to reduce cost and make process more effective. The catalyst should be so strong that it can catalyze both HER (Hydrogen Evaluation Reaction) and OER (Oxygen Evaluation Reaction) making the catalyst best choice for water splitting during artificial photosynthesis.

Recently in a study Ruthenium Telluride ($RuTe_2$) came to be a robust electro catalyst and is successfully fabricated in amorphous nano rods. During the water splitting Ruthenium Telluride reported about 100% efficiency of Hydrogen and Oxygen gas and the current density was observed more than 110mA/cm^2, so it is considered as exceptional bi-functional catalyst. This catalyst shows us its tremendous power still we can say that research in the field is on infant level and more people have to come forward to solve this puzzle.

The biggest challenge for artificial photosynthesis is reduction of Carbon-di-oxide concentration, [9] various catalysts now days use this carbon-di-oxide and reacts quickly with it showcasing a promising future to us. [10]

Conclusion – It can be concluded that various solution matters and reacts differently. This asymmetric photosynthesis alters the photon liberation and Hydrogen bond problems. Considering recent advances in artificial photosynthesis fields the future depicts promising. The main hurdle is catalyst cost and availability, this hurdle makes us more efficient in working and so we are continuously working on enhancing the catalyst towards low cost running and high availability that too without compromising the nature and efficiency of the system. Therefore a positive advancement is waiting for us if we re-emphasize the future of artificial photosynthesis properly.

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