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ORGANIC SOLAR CELL BASED ON EXTRACTION OF PAPAYA (*Carica papaya*) AND JATROPHA (*Ricinus communis*) LEAVES IN DSSC (DYE SENSITIZED SOLAR CELL)

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Abstract

This article shows an experimental result of DSSCs (Dye Sensitized Solar Cell) fabrication and characterization of based on papaya (Carica papaya L.) leaves and jatropha (Ricinus communis) leaves. Chlorophyll was extracted from the both leaves as organic dye materials to replace previous solar cells based on inorganic materials such as silicon. A TCO (Transparent Conductor Oxide) was used as a substrate material that surrounds the inner layer of DSSC. TiO_2 nano particles, natural dyes, electrolytes, and counter electrode combined as an donor-acceptor layer. Thick film screen printing method is used for the adhesion of the TiO_2 layer to the substrate. Couples of iodine and tri-iodine electrolyte solution used as an electron donor layer. We designed the active area cell size of 1.8 x 1.8 cm on two layers of TCO glass substrate. The wavelength absorption measurements of extracted chlorophyll occurs in the spectrum of 300-700nm. We measured open circuit voltages (Voc) under light illuminance of 18,000 lux are 289 and 245 mV of papaya and jatropha leaves, respectively. A Sort circuit current was achieved at -17 and -6.7 µA. These cells have already reached fill factors (FF) exceeding 26% and 25%.

Keywords*: DSSC, chlorophyll, organic, papaya, jatropha leaves.*

I. BACKGROUND

DSSC (Dye Sensitized Solar Cells) have been developed to improve performance and new material solar cell since photoelectrochemical reaction was found by Gratzel [1]. This phenomenon gives a significant impact on the system of conventional-based solar cells. Development of organic solar cells has been offering cost-efficiency of production, flexible substrates, and low-cost materials [2]. In recent years, a lot of research have been done to obtain organic material substitute inorganic materials are low-cost and high efficiency from 1 to 11% [3-5]. Photosynthesis process convert light energy into chemical energy in plants is a fundamental biomimetic approach to the process of converting light energy into electrical energy in DSSC. The role of chlorophyll at leaves is to harvest the light at a certain wavelength spectrum of sunlight. The efficiencies of the DSSC up to 11% have been designed using ruthenium (Ru) based dye but limited availability and high cost [6]. Some methods have been developed to assemble the DSSC, including screen printing, simple brush printing, doctor-bladding, and spin-coating [7,8]. In this paper will be presented the result of the research combination of organic and inorganic material based on DSSC. Organic dye materials are used in the extraction are papaya and jatropha leaves that estimated has high levels of chlorophyll thus expected to absorb more photons.

II. METHOD

A. Materials

A basis substrate was used in this research is conductive (indium tin dioxide coated) transparent glass (*Aldrich corp*, TCO-ITO) cut with area of 2x2cm and surface resistivity of 15-25Ω/sq. TCO (Transparent Conductive Oxide) is a transparent conductive glass that function as the body of the solar cell and it conductive layer. This solar cell body serves as a charge flows. Nano powder TiO_2 (*Aldrich corp*., titanium dioxide) 21 nm particles size were used as photoactive layer material. Nanopori TiO_2 has a band gap energy of 3.2 eV is needed as transparent semiconductor in most solar light spectrum. In addition, the TiO2 structure that the pore size in the nanoscale will increase the system performance because nanopori structure has the characteristics of high surface area so it will increase the amount of dye that adsorpted.

Electrolyte used in DSSC consists of iodine (I^-) and tri-iodide (I^{3-}) as redox couple in the solvent. The Electrolyte-making procedures performed as follows:

- prepapring a solution of KI (Potassium Iodide) 0.5 M by dissolving 0.83 g in 1 ml of distilled water, then added 9 ml acetonitrile
- preparing solution of iodine (I2) 0.05 M by adding a solution of 0.126 g to (1)

- Mixture solution of (1) and the solution (2) was stirred with a rotary motor for 15 minutes to homogenize the solution.
- The solution was stored in sealed bottles

Counter Electrode catalyst needed to accelerate the reaction kinetics of the reduction process triiodide on TCO. The material used as a catalyst is obtained from the combustion of carbon from wax attached to TCO.

