DETERMINATION THEEFFICIENCY OF SOLAR CELL DERIVED FROM POINSETTIA DYE EXTRACTION

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Abstract

In this research, the natural dyes, Poinsettia leaves were used as photosensitizer. These dyes were measured with ethanol solvent at different temperatures (25℃,45℃,65℃). The absorbance and energy levels of the dye solution were characterized using UV-Vis Spectroscopy measurement. XRD measurement was used to know the purification and structural properties of TiO_2 powder. The sandwich structure of DSSC consisted of TiO_2as photo electrode, carbon layer as counter electrode, poinsettia as photosensitizer and electrolyte as electron transfer media. The efficiencies of DSSC were calculated by using I-V measurement.

Keywords – Natural Dye, TiO_2, UV-Vis, XRD

Introduction

Dye Sensitized Solar Cells (DSSCs) are device that convert solar to electric energy by light sensitization established on wide energy band semiconductor. A DSSC is the third generation photovoltaic device for low cost conversion of solar energy into electrical energy. DSSCs have received an increasing interest due to the simple fabrication process and relatively high conversion efficiency. Moreover, DSSCs is gaining traction due to their unique advantages such as flexibility and low manufacturing cots. The principle operation of DSSCs is based on sensitization of a wide band gap metal oxide semiconductor to the visible region by an absorbed molecular dye. TiO_2 is a potential material for Dye Sensitized Solar Cells (DSSCs. The DSSC consists of a dye sensitizer, a metal oxide semiconductor, an electrolyte and transparent conductors which are responsible for determining the efficiency.

Experimental Procedure

Preparation of Natural Dye

In this research, Poinsettia Leaves were used as sensitizer. Firstly, Poinsettia leaves were washed with distilled water and cut into small pieces. After that, 10 g of sample was mixed with 200 ml of ethanol and the samples were stirred using magnetic stirrer at 25℃, 45℃ and 65℃ for 1 hr respectively. The procedure continued with the filtration of the samples to remove large residue. Subsequently, the extracts were centrifuged at 4000 rpm using a Denley BS 4000 (UK) centrifuge machine for 10 minutes to separate any remaining residues. The band gap energy of these dyes was determined by UV-Vis spectroscopy measurement.

Preparation of Glass Substrate

Indium doped Tin Oxide (ITO) glass sheets with resistance of 10 Ω were cut into 25 cm square pieces. Each of the sheets was cleaned with ethanol and rinsed with deionized water.

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Preparation of photo electrode

Titanium Dioxide (TiO_2) powder was used as photo electrode material. TiO_2powder was checked by X-Ray Diffraction (XRD) method.TiO_2 paste was prepared by adding 1 g of TiO_2 powder and 3 ml of ethanol solvent and then grinding the mixture for an hour at 180℃. TiO_2 paste was deposited on the ITO glass substrate by rolling method. And then, the electrodes were immersed in the dye solution and kept overnight at room temperature to absorb the dye on theTiO_2 surface. They were kept in the dye until being used in a cell.

Preparation of counter electrode

Carbon powder was used as carbon catalyst counter electrode. Firstly, 1 g of carbon was put in a mortar and pestle. And then, 3 ml of ethanol was poured drop by drop into a mortar and pestle. After grinding for 1hr, the carbon solution was obtained. The glass sheet was coated by using spray method.

Preparation of Electrolyte

1 g of iodine and 2 ml of ethanol were mixed in a beaker. The mixture was dissolved for 30 min and brown solution was obtained.

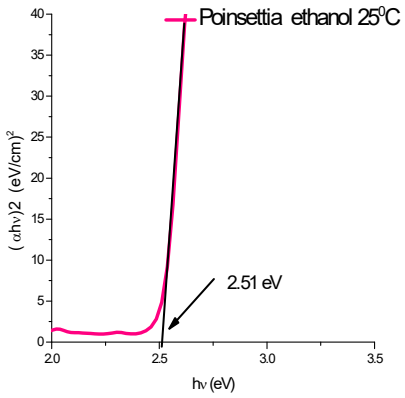
DSSC Assembly

DSSC is composed of five elements: two transparent conductive substrates, TiO_2 layer Carbon layer, dye molecules and electrolyte. Firstly, TiO_2 photo electrode and carbon counter electrode were assembled to form a solar cell. And then, a drop of iodine electrolyte solution was sandwiched between the positively and negatively charged electrodes and clipped together to form a complete cell. The photo electric conversion efficiency measurement was carried out using I-V measurement.

