Study Fabrication Dye Sensitized Solar Cells Using The Combined Organic Polymer Poly (3-Hexylthiophene) P3HT With Extracts Dye Natural Organic

Muh. Iman Darmawan1,*, Basransyah2, Dwi Rahayu Susanti3
123Environmental Engineering, Universitas Hamzanwadi, Lombok, Indonesia
*E_mail: Darmawan@hamzanwadi.ac.id

Abstract: Energy derived from fossil the decrease and cannot renewable. Thus many experts looking at other alternatives to create new energy that is renewable and dye-sensitized solar cells (DSSC) is one of them. The study aims to determine the characteristic of the electrical properties of each dye material natural organic, characteristic of the electrical properties of the dye material combined with Poly(3-Hexylthiophene) (P3HT). Sample testing conducted at the Laboratory of UV- Vis Spectroscopy, P3HT electrical properties combined with dye extracts will be investigated using IV Meter El – Kahfi. Test optical properties, electrical properties, and I-V characterization of the DSSC using UV Visible Spectrophotometer 1601 PC and Keilay Type 2600A, respectively.

1. Introduction

Highly energy demand of our world onto fossil fuels has posed several drawbacks since fossil fuels are nonrenewable, causing many environmental problems and are likely not to continue to remain abundant for the next generations[1]. Therefore, the search for alternative renewable energy technologies is of crucial importance for the sustenance and development of modern society[2]. One of the possible solutions to the energy challenge is to make efficient use of solar energy, which is abundant, long-lasting and clean. Solar cells are being the most area of interest in solar energy utilization because it can directly convert the solar energy to electricity[3].

Nowadays it is quite usual to focus on the generation of electricity on renewable energies[4]. Solar energy is regarded as one of the most perfect energy sources that have the largest potential to cater to the growing energy need without an appreciable greenhouse effect [5]. Many were to use energy derived from the sun very abundantly. As seen on herbs converts sunlight into the chemical energy to the proses of photosynthesis [6]. Solar energy is one of the energy is actively to develop[7]. One application is to use solar energy in the conversion of light energy into electricity the solar cells. So, the term” solar energy” have the meaning convert sunlight directly or electrical energy to heat energy[8].

A typical dye-sensitized solar cell (DSSC) consists of a dye-adsorbed TiO2 photoanode counter electrode (CE), and iodide electrolyte[9]. The counter electrode Plays a key role in regulating the DSSC performance by catalyzing the reduction of the iodide-triiodide redox species used as mediators to regenerate the sensitizer after electron injection[10]. One of the key material issues in DSSCs is the photosensitizer, which plays a crucial role in getting a higher solar to electricity conversion efficiency. To date, overall conversion efficiencies of up to 12%,11%, and 12 % were achieved from liquid DSSCs by employing zinc, ruthenium complex and pure organic dyes, respectively [11]. Organic dye has many advantages such as high molar extinction coefficient, simple structural modification and lower cost than Ru complexes [12]. Solar cell type this or commonly known as device photovoltaic
work by converting photon of solar energy into electrical energy, based on a tape energy semiconductor dye electrolyte [13].

One of the dyes that are often used as an ingredient of photosensitizer is chlorophyll[14]. In this research used dye polymer Poly(3-hexylthiophene) (P3HT)[15][16]. Polymer Poly(3-hexylthiophene) (P3HT) is one of organic polymer much used the research as material active in solar cells based solar cells organic [17]. From her research obtained efficiency solar cells as much as 0.42%. Also based solar cell research, someone, using a mixture of nano Kristal TiO2 as electron acceptor P3HT and as an electrons donor produce 1.35% efficiency as much as[18]. The scheme operation DSSC, in general, is presented in figure 1

![Scheme Operation DSSC](image)

Figure 1. Scheme Operation DSSC[19]

