Influences mass concentration of P3HT and PCBM to application of organic solar cells

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Abstract. Poly (3-hexylthiophene) (P3HT) and [6, 6] -phenyl-C61-butyric acid methyl ester (PCBM) are used for the organic solar cell applications. P3HT and PCBM act as donors and acceptors, respectively. In this study the efficiency of the P3HT: PCBM organic solar cells as function of the mass concentration of the blend P3HT: PCBM with 1, 2, 8, 16 mg/ml. Deposition P3HT:PCBM film using spin coating with a rotary speed of 2500 rpm for 10 seconds. Optical properties of absorption spectra characteristic using a UV-Visible Spectrometer Lambda 25 and electrical properties of I-V characteristic using Keithley 2602 instrument. The results of absoption spectra for P3HT:PCBM within different mass concentration obtained 500-600 nm wavelengths. The Energy-gap obtained about 1.9eV. The organic solar cells device performance were investigated using I-V cahractyeristic. For mass concentration of 1, 2, 8 and 16 mg/ml P3HT:PCBM were obtained $0.5x10^{-3}$ %, $2.2x10^{-3}$%, $5.9x10^{-3}$ %, and $6.1x10^{-3}$% efficiency of organics solar cells respectively.

1. Introduction

Research on solar cells currently widely used organics and conjugated polymer materials[1-2]. Organics Solar cells (OSC) have attracted increasing interest as a lightweight, low-cost, and easy to process replacement for inorganics solar cells. The most efficient organic solar cells produced to date are bulk heterojunction (BHJ) photovoltaic devices based on blends of semiconducting polymers such as poly(3-hexylthiophene-2,5-diyl) (P3HT) and [6,6]-penyl-C61-butyric-acid-methyl-ester (PCBM). Conjugated polymer has a delocalized p-electrons so as to absorb sunlight, forming a carrier, the transport charges and generate electricity[3].

The efficiency of OSC increases significantly with the introduction of the bulk hetero-junction concept consisting of an interpenetrating network of electron donor and acceptor materials. The work done is to maximize the separation exciton. Exciton a pair of attraction between electrons and holes[4]. The separate of exciton the more electrons and holes are obtained. Optimization of the thickness of the active layer is one of the steps that can be taken, it relates to the diffusion length exciton[5]. Other efficiency improvement efforts done by extending the

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active region including the polymer blend insert[6]. Blending process is blending between donor and acceptor materials using solvents. Blending process can use a variety of polymer materials. The active ingredients are frequently used polymer is poly (3-hexylthiophene) (P3HT) and [6, 6] phenyl C61 butyric acid methyl ester (PCBM) [7-10].
In this article, we investigated the effect of mass concentration P3HT and PCBM in the optical and electrical properties of organics solar cells.

2. Experimental Procedure

In this study, organics solar cells based on poly(3-hexylthiophene-2,5-diyl) P3HT as donor and [6,6]-penyl-C61-butyric-acid-methyl-ester (PCBM) as acceptor were investigated. P3HT:PCBM in accordance with the variation of mass concentration of 1, 2, 8 and 16 mg/ml respectively. P3HT:PCBM were dissolved with blending methods using the ultrasonic cleaner for 30 minutes. P3HT:PCBM blend using a solvent chlorobenzena.
P3HT: PCBM film was deposited on glass substrates. The deposition was performed by spin coater instrument at 2500 rpm of angular velocity for 20 seconds [10]. The optical characterization, which is absorbance properties, of samples were then observed using a UV-Vis Spectrometer Lambda 25 type with a wavelength ranging from 300-800 nm. PEDOT: PSS was spin coated onto FTO at 2500 rpm, 20 seconds. P3HT: PCBM film were dissolved in 1, 2, 8 and 16 mg/ml at different mass concentration. by spin coater as well. The last process was metallization of Al by evaporator. The structure of organic solar cells are FTO/PEDOT: PSS/P3HT:PCBM/Al
The current–voltage characteristic in dark at room temperature was obtained using a 2602A Keithley instrument high voltage source. The performance under dark and illumination was performed to study the photosensitizing effect in the device. The device was illuminated by a visible light from xenon light source. The xenon light source was calibrated by adjusting the light intensity 1000 W/m^2 was obtained. The current-voltage of the device under illumination was recorded using a Keithley high voltage source model 2602A and a personal computer. The intensity was controlled by solar powermeter and temperature was measured by thermocouple. The illuminated cell area was 10 mm^2. The photosensitizing parameters of short circuit current density *(I_{sc})* and open circuit voltage *(V_{oc})* were obtained from the intersection axis of current and voltage from the current-voltage curve under dark and illumination, respectively.