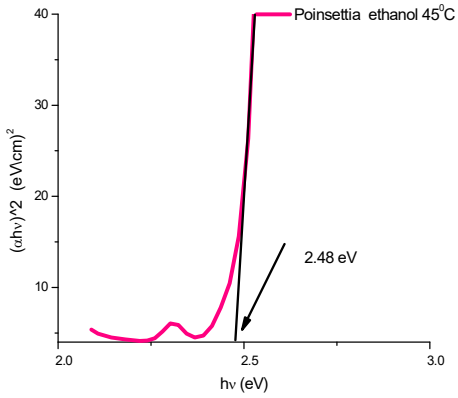
Results and Discussion

UV-Vis Analysis

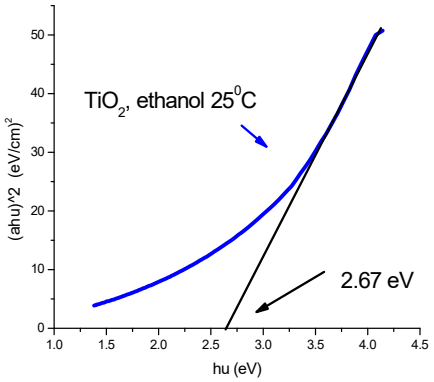
The energy band gaps were examined from UV-Vis Spectroscopy measurement. By using Tauch Mehod, $(\alpha h\nu)^2 = A(h\nu - Eg)^n$,the energy band gaps of the dyes andTiO_2 photo electrode were obtained as shown in Fig 1 (a-d) and the results were listed in Table (1) Table (2).



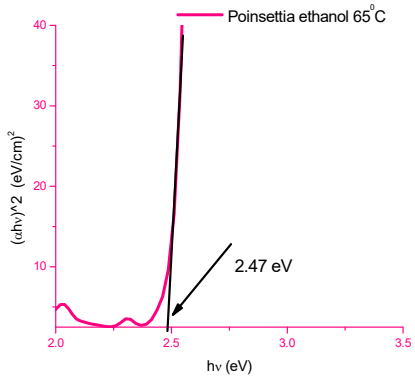
(a) Poinsettia Dye at 25℃



(b) Poinsettia Dye at 45℃



(c) Poinsettia Dye at 65℃



(d) TiO_2 photo electrode

Figure 1(a-d) The relation between energy (hν) and $(\alpha h\nu)^2$

Table 1 Energy band gap for Poinsettia Dye with Ethanol at 25℃, 45℃, 65℃

Temperature (°C)	Wavelength (nm)	Energy Band gap (E_g)(eV)
25	492	2.51
45	498	2.48
65	499	2.47

Table 2 Energy band gap for TiO_2 photo electrode at 25°C

Temperature(°C)	Wavelength (nm)	Energy Band gap (E_g)(eV)
25	462	2.67

XRD Analysis of TiO_2 photo electrode

XRD analysis was carried out to study the phase assignment and crystallographic properties of TiO_2 powder. According to XRD result, eight distinct peaks as shown in Fig (2) were observed such as (101), (103), (004), (112), (200), (105), (211) and (204). All peaks were well matched with the standard profile of TiO_2. Thus, the sample of TiO_2 was indicated the pure phase. The crystallite size was calculated by Debye Scherer equation using FWHM and Bragg angle obtained from the XRD data. From calculated result, the crystallite size of TiO_2 was 39.949 nm.