Two materials ware used in this research are papaya and jatropha leaves as organic natural dye. Those leaves was extracted by ethanol of 95% to produce their chlorophyll. The principle of extraction of chlorophyll from the leaves of papaya/jatropha performed by stages as follows:

- Papaya/jatropha leaves washed with distilled water, then dried.
- Papaya/jatropha leaves weighed 10 grams
- Papaya/jatropha leaves that had been crushed in a clean porcelain dish until smooth and put into 50 ml of 96% ethanol. Comparison of leaf: ethanol is 1:5. The function of ethanol as a solvent to dissolve the chlorophyll in the leaves of papaya/jatropha.
- Chlorophyll extract was stirred with a rotary motor for 30 minutes
- Extract chlorophyll put in dark bottles and left for 24 hours to maximize extraction process
- Chlorophyll extract was filtered with a filter paper, stored in a dark bottle that had been wrapped in aluminum foil and stored in the dark/fridge.

B. *Experimental Setup*

We design the structure of DSSC was shown in Figure 1 and 2.

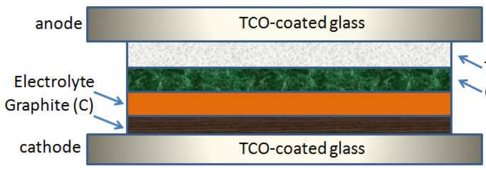

Fig. 1. Layer structure

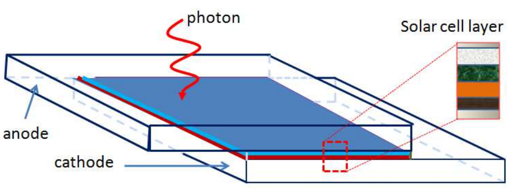

Fig. 2. Configuration of DSSC

Material layers are arranged from top to bottom in the order of substrate, TiO_2, natural dye, electrolyte, carbon counter electrode, and TCO substrate, respectively. A screen printing was applied for fabrication method of TiO_2 deposition.

C. *Measurement and Data Analysis*

Light absorbance measurement of the chlorophyll sample was used spectrophotometer. The wavelength was chosen for measurement of 200-800 nm. The experimental setup for measurement of the electricity of DSSC is shown in Figure 3. The light measured by lux meter (Lx) trough the DSSC can be varied, so the output voltage and current varied too. The second method, value of the load resistance be varied to get electricity performance of DSSC.

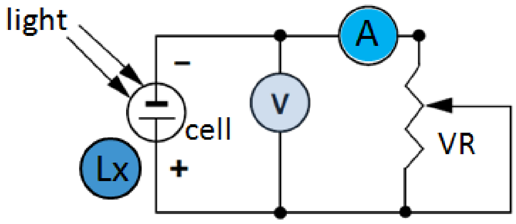

Fig. 3. Experimental setup of DSSC measurement

Some parameters were observed are open voltage circuit (Voc) and short circuit current (Isc), Vmax, and Imax to obtain fill factor (FF) and efficiency (η). The FF is defined by the rasio of the maximum power output of DSSC device its theoretical power output if both current and voltage were at their maxima, *Isc* and *Voc*, recpectively [9]. The calculation of fill factors is given as:

$$FF = \frac{I_{max} x V_{max}}{I_{sc} x V_{oc}} \quad (1)$$

III. Result and Discussion

The result of chlorophyll extractions were measured by the spectrophotometer are shown in Figure 4.

