American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-3, Issue-9, pp-35-40
www.ajer.org
Research Paper Open Access

A New Technique to Produce Electricity Using Solar Cell in Aspect of Bangladesh: Dye-Sensitized Solar Cell (DSSC) and It's Prospect

M. F. Ali[1], Rabiul Islam[2], Nadia Afrin[3], M. Firoj Ali[4], S.C. Motonta[5], M. F. Hossain[6]

[1]*Lecturer, Dept. of EEE, Pabna University of Science & Technology (PUST), Bangladesh*
[2]*Student, PPRE, Carl von Ossietzky University of Oldenburg, Germany*
[3]*Lecturer, Dept. of EEE, Pabna University of Science & Technology (PUST), Bangladesh*
[4]*Lecturer, Dept. of EEE, Pabna University of Science & Technology (PUST), Bangladesh*
[5]*Lecturer, Dept. of EEE, Pabna University of Science & Technology (PUST), Bangladesh*
[6]*Assistant Professor, Dept. of EEE, Rajshahi University of Engineering & Technology (RUET), Bangladesh*

ABSTRACT: *The Bangladesh is a developing country where electricity crisis is the most serious problem now-a-days. In order to meet electricity demand of our country we need to change the procedure of electricity production. For that we have to implement our renewable energy resources properly like solar cell. The dye sensitized solar cell (DSSCs) is another new method to produce electricity which is more cost effective and also efficient comparing conventional silicon solar cell. When the visible light is absorbed by the thin film such as TiO2, an electron is injected by the excited sensitizer molecules into the conduction band of that thin film (TiO2). These electrons are then transported toward and collected by a back-contact electrode which travel in a big circle and create an electrical circuit which powers a device. In this paper we tried to describe the new DSSCs technology compared to conventional silicon solar cell according to the electricity demand of Bangladesh.*

Keywords *-Nanotechnology; Thin film; Dye; Nanoporous; Light's wavelength*

I. INTRODUCTION

Solar energy is another topic that becomes increasingly hot over recent years as the fossil and mineral energy sources are approaching inevitable exhaustion in the coming fifty years. The supply of energy from the sun to the earth is gigantic; it is estimated to be 3×10^{24} J/year, which is 104 times more than what mankind consumes currently [3]. In other words, covering only 0.1% of the earth's surface with a conversion efficiency of 10% would suffice to satisfy our current needs [4]. The conversion of solar energy into electricity relies on photovoltaic devices, i.e., so-called solar cells, which have undergone three generations with an evolution from the initial single silicon solar cells [5] to the second generation solar cells based on semiconductor thin films [6, 7] and, now, the third generation solar cells represented by dye-sensitized solar cells (DSSCs) and organic semiconductor solar cells [8-11].

A dye sensitized solar cell (DSSC) is a low cost solar cell belonging to the group of thin film solar cells [1]. It is based on a semiconductor formed between a photo-sensitized anode and an electrolyte, a photo electrochemical system. The dye-sensitized solar cells (DSSCs) provide a technically and economically credible alternative concept to present day p–n junction photovoltaic devices [2]. The word photovoltaic means to convert the photo (sunlight) into voltage e.g. power. The DSSC has a number of attractive features; it is simple to make using conventional roll-printing techniques, is semi-flexible and semi-transparent which offers a variety of uses not applicable to glass-based systems, and most of the materials used are low-cost. Although its conversion efficiency is less than the best thin-film cells, in theory its price/performance ratio should be good enough to allow them to compete with fossil fuel electrical generation by achieving grid parity. However, DSSCs take obvious advantages in several aspects, such as higher efficiency, better stability, longer life time, and less dependence on the manufacturing equipments comparison with others solar cell. There are good prospects to produce these cells at lower cost than conventional devices. Here we present the current state of the field, discuss new concepts of the dye-sensitized nanocrystalline solar cell (DSSCs) including heterojunction variants and analyze the perspectives for the future development in Bangladesh [12].

II. EFFECT OF LIGHT'S WAVELENGTH ON DSSCs

Solar cells can only absorb specific wavelengths of light. In both, light that isn't absorbed is either transmitted through or reflected back. Whether a certain wavelength of lights gets absorbed depends on its energy. Different colors of light have different wavelength and different energies. So, all wavelengths of light are not absorbed by the solar cell's atom or molecules. We have a formula that

$$\lambda=1.24/Eg \quad (nm)$$

Where, Eg= band gap energy/ energy of incident light

λ= wavelength of incident light

So, the light which has higher wavelength occupies lower energy or vice versa. A little background on light is given bellow in Fig. 1.