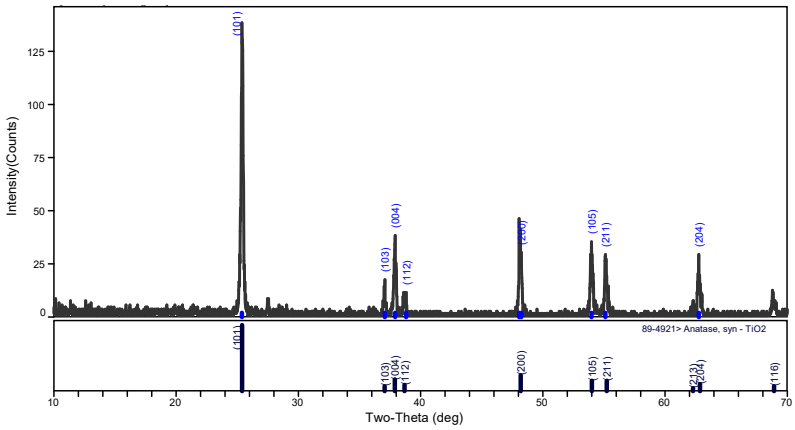


Figure 2 XRD Spectrum of TiO_2

Photovoltaic analysis of DSSC

The current-voltage characteristic of the solar cell was studied by I-V measurement. The I-V characteristic of the dye at 25℃ was shown in Figure (3). The photovoltaic parameters ofDSSC were obtained from I-V data and the results were shown in Table (3). The Fill Factor and total energy conversion efficiencies were calculated using equations(1) and (2)

$$FF = [(I_{max} \times V_{max})/ (I_{sc} \times V_{oc})] \quad (1)$$

$$\eta = [((I_{max} \times V_{max})/ P_{in}) \times 100] \quad (2)$$

Where, I_{max} and V_{max} denote the maximum output value of current and voltage respectively. I_{sc} and V_{oc} denote theshort circuit current and open circuit voltage respectively. And, P_{in} is the energy of incident photon.

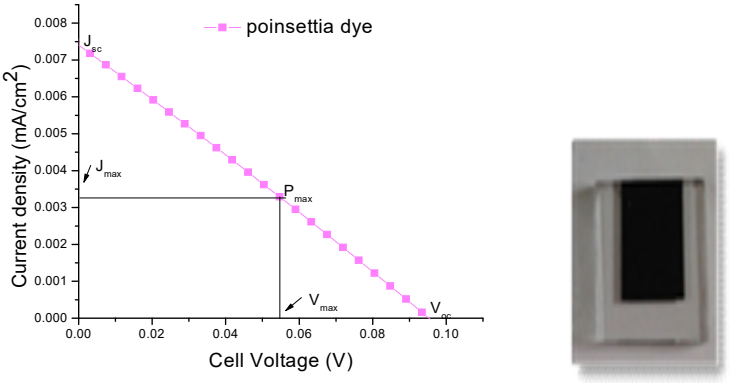


Figure 3 I-V characteristics of poinsettia dye sensitized TiO_2 based DSSC

Table 3 The photovoltaic parameters of the DSSC sensitized for three dyes

Dye	I_{max} (mA/cm^2)	V_{max} (V)	J_{sc} (mA/cm^2)	Voc (V)	Efficiency (%)	FF
Poinsettia	3.96×10^{-3}	0.0461	7.40×10^{-3}	0.096	0.75	0.2582

Conclusion

Poinsettia dyes were studied for photovoltaic applications. From UV-Vis measurement, the band gap energies of the dyes were similarly equal. The band gap energy of the dye (2.51 eV) at 25˚C wasalmost matched well with that of TiO_2 photo electrode (2.67eV). According to XRD result, the powder of TiO_2 was pure and crystallite size was 35.349 nm. From I-V measurement, photovoltaic parameters of DSSC were obtained. Fill Factor and efficiency of the dye were 0.2582 and 0.75 %. Therefore, solar energy to electrical conversion efficiency was very low. Advanced fabrication procedure followed many result in obtaining good efficiency measurement. The photo electrode presents nanowire, nanotube, nanorod and nanofiber can also be performed to extend present research work.

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References

O. Adedokun*et al.,* (2016) *"*Review on Natural Dye -Sensitized Solar Cells (DSSCs)."*International Journal of Engineering Technologies*, vol.2, pp. 34-41

S.A.Taya*et al.,*(2013) "Dye -Sensitized Solar Cells using fresh and dried natural dyes." *International Journal of Materials Science and Application*, vol.2, pp. 37-42

D.Wook Chang *et al.,*(2014)" Graphene in photovoltaic applications: organic photovoltaic cells (OPVs) and dye -Sensitized Solar Cells (DSSCs)." *Journal of Materials Chemistry*, vol.2, pp. 2

R.Oommen *et al.,*(2012) " Optical Characteristic of TiO_2 thin films sensitized with the natural dye of ClitoriaTernatea." *International Journal of Applied Physics and Mathematics,*vol.2, pp. 439

P.Murugakoothan*et al.,* (2014)"Natural Dye Extracts of Areca Catechu Nut as dye Sensitizer for Titanium dioxide Based Dye Sensitized Solar Cells. "*Journal of Nanotechnology and Electronic physics*, vol.6, pp.1