DSSCs were prepared following a similar procedure to that detailed by Gratzel and coworkers[20]. A semiconductor TiO2 in DSSC does not act solely as a support for dye sensitizer but also serves as electronic electron acceptor and conductor. The performance of solar cells based on dye-sensitized solar cells (Dssc) can be seen based on the efficiency of the conversion of electrical energy [21]. DSSCs with efficiencies of up to 12% have been designed using ruthenium (Ru) based dyes but the limited availability and high cost of these dyes together with their undesirable environmental impact have led to the search for cheaper and safer dyes[22]. In the present study, a cheaper, faster, low-energy requiring and environment friendly alternative sensitizer Indigo dye was used to fabricate DSSCs[23]. Improvement of TiO2 photoactivity through nitrogen doping could be determined by the light absorption shift to the visible region. Titanium dioxide (TiO2) is one of the most important wide band gap semiconductors which are investigated for application in dye sensitized solar cells, photocatalysis, water splitting, electro- chromic devices and gas sensors[24]. The excited electrons are injected into the conduction band of the semiconductor and transported to the counter electrode. The dye molecule is regenerated by the redox system, which itself is regenerated at the counter electrode by electrons passed through a load[25]. This is in contrast to conventional silicon-based solar cells, where the semiconductor performs both tasks of light absorption and charge separation. It is quantified by band gap energy which can be calculated by the equation[26]. Dye-sensitized solar cell efficiency has been determined by current-voltage measurement. Efficiency can be seen through a curve current-voltage (I-V) generated by the solar cells. Figure 2, shows a curve I-V solar cells.
Figure 2. I-V Dssc curve[22]

On condition of the open or open circuit and the result, is zero so that it will yield maximum voltage or voltage open circuit (Voc). Pmax is a point where the maximum[27]. Solar cells produced by a fill of (Fill Factor) size of the quality of a solar cell, quantitative as well as a square of measure beyond the I-V fill curve can be obtained using the equation[28]. The current-voltage characteristics of the cells were determined by biasing the cells externally and measuring the generated photocurrents. The overall photo-conversion efficiency is calculated from the integral photocurrent density (Isc), the open circuit photocurrent (Voc), the fill factor of the cell (ff), and the intensity of incident light (Ils) using the formula

\[
FF = \frac{V_{max}}{V_{oc}}
\]

\[
P_{max} = V_{oc}I_{sc} FF
\]

\[
\eta = \frac{P_{max}}{P_{cahaya}}
\]

This is what the being of a measure the efficiency global in determining the quality of performance a solar cell[29]. The efficiencies of DSSCs are determined mainly by the sensitizer used. The dye as a sensitizer plays a key role in absorbing sunlight and transforming solar energy into electrical energy[30].

2. Method

The titanium isopropoxide is purchased from Sigma Aldrich and used as titanium precursor. The isopropanol and nitric acid are purchased from Merck and dye Cellosia Argentum and combined using P3HT material. TiO2 used in this research is titanium dioxide 21 nm. TiO2 about 0.5 gram dissolved in 1.5 ml ethanol stirred for 30 minutes use vortex stirrer. TiO2 superimposed into the glass conductive Fluorine Tin Oxide (FTO) with if 2 cm x 2 cm uses the spin coating. A layer of TiO2 already heated at a temperature of 5000C for 60 minutes on a hot plate. In this research used dye of P3HT of being dissolved 1% to chloroform. That is used is a construction executive DSSC system a sandwich.

An electrode in the form of his best work inside the glass conductive FTO that has been plated TiO2 that had already been soaked with dye P3HT material. The electrode of an opponent in the form of glass conductive FTO that has been plated a thin coating of Pt (hexachloroplatinic (IV) acid 10 % an electrolyte made of KI added I2 0.127 gr is dissolved by 10 ml PEG, opponent and given a working electrode using a keyboard to avoid possible protector for current a short circuit.
3. Result and discussion

An extract made from a dye solution can absorb and continue the spectrum visible light. Some of the dye extracts P3HT 1% as well as of their dye stuff DSSC use the extraction of organic matter as dye sensitizer has been done. Testing the extraction of organic matter uses UV spectrophotometer highly visible 1601 PC to know absorbance resources from the extraction of organic matter against a wavelength looked. Measured in the spectrum absorbance 200-800 nm. Until the spectrum characterization absorbance figure 3 shows that spectrum absorption extract organic material is in 300 until 800 nm.