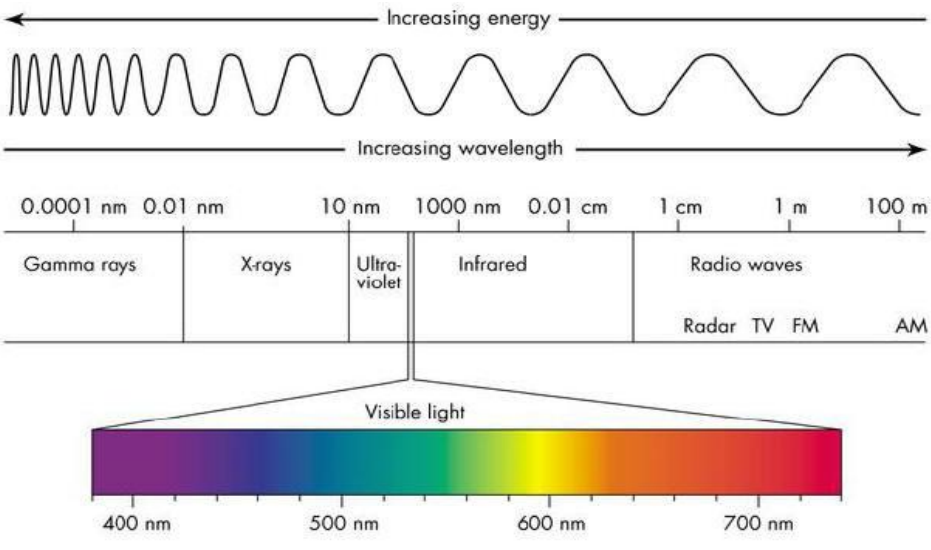

Fig. 1 Spectrum of light and visible light wavelength [13]

Absorption of light energy occurs only when the energy of the light equals the energy of transition of an electron [13]. Molecules have multiple atoms bonded together. So, there are more energy states in molecules than atom. However, in molecules more electron "jumps" possible when light with a range of frequencies are absorbed. For ionic compound, electrons can jump between the valence band and conduction band. The gap between these two bands is known as band gap or energy gap. When the energy of incident light is greater than or equal to the band gap energy, then this light's energy can be used to excite the electrons from the valence band to conduction band.

III. COMPONENTS USED IN DSSCs

There are various types of components used in DSSCs. Among them the Granular TiO_2, dye, redox, solvent, F-SnO2glass slides, Iodine and Potassium Iodide, Mortar/Pestle, Air Gun, Surfactant (Triton X 100 or Detergent), Colloidal Titanium Dioxide Powder, Nitric Acid, Blackberries, raspberries, green citrus leaves etc., Masking Tape, Tweezers, Filter paper, Binder Clips, Various glassware, Multi-meter etc. The granular TiO_2 formed ananoporous structure. A dye, which is a light sensitive substance spread on the TiO_2 surface.A redox couple (I^-/I_3^-), located in the space between the dye and the cathode.A solvent for the redox couple, e.g. a Room temperature Ionic Liquid.The glass substrates are coated with a transparent conducting oxide (TCO). Fluorine doped tin oxide (SnO2:F), FTO is most commonly used. The nanoporous metal-oxide semiconductor electrode prepared on FTO glass substrate, called working electrode (WE). The thickness of the metal oxide semiconductor layer is about 10 μm; the resulting effective surface is about 1000 times larger as compared to a dense, compact metal oxide layer [14]. The FTO at the counter electrode is coated with few atomic layers of platinum (Pt), in order to catalyze the redox reaction with the electrolyte. On the surface of the metal oxide electrode, a monolayer of dye molecules is adsorbed [15]. The huge nanoporous surface of metal-oxide electrode allows for adsorbing sufficiently large number of dye molecules for efficient light harvesting. The employed dye molecule is usually a ruthenium (Ru) metal-organic complex. The spectral absorption of the dye lies between 300 nm and 800 nm [12]. The DSSC structure is given in Fig. 2. Here Two transparent conducting oxide (TCO) substrates. (FTO (SnO_2:F)) are used as electrodes. TiO_2/ZnO is highly porous metal-oxide semiconductor. Ru-complexes (N3-dye) is a monolayer of a sensitizing dye.