3. Results and Discussion

Fig. 1. Shows UV-Visible absorption spectra of P3HT:PCBM layer spin coated onto glass substrates FTO prepared from different mass concentration. Initial of mass concentration at 1, 2, 8 and 16 mg/ml are WC1, WC2, WC8 and WC16 respectively.

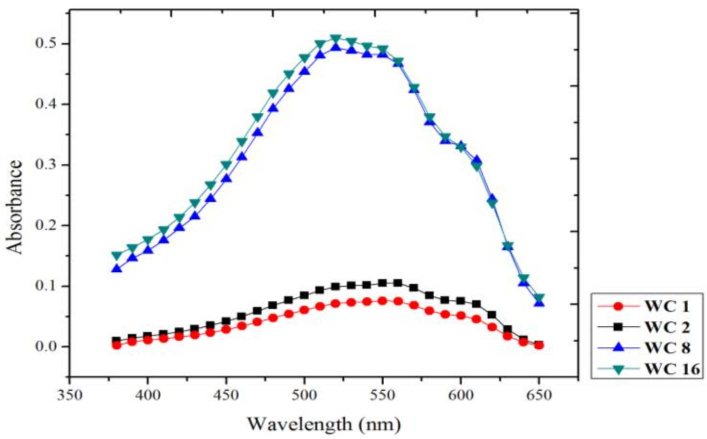

Figure 1. Absorption spectra of P3HT:PCBM in different mass concentration

The results of absoption spectra with different mass concentration have a peak maximum of absorbance 0.72; 0.10; 0.16; 0.49 and 0.51 respectively at 450-600 nm wavelengths. In the first and second peaks had relatively high difference in this case because have mass concentration against mass ratio between the PCBM and P3HT of 1:5, so that comparatively high in the second peak that P3HT.

From absorption spectra graph can determine energy-gap (*Eg*). Absorption spectra curve convert to energy (*hυ*) vs absorption coefficient $(\alpha h\upsilon)^2$ curve. The determination of energy-gap is obtained by Tauc's equation [11] . This method using draw a tangent when the chart has the highest peak and the value $(\alpha h\upsilon)^n$ is zero, Fig.2.