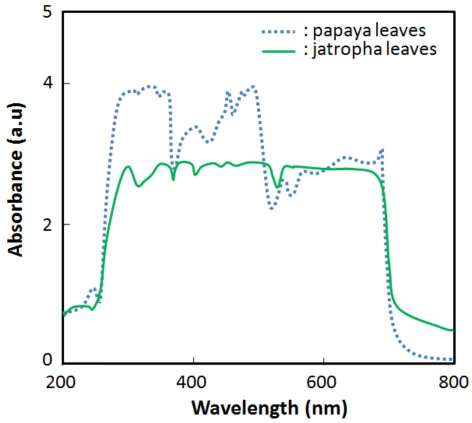

Fig. 4. Absorbance spectra of chlorophyll

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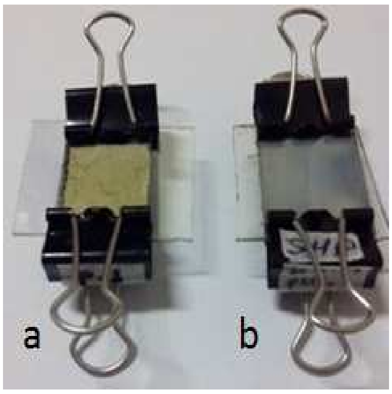

Fig. 5. Construction of DSSC
(a). Papaya leaves. (b) Jatropha leaves

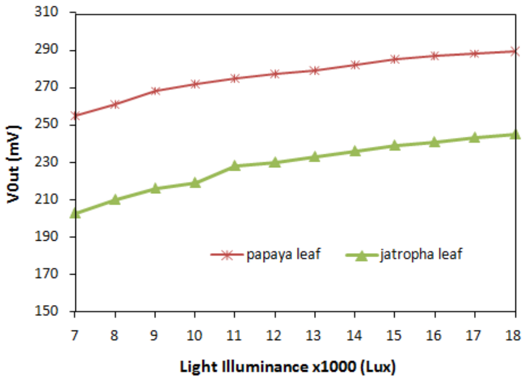

Fig. 6. Characteristic of Vout DSSC
Papaya leaves (red), Jatropha leaves (green)

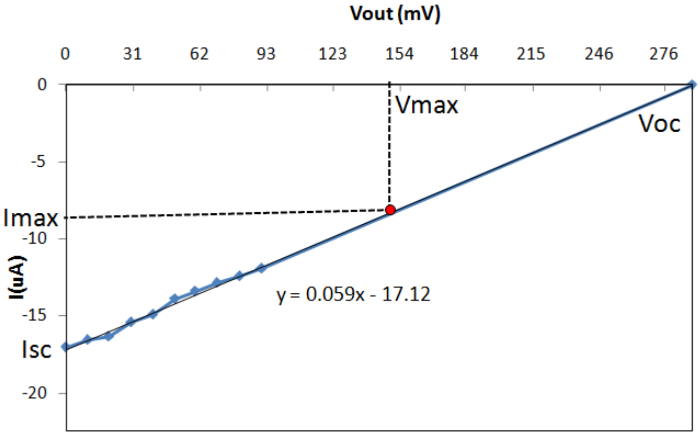

Fig. 7. Measurement Characteristic of Papaya leaves DSSC

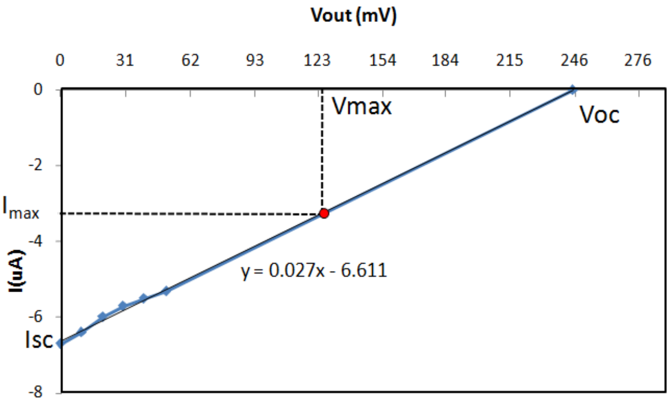

Fig. 8. Measurement Characteristic of Jatropha leaves DSSC

Figure 4 shows that there are differences in the peak absorbance values generated by the two types of chlorophyll. The average maximum peak of papaya leaves chlorophyll higher than the jatropha chlorophyll. This difference will have consequences on the rate of photon absorption and the subsequent effect on the voltage outputs produced by the DSSC. The comparison of the open circuit voltage (Voc) between papaya and jatropha leaves extraction from their DSSC that produced by DSSC are shown in Figure 6.