![Absorption P3HT 1%](image)

**Figure 3. Absorption P3HT 1%**

Characterization current-voltage (I-V) is a method of underway to find out the performance of DSSC at promised to supply the extent to which unsolved the ability of DSSC can convert light to become the electric energy the measurement of I-V made in the condition of the darkness and the light at promised to supply under the illumination of a lamp the halogens with intensity as much as 100 mW/cm2. The current-voltage (J-V) characteristics under illumination as well as in dark, of the devices, were recorded using a Keithley source meter (model 2400)(Mohr et al., 2015). A xenon lamp coupled with AM 1.5 optical filter (100 mW/cm2) was used as a light source for illumination. The incident photon to current conversion efficiency (IPCE) of the devices was measured using a monochromator and xenon lamp as a light source and the resulting photocurrent was measured with source meter under short circuit condition. To value the conductivity of DSSC to see from the figure below.
Figure 4. Curve I-V Natural Organic

Of figure showing curve I-V Characterization value from organic matter of light is greater than the current dark efficiency produced by DSSC extract using organic matter combined with P3HT 1% difference in treatment. TiO2 is presented in the table to research it uses electrode counter Pt (Hexachloroplatinic (IV) acid 10%).

| Dye + P3HT 1% | Vmax  | I max  | Isc    | Voc    | FF     | Ef %   |
|--------------|-------|--------|--------|--------|--------|--------|
| *Cellosia Argentum* | 2.4 x 10^{-1} | 7.3 x 10^{-4} | 1.1 x 10^{-3} | 4.2 x 10^{-1} | 4.9 x 10^{-7} | 9.5 x 10^{-2} |

Efficiency in research is still relatively low. It was because organic material having the nature of mobility low and combination easily and also on use electrolyte liquid. Where electrolyte the longer used the up because and produce a catalyst transfer yet optimal. According to a function of electrode or change if the electrolyte is not even so effective transfer of electron will be reduced.

4. Conclusion

*Dye-Sensitized Solar Cells* (DSSC) used the extract organic material and combined with P3HT 1% have been in the fabrication. With the introduction of current and voltage is produced. If a curve show DSSC of an extract organic material with a method of soaking producing curves I-V good. Electrode opposed to is one of the important components unusual released on the structure of DSSC. The provision of Pt (Hexachloroplatinic (IV) acid 10%) on an electrode opposed to giving some of from that fare particularly better on DSSC. Pt (Hexachloroplatinic (IV) acid 10%) serves as a catalyst in speed up a reaction redoks with an electrolyte. The efficiency with which produced by each part severally and distinct each part severally and distinct org- prices of staples pushed up the costumers. The things that need to be advised to further research are to improve the structure of DSSC performance and better efficiency. Using electrode material opposed to others has its conductivity and the nature of the catalysts better.

Acknowledgment

Research say thank you to laboratory FMIPA Universitas Sebelas Maret Surakarta.

Reference

[1] D. Pathak, T. Wagner, T. Adhikari, and J.-M. Nunzi, “AgInSe2. PCBM. P3HT inorganic organic blends for hybrid bulk heterojunction photovoltaics,” *Synth. Met.*, vol. 200, pp. 102–
108, 2015.

[2] C. Kusumawardani and K. Indriana, “Synthesis of Nanocrystalline N-Doped TiO 2 and Its Application on High Efficiency of Dye-Sensitized Solar Cells,” vol. 1, no. 1, pp. 1–8, 2010.

[3] R. Parthiban, D. Balamurugan, and B. G. Jayaprakash, “Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy Dye-sensitized solar cell based on spray deposited ZnO thin film: Performance analysis through DFT approach,” Spectrochim. Acta Part A Mol. Biomol. Spectrosc., vol. 136, pp. 986–992, 2015, doi: 10.1016/j.saa.2014.09.121.

[4] C. Giansante et al., “Molecular-Level Switching of Polymer/Nanocrystal Non-Covalent Interactions and Application in Hybrid Solar Cells,” Adv. Funct. Mater., vol. 25, no. 1, pp. 111–119, 2015.