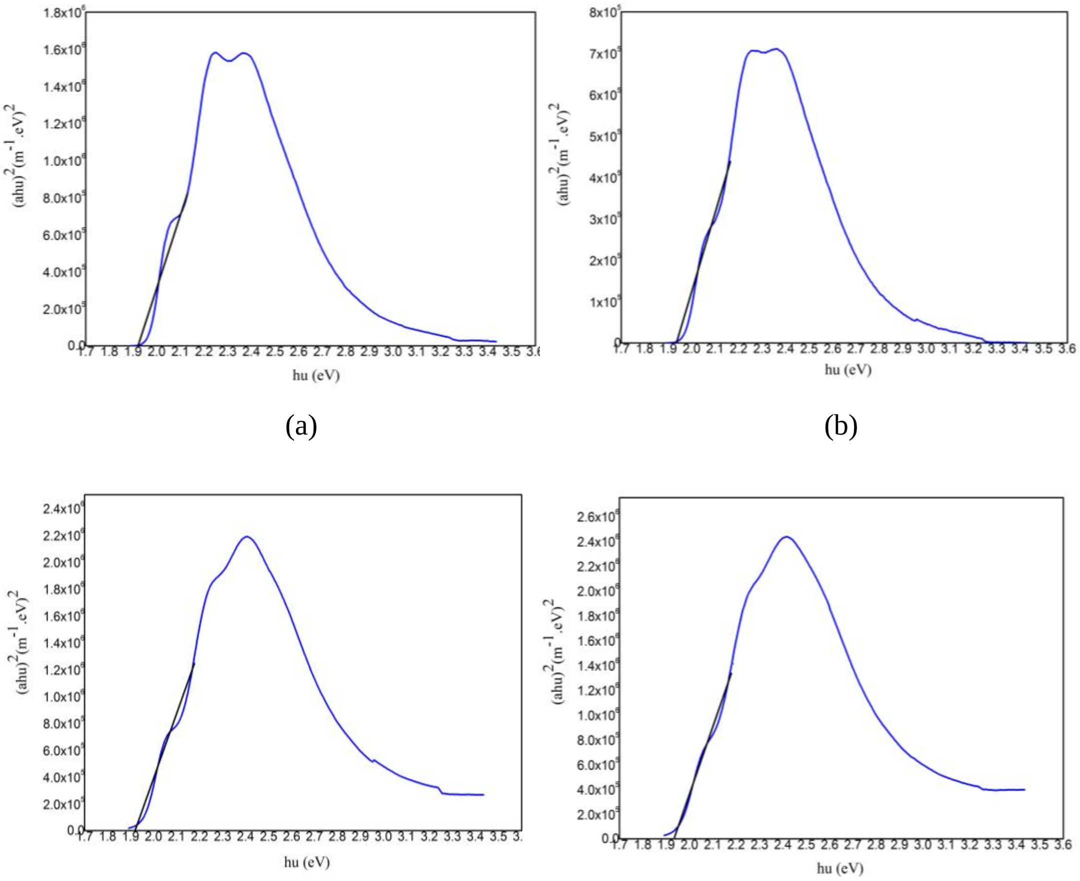

Figure 2. Curves *hυ* vs $(\alpha h\upsilon)^2$ of PCBM: P3HT of the blend mass concentration
(a) 1 mg/ml, (b) 2 mg/ml, (c) 8 mg/ml and (d) 16 mg/ml

From the graph on Fig 2, the results of tauc plot methods that energy-gap obtained 1.9 eV. The different mass concentration of P3HT:PCBM have near of energy-gap in P3HT which have 1.8 to 2.0 eV. The result calculation of energy-gap P3HT:PCBM with different mass concentration shows in Table 1.

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Table 1. Energy-gap of P3HT: PCBM with different mass concentration

Mass Concenteration (mg/ml)	E_g (eV)
1	1.933 ± 0.037
2	1.957 ± 0.036
8	1.970 ± 0.067
16	1.992 ± 0.036

Electrical properties of I-V characteristic on organic solar cells using Keithley 2602A. The OSC performance was investigated solar cells characteristic on under dark and illumination condition. The device was illuminated by a visible light from xenon light source. The xenon light source was calibrated by adjusting the light intensity 1000 W/m^2 was obtained. Measurements were taken at the dark and the light. The curve in a dark state is above the curve in light of the circumstances. In the light of the circumstances curve is used as a parameter for determine of efficiency. The results of graph I-V can be determine the value of I_{sc}, V_{oc}, FF (fill factor) and the efficiency of organic solar cells. I_{sc} is the current that occurs when a short circuit. V_{oc} is the voltage value when an open relationship.

The performance of organic solar cells in the dark and illumination. In the state of illumination are used as a parameter for determining the value of efficiency. The I-V characteristic results are showed in Fig 3.

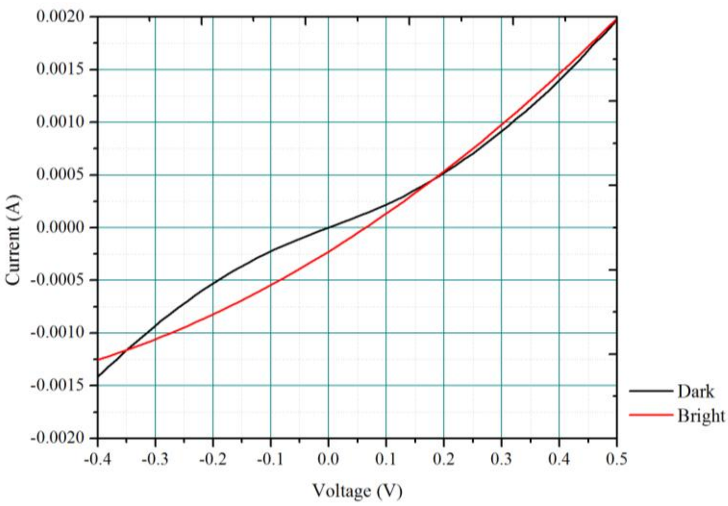

Figure 3. The I-V characteristic on dark and illumination condition of organics solar cells

Dark curve is at the top, while the light curve is on the bottom or fourth quadrant. At the time of dark state no current is flowing so dark curves are not on a four quadrant. For illumination condition of I-V characteristic with the mass concentrations 1, 2, 8 and 16 mg/ml respectively are showed in Fig 4.

