

## Dye Sensitized Solar Cells: Tool to Overcome the Future Energy Crisis

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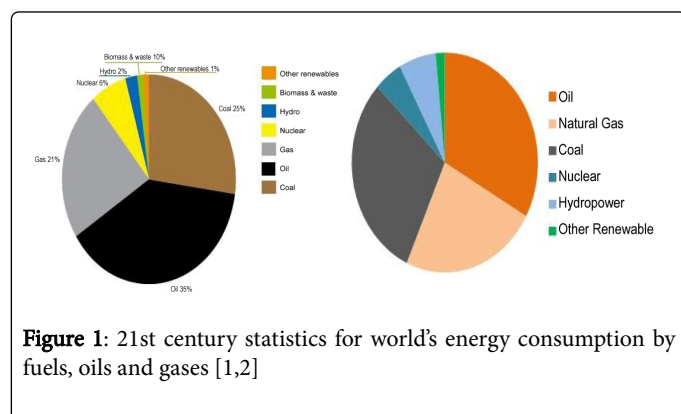
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### Editorial

Recently, world's main concern is fuel and energy crisis, because fossil fuels are depleting as days progressing. On the other hand the demand for energy is growing day by day and many countries around the world have no alternative, but to increase domestic oil process. Hence, there is a crucial requirement of sustainable energy resources like solar energy, which is considered as an eco-friendly and promising method to over this problem. The 21<sup>st</sup> century statistic shows the world's energy consumption by fuels, oils and gases [1,2] as shown in Figure 1.



For many decades scientists have been working for effective conversion of sunlight into the energy, as Sunlight is an abundant natural resource in the universe. A very attractive direct route for solar energy conversion and storage, with a high potential impact is the production of electricity. A dye sensitized solar cell (DSSC) is a low cost solar cell which belongs to a group of thin solar cells. It is based on a photoelectrochemical system where a semiconductor is formed between photosensitized anode and an electrolyte. These cells provide an economical alternative to present day p-n junction photovoltaic devices which are based on the charge separation concept at an interface of two materials [3]. Solar energy is an abundant natural resource and from many decades scientists have been trying to harness this energy for use in electricity. These involve conversion of solar energy and are based on a combination of donor- $\pi$ -acceptor (D- $\pi$ -A) dyes in conjugation with metal based redox mediators [4-6]. The strong molar absorptivity of dyes enables the use of thin nanocrystalline films thereby reducing fabrication costs.

Porphyrin dye based solar cells have provided a very flexible environment for the development of such kind of cells. Porphyrin chromophore has a strong light absorption [7]. Earlier metal

containing dyes were used like ruthenium which is expensive and require careful synthesis and many purification steps. Nowadays, metal free organic dyes are used which are inexpensive with tunable absorption and electrochemical properties [8]. Organic dyes have several advantages as sensitizers:

- Available in abundant.
- Large absorption coefficients due to intramolecular  $\pi$ - $\pi^*$  transitions.
- Organic dyes have wide variety of structures which can be easily modified.

Therefore, sophisticated design of dyes is required to make solar cells with high efficiency.

### Design of DSSC

DSSC is a sandwich structure made of two conducting electrodes with an electrolyte filling the interlayer separation. An oxide layer composed of nanoparticles is deposited on the conducting oxide substrate and has sponge-like structure picks up dye molecules when immersed in dye solution giving intense coloration. When visible light falls on a solar cell, the molecules of the dye move to excited state. This injects electrons to the conduction band of the oxide semiconductor. Subsequently, the original state of the dye is restored by the reduction of the oxidized form of dye by the redox electrolyte. The electrolyte usually used is iodide/triiodide mixture dissolved in an organic medium [9].

The nanoparticles coated with dye molecules convert photons (light) into electrons (electricity). The electrons travel through the electrolyte and the nanoparticles to create an electric current. This electric current powers any appliance needing electricity outside the cell. Different color dyes can be used which can absorb different wavelengths of light which in turn carry varied amount of energy. Finding an optimal size and density of nanoparticles is one of the challenges in building DSSC. The productivity of a DSSC mainly depends on energy levels of the component: the excited state (approximately LUMO) and the ground state (HOMO) of the photosensitizer, the Fermi level of the  $\text{TiO}_2$  electrode and the redox potential of the mediator ( $\text{I}^-/\text{I}_3^-$ ) in the electrolyte.

### Mechanism of DSSC

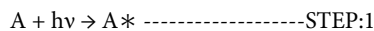
The DSSC mechanism mainly involves in four steps:

**In the first step photons are converted to current as follows:**

The incident photon is absorbed by metal complex or a dye molecule (photosensitizers adsorbed on the  $\text{TiO}_2$  surface)

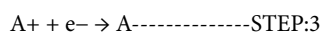
**In the second step:**

The photosensitizers are excited from the ground state to the excited state. Then the excited electrons are injected into the TiO<sub>2</sub> electrode (conduction band). This results in the oxidation of the photosensitizer (metal complex or a dye molecule).



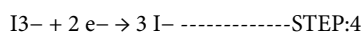
**In the third step:**

The injected electrons in the conduction band of TiO<sub>2</sub> are transported between TiO<sub>2</sub> nanoparticles with diffusion and reach the counter electrode through the circuit.



**In the fourth step:**

The oxidized photosensitizer accepts electrons from the electrolyte (I<sup>-</sup> ion redox facilitator) leading to regeneration of the ground state, and the I<sup>-</sup> is oxidized to I<sup>3-</sup>. Finally, the I<sup>-</sup>, I<sup>3-</sup>, diffuses toward the counter electrode and then it is reduced to I<sup>-</sup> ions.



### Advantages of Dye Sensitized Solar Cells

a) Since, nanoparticles are used these can absorb almost all the photons from the sunlight. Further, dyes used in the solar cells convert photons into electrons efficiently.

b) They are cost effective as compared to other semiconductor cells,

c) DSSC can absorb diffuse sunlight and fluorescent light. Thus, these can work efficiently in cloudy weather. These have low cutoff and therefore, are suitable for running small devices indoor

d) They last long thereby reducing frequent replacements.

e) Mechanically robust which makes them easy to use and handle?

f) As these are composed of thin layers heat is easily radiated to reduce the internal temperature. This helps in increasing the efficiency of the cells.

### Applications

The first commercial application of DSSC created by G24 innovations was in 2009 where these were used in backpacks and bags in Hong Kong. The solar panels built into these backpacks and bags could harvest energy to repower mobile electronic devices such as mobile phones, e-books, cameras, and portable LED lighting systems. The portable electronics, cellphones and cameras could be recharged. The modules could also be cheaply incorporated into power-generating windows and billboards.

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