The construct result of DSSC is shown in Figure 5. The dimension of active area of the device is 1.8x1.8cm.

Figure 6 shows a correlation between the level of chlorophyll absorption against electrical power generated by the DSSC. The average value of the output voltage difference indicates the same value relative is 60.2 mV in the range of light intensity of 7000-18000 lux. The magnitude of the voltage generated by the two DSSC was comparable to the magnitude of the incident light radiation.

Electrical characteristic of DSSC shown in Figure 7 and 8. The maximum power point of papaya leaves chlorophyll was obtain at I_{max}, and

V_{max}, are 8.586uA, and 146mV, respectively. In the other hand, the maximum power point of jatropha leaves was obtain at I_{max}, and V_{max}, are 3.317uA, and 122mV, respectively. Figure 7 and 8 show the characterization of the output voltage against current is increasing linearly. Comparison between two cells, the key of DSSC parameter have already reached fill factors (FF) up to 26% and 25%.

IV. Conclussion

According to the result of this experiment, we conclude that DSSCs (Dye Sensitized Solar Cell) have been fabricate based on papaya (*Carica papaya* L.) leaves and jatropha (*Ricinus communis*) leaves. Chlorophyll was extracted from the both leaves as organic dye materials. We designed the active area cell size of 1.8 x 1.8 cm on two layers of TCO glass substrate. The wavelength absorption measurements of extracted chlorophyll occurs in the spectrum of 300-700nm. We measured open circuit voltages (Voc) under light illuminance of 18,000 lux are 289 and 245 mV of papaya and jatropha leaves, respectively. A Sort circuit current was achieved at -17 and -6.7 µA. These cells have already reached fill factors (FF) exceeding 26% and 25%.

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References

[1] O' Regan, M Gratzel. A low cost, high efficiency solar cell based on dye-sensitized colloidal TiO_2 films. Nature 353 (1991) 737-739

[2] M. Gratzel. Photoelectrochemical cell. Nature 414 (2001) 338-344.

[3] S. Ito, T. N. Murakami, et.al, Fabrication of thinfilm dye sensitized solar cell with solar to electric power conversion effieciency over 10%, Thin Solid Film 516 (2008) 4613-4613.

[4] M. Gratzel, Photovoltaic Performance and long-term stability of dye-sensitized solar meosocopic solar cell, C. R. Chimie 9 (2006) 578-583.

[5] S. Ito, P. Chen, P. Comte, et. al, Fabrication of Screen Printing Pastes From TiO2 Powders for Dye-Sensitized Solar Cells. Prog. in Photovolaics: Research and Applications (2007) DOI: 10.100/pip. 768.

[6] M. Syahid, et. al, Recent Advancement in natural dye applications: a review. Jurnal of Cleaner Production (2013) 1-22.

[7] I. K. Ding, J. M. Kyriazi, N. L. Cevey-Ha, et.al, "Deposition of hole-transport materials in solid-state dye-sensitized solar cells by doctor-blading, Organic Electronic 11 (2010) 1217-1222.

[8] S. S. Kim, et. al, Annealing-free fabrication of P3HR:PCBM solar cell via simple brush painting, Solar Energy Material and Solar Cell 94(2010) 171-175.

[9] V. W. W. Yam , *WOLEDs and Organic Photovoltaics*. New York: Springer-Verlag, 2010, ch. 1

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