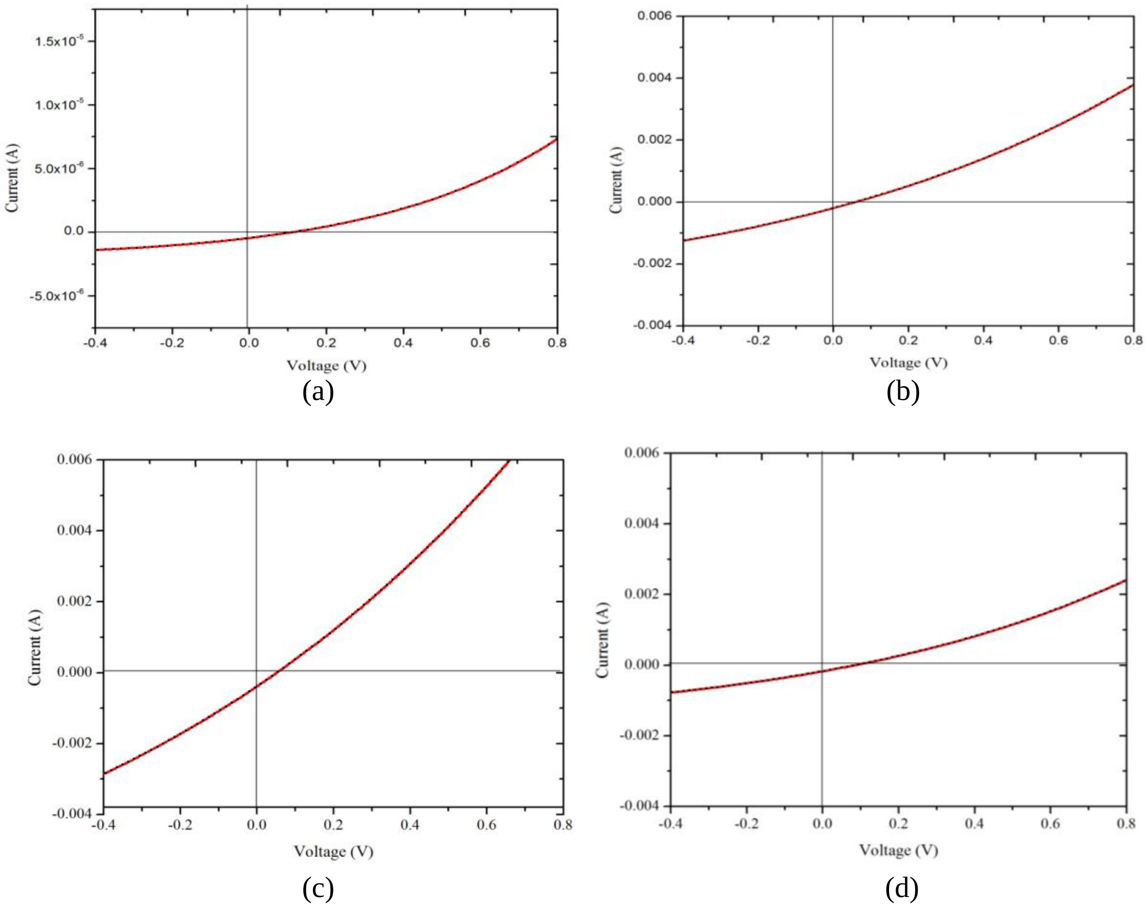

Figure 4. The I-V characteristic of P3HT: PCBM with different mass concentration :
(a) 1 mg/mL (b) 2 mg/mL, (c) 8 mg/mL and (d) 16 mg/mL

The results I-V characteristic of value I_{max}, V_{max}, I_{sc} and V_{oc} are showed in Table 2.

Table 2. The Results of organics solar cells characteristic

Mass concenteration (mg/mL)	I_{max} (10^{-5} A)	V_{max} (V)	I_{sc} (10^{-4} A)	V_{oc} (V)	*FF*	**Efficiency (x10^{-2}%)**
1	0.03	0.022	0.004	0.1111	0.15	0.02
2	6.01	0.020	1.631	0.0851	0.09	3.06
8	11.69	0.024	3.136	0.0550	0.21	7.09
16	21.30	0.017	9.438	0.0002	0.18	9.13

From Table 2 shows that, for the mass concentration of 1 mg / ml obtained 0.004 of I_{sc}, 0.1111 of V_{oc}, 0.15 of *FF* and 0.02x10^{-2}% of efficiency. For the mass concentration of 16 mg/ml was obtained 9.438 of I_{sc}, 0.0002 of V_{oc}, 0.18 of *FF* and 9.13x10^{-2}% of efficiency. This shows that the higher of the mass concentration will increasing I_{sc} and power conversion efficiency.
Absorbance value affects the value of photons that are absorbed organic solar cells. The more photons are absorbed so the more electrons are obtained. V_{oc} values associated with donor

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material HOMO and LUMO acceptor material. The resulting efficiency value also increases with the increase in the value of I_{sc}.

4. Conclusion

P3HT: PCBM blend have 1, 2, 8 and 16 mg/ml at different mass concentration. It is increasing absorption spectra in the range of about 450-600 nm. The results calculation of the energy-gap obtained about 1.9 eV. The characteristic of organics solar cells for efficiency at 1, 2, 8 and 16 mg/ml P3HT:PCBM were obtained 0.5×10^{-3} %, 2.2×10^{-3}%, 5.9×10^{-3} %, and 6.1×10^{-3}% efficiency of organics solar cells respectively. The higher of mass concentration in the active solution of P3HT: PCBM then the value of the efficiency of organic solar cells produced higher as well.

5. Acknowledgment

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