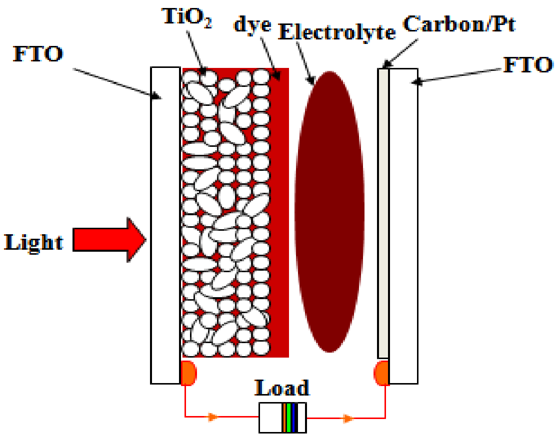

Fig. 2 The DSSC structure

Carbon/Platinum is a counter electrode (CE). DSSC: KI/I_2, and CdS sensitized solar cells: Polysulfide (Na_2S/S) is an electrolyte. After that a load is connected between two FTOs. The light is given at working electrode (WE). Then the cell is ready to supply the power to the load by absorbing the energies from the sunlight.

IV. WORKING PRINCIPLES OF DSSCs

The schematic diagram of DSSCs is given in Fig. 3 where we will explain how a DSSC is really worked. The DSSCs is based on the mechanism of a regenerative photo electrochemical process. It consists of five steps:

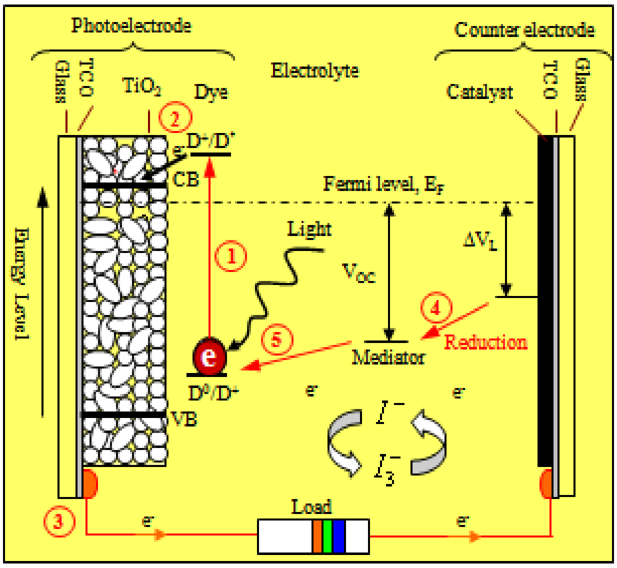

Fig. 3 Schematic diagram of DSSCs [12]

1. The dye (Do) absorbs a photon from the light and an electron is transferred to a higher lying energy level.dye is in excited state (D*).

2. Injection of the excited electron into the conduction band of the metal-oxide.

$$D^0 + h\nu \rightarrow D^*$$

3. The electron percolates through the porous metal-oxide layer to the FTO and passes the external load to the counter electrode.

$$D^* \rightarrow D^+ + e^-$$

4. At the counter electrode the electron is transferred to I3- to yieldI-.

5. The I^- reduces the oxidized dye (D^+) to its original state (D^o).

$$I_3^- + 2e^- \rightarrow 3I^-$$

$$2D^+ + 3I^- \rightarrow 2D^0 + I_3^-$$

The operating cycle can be summarized in chemical reaction technology as (Mathews et. al. 1996)

Anode: $S + h\nu \rightarrow S^*$ (Absorption)

$S^* \rightarrow S^+ + e^-(TiO_2)$(Electron injection)

$2s^+ + 3I^- \rightarrow 2S + I_3^-$(Regeneration)

Cathode: $I_3^- + 2e^-(Catalyst) \rightarrow 3I^-$

Cell: $e^-(Catalyst) + h \rightarrow e^-(TiO_2)$ [12]

V. FABRICATION PROCESS OF DSSCs

The materials which are used to fabricate the DSSC are: Indium doped tine oxide (ITO), TiO_2 paste, dye (such as Eosin Y), Ethanol and mediator such as iodide liquid. The fabrication process of DSSCs is very simple. One can easily make these DSSCs in a lab. To fabricate DSSCs there are two types of electrode are used, where one is photo-electrode and another is counter-electrode and for that two pieces of transparent glasses are used. In that transparent glass, one side is conducting side and the other side is non-conducting. In the conducting side of the photo-electrode two plastic tapes are used by keeping some gap between the tapes. The gap is filled up by using TiO_2. Small amount of TiO_2 paste is put on the surface between the gap of the tapes and the paste is spread with the help of glass rod which is called doctor blading. After the completion of doctor blading the tapes are removed and the photo-electrode with TiO_2 is heated at the temperature of 150^0 C for 15 minutes.