[5] X. X. Dai et al., “Synthesis of phenothiazine-based di-anchoring dyes containing fluorene linker and their photovoltaic performance,” Dye. Pigment., vol. 114, no. C, pp. 47–54, 2015, doi: 10.1016/j.dyepig.2014.10.016.

[6] S. H. Kim et al., “The effect of the number, position, and shape of methoxy groups in triphenylamine donors on the performance of dye-sensitized solar cells,” Dye. Pigment., vol. 113, pp. 390–401, 2015, doi: 10.1016/j.dyepig.2014.09.014.

[7] M. Thanhaichelvan, M. Kodikara, P. Ravirajan, and D. Velauthapillai, “Enhanced performance of nanoporous titanium dioxide solar cells using cadmium sulfide and poly (3-hexylthiophene) co-sensitizers,” Polymers (Basel.), vol. 9, no. 10, p. 467, 2017.

[8] D. Wang, W. Ying, X. Zhang, Y. Hu, W. Wu, and J. Hu, “Near-infrared absorbing isoindigo sensitizers: Synthesis and performance for dye-sensitized solar cells,” Dye. Pigment., vol. 112, pp. 327–334, 2015, doi: 10.1016/j.dyepig.2014.07.017.

[9] Hardani, Cari, and A. Supriyanto, “Efficiency of dye-sensitized solar cell (DSSC) improvement as a light party TiO2-nano particle with extract pigment mangosteen peel (Garcinia mangostana),” in AIP Conference Proceedings, 2018, vol. 2014, no. 1, p. 20002.

[10] A. Supriyanto, U. M. Fadli, and A. B. Prasada, “Fabrication and Characterization of Sansevieria trifasciata, Pandanus amaryllifolius and Cassia angustifolia as Photosensitizer for Dye Sensitized Solar Cells,” in Journal of Physics: Conference Series, 2016, vol. 710, no. 1, p. 12027.

[11] Y. Qin et al., “Achieving 12.8% Efficiency by Simultaneously Improving Open-Circuit Voltage and Short-Circuit Current Density in Tandem Organic Solar Cells,” Adv. Mater., vol. 29, no. 24, p. 1606340, 2017.

[12] H. Hasniah Aliiah, “Potensi Aplikasi Bayam Merah dan Jahe Merah Sebagai DYE Pada Sel Surya Berbasis DYE (DSSC),” POTENSI Apl. BAYAM MERAH DAN JAHE MERAH SEBAGAI Dye PADA SEL SURYA Berbas. Dye, no. 6, pp. 1–146, 2016.

[13] F. Bella, C. Gerbaldi, C. Barolo, and M. Grätzel, “Aqueous dye-sensitized solar cells,” Chem. Soc. Rev., vol. 44, no. 11, pp. 3431–3473, 2015.

[14] B. Boisandi and N. Nurussannah, “OPTIMASI METODE TWO POINT PROBE UNTUK KARAKTERISASI SIFAT FOTOLISTRIK MATERIAL,” J. Akrab Juara, vol. 3, no. 1, pp. 10–16, 2018.

[15] S. A. Malik, A. Aziz, and F. H. Naning, “MORPHOLOGICAL STUDY OF CdSe QUANTUM DOTS IN POLY (3-HEXYLTHIOPHENE)(P3HT) PREPARED BY ANGLE LIFTING DEPOSITION METHOD.”

[16] S. Yao et al., “High-efficiency aqueous-solution-processed hybrid solar cells based on P3HT dots and CdTe nanocrystals,” ACS Appl. Mater. Interfaces, vol. 7, no. 13, pp. 7146–7152, 2015.

[17] U. Jabeen, T. Adhikari, S. M. Shah, D. Pathak, T. Wagner, and J.-M. Nunzi, “Influence of the dopant concentration on structural, optical and photovoltaic properties of Cu-doped ZnS nanocrystals based bulk heterojunction hybrid solar cells,” Eur. Phys. J. Appl. Phys., vol. 78, no. 3, p. 34811, 2017.

[18] T. Rath and G. Trimmel, “In situ syntheses of semiconducting nanoparticles in conjugated
polymer matrices and their application in photovoltaics.,” Hybrid Mater., vol. 1, no. 1, 2015.

[19] F. Barzegar et al., “Preparation and characterization of poly(vinyl alcohol)/graphene nanofibers synthesized by electrospinning,” J. Phys. Chem. Solids, vol. 77, pp. 139–145, 2015, doi: 10.1016/j.jpcs.2014.09.015.

[20] S. Y. Brauchli, E. C. Constable, and C. E. Housecroft, “Concentration effects on the performance of bis(diimine) copper(I) dyes in dye-sensitized solar cells,” Dye. Pigment., vol. 113, pp. 447–450, 2015, doi: 10.1016/j.dyepig.2014.09.011.

[21] S. Y. Lin and J. J. Wu, “Chemical assembly of zinc oxide aggregated anodes on plastic substrates at room temperature for flexible dye-sensitized solar cells,” Electrochim. Acta, vol. 152, pp. 61–67, 2015, doi: 10.1016/j.electacta.2014.11.108.

[22] J. Huang et al., “Dyes and Pigments Novel carbazole based sensitizers for efficient dye-sensitized solar cells: Role of the hexyl chain,” Dye. Pigment., vol. 114, pp. 18–23, 2015, doi: 10.1016/j.dyepig.2014.10.022.

[23] Y. F. Wang, W. X. Zhao, X. F. Li, and D. J. Li, “Engineered interfacial and configuration design of double layered SnO2@TiO2-ZnO nanoplates ternary heterostructures for efficient dye-sensitized solar cells,” Electrochim. Acta, vol. 151, pp. 399–406, 2015, doi: 10.1016/j.electacta.2014.11.059.

[24] M. Rajabi, S. Shogh, and A. Iraji Zad, “Defect study of TiO2 nanorods grown by a hydrothermal method through photoluminescence spectroscopy,” J. Lumin., vol. 157, pp. 235–242, 2015, doi: 10.1016/j.jlumin.2014.08.035.

[25] S. Ananth, P. Vivek, G. S. Kumar, and P. Murugakoothan, “Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy Performance of Caesalpinia sappan heartwood extract as photo sensitizer for dye sensitized solar cells,” Spectrochim. ACTA PART A Mol. Biomol. Spectrosc., vol. 137, pp. 345–350, 2015, doi: 10.1016/j.saa.2014.08.083.

[26] S. Cogal, S. Erten-Ela, K. Ocakoglu, and A. U. Oksuz, “Asymmetric phthalocyanine derivatives containing 4-carboxyphenyl substituents for dye-sensitized solar cells,” Dye. Pigment., vol. 113, pp. 474–480, 2015, doi: 10.1016/j.dyepig.2014.09.018.

[27] H. Hardani, H. Hendra, M. I. Darmawan, C. Cari, and A. Supriyanto, “Fabrication of dye natural as a photosensitizers in dye-sensitized solar cells (DSSC),” J. Phys. Theor. Appl., vol. 1, no. 1, pp. 21–28, 2017.

[28] A. Baheti, S. R. Gajjela, P. Balaya, and K. R. Justin Thomas, “Synthesis, optical, electrochemical and photovoltaic properties of organic dyes containing trifluorenylamine donors,” Dye. Pigment., vol. 113, pp. 78–86, 2015, doi: 10.1016/j.dyepig.2014.07.036.

[29] U. Mehmoond, H. Asghar, F. Babar, and M. Younas, “Effect of graphene contents in polyaniline/graphene composites counter electrode material on the photovoltaic performance of dye-sensitized solar cells (DSSCSs),” Sol. Energy, vol. 196, pp. 132–136, 2020, doi: 10.1016/j.solener.2019.12.024.

[30] D. Maheswari and P. Venkatachalam, “Enhancing the performance of dye-sensitized solar cells based on organic dye sensitized TiO 2 nanoparticles / nanowires composite photoanodes with ionic liquid electrolyte,” MEASUREMENT, vol. 60, pp. 146–154, 2015, doi: 10.1016/j.measurement.2014.10.016.