The next step of the fabrication process is "dye-sensitization". The heated transparent glass with TiO_2 is put into a dye bath containing dye molecule. The dye is prepared by 20 mL of 1 mM Eosin Y in Ethanol. The electrode is put in that dye molecule approximately 12 hours. So, a chemical bond is formed between the TiO_2 and dye molecule in order to attach with each other. This process is called sensitization and that's why this type of solar cell is called Dye-Sensitization Solar Cells (DSSCs). When the electrode is withdrawn from the dye the TiO_2 colored with that dye-color. This is done in order to absorb more sunlight and for better performance. For counter-electrode another transparent glass is used which is also one sided conducting glass.

Now the next step is to add the electrolyte between the electrodes. This electrolyte acts as a mediator which takes and gives electrons between the dye molecule and counter-electrode. In order to add that electrode two holes are drilled on the surface of the counter-electrode and platinum metal is sprayed on it for better conductivity. A square tape is put between the two electrodes and after that the cell is filled with the electrolyte. The hole is covered with another tape so that the electrolyte can't come out.

Now the solar cell is ready to produce electricity. When it is put into the sun, the energy of sun-light particle called photon is absorbed by the dye atom's electrons. The dye atom's electrons are excited and leave the dye atoms. The TiO_2 paste is used as a nonporous path for the electrons to move to the photo-electrode. If a closed path is made with the two electrodes by connecting a load, then the excited electrons will flow to the closed path that's can deliver power to the load.

VI. ADVANTAGES OF DSSCs

The DSSCs have the following advantages over the conventional silicon solar cell:

- Relatively inexpensive
- Made in non-vacuum setting mainly at room temperature
- Relatively simple manufacturing process
- Need little TLC
- Thin, lightweight, flexible
- Short return on investment
- Takes approx 3 months to produce energy savings equivalent to cost of production

VII. CONCLUSION

Although there are few disadvantages in DSSCs, yet it is more effective and efficient system to produce electricity. This Solar Energy is inexhaustible and pollution free i.e. green product. Bangladesh is expecting very much power according to its electricity demand and DSSCs is one of the important, prosperous and effective processes to produce electricity in the near future. We hope that it will play an important role to fulfill the power crisis of Bangladesh in the nearest future.

VIII. ACKNOWLEDGEMENTS

The authors would like to thank 'University of Oldenburg, Germany', 'Rajshahi University of Engineering & Technology (RUET), Bangladesh' and 'Pabna University of Science and Technology (PUST), Bangladesh', for giving the chance to use different equipments of Photovoltaic and Nanotechnology lab to give various ideas and knowledge successfully.

REFERENCES

[1] "Dye-Sensitized vs. Thin Film Solar Cells", European Institute for Energy Research, 30 June 2006
[2] B. O'Regan and M. Grätzel, "A Low-Cost, High Efficiency Solar Cell Based on Dye-Sensitized Colloidal TiO2 Films," Nature 353, 737 (1991).
[3] Qifeng Zhang, Guozhong Cao, "Nanostructured photoelectrodes for dye-sensitized solar cells" NanoToday (2011) 6, 91—109
[4] M. Grätzel, Inorg. Chem. 44 (2005) 6841—6851.
[5] J. Perlin, National Renewable Energy Lab., Golden, CO., US,2004.
[6] Shah, H. Schade, M. Vanecek, J. Meier, E. Vallat-Sauvain,N. Wyrsch, U. Kroll, C. Droz, J. Bailat,Progr. Photovoltaics:Res. Appl. 12 (2004) 113—142.
[7] K. Chopra, P. Paulson, V. Dutta, Progr. Photovoltaics: Res.Appl. 12 (2004) 69—92.
[8] M. Grätzel, J. Photochem. Photobiol. C: Photochem. Rev. 4(2003) 145—153.
[9] Hagfeldt, M. Grätzel, Acc. Chem. Res. 33 (2000) 269—277.
[10] H. Hoppe, N. Sariciftci, J. Mater. Res. 19 (2004) 1924—1945.
[11] D. Wohrle, D. Meissner, Adv. Mater. 3 (1991) 129—138.
[12] M.F. Hossain, "Introduction to Dye Sensitized Solar Cells in Bangladesh", ICECTE2012: PI-0017
[13] http://members.aol.com/WSRNet/tut/absorbu.htm, http://csep10.phys.utk.edu/astr162/lect/light/absorption.html
[14] M. Grätzel, "Dye-Sensitized Solar Cells," JPhotochem. Photobiol.C - Photochem. Rev. 4,145 (2003).
[15] M. Grätzel, "The Advent of Mesoscopic InjectionSolar Cells," Prog. Photovoltaics 14, 429 (2006).