Performance of natural chlorophyll *Amaranthus* and *Carica Papaya* dye on TiO_2 coating in the making of dye sensitized solar cell (DSSC) through the spin coating method

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Abstract. The natural dye extracted from Amaranthus dye and Carica Papaya dye which has been prepared in ethanol solution as a sensitizer on DSSC. The Spin coating method is used so that the deposition on TiO_2 gets a homogeneous thin layer on the active area of the FTO substrate. The dye solution was tested for characterization using the Elkahfi I-V Meter and UV-Vis 1601 while the FTO structure substrate that had been prepared as a sandwich was tested using Keithley I-V type 2602A. The result of absorbance of dye is at a wavelength of 400 nm - 800 nm and there is also a shift in wavelength and peak absorption of the dye. The greatest efficiency was obtained from chlorophyll amaranthus which is 0.407% while chlorophyll Carica papaya obtained an efficiency of 0.321%. In the combination of Amaranthus dye and Carica papaya dye, the efficiency was 0.526%. High efficiency on TiO_2 electrodes shows good performance on Dye-sensitized solar cells.

Keywords: Spin coating method, TiO_2 paste, Amaranthus and Carica Papaya dye chlorophyll, Dye-sensitized solar cell (DSSC)

1. Introduction

Solar cells (DSSC) are one of the major and economic challenges of the 21st century. The ultimate goal is to create and find the best configuration of solar cells based on inexpensive and highly efficient materials in the conversion of solar energy and further test the efficiency of dye-sensitive titanium dioxide solar cells (Ari, *et* al, 2015). DSSC has also produced high-efficiency cells based on Titanium dioxide (TiO_2) nanoparticles and dye solutions on transparent glass substrates, natural dyes, and electrolyte solutions.

DSSC is composed of two parts, namely the generation of charge carried out on semiconductor dyes and the transport of the charge carried out by semiconductors and electrolytes which is an optimization of spectral properties can be done by modifying the dyes only, while carrier transport properties can be increased by optimizing the composition of semiconductors and electrolytes.

High efficiency and low-cost solar cells are needed to capture sunlight and convert light to energy (Ito, 2008). An important goal in the development of DSSC technology is also the manufacture of solar cells because of its advantages as power supply equipment. New designs and applications such as renewable resources and power for laptops, cellphones, watches, pocket calculators, etc., are expected shortly. The device related to the photosynthesis process is DSSC, first reported by O 'Regan and Grätzel in 1991, with a relatively high power conversion efficiency of 7.1-7.9%. Other parameters are the open-circuit voltage of 0.65 - 0.7 V and the charging factor of 0.68 to 0.76 V (Zeng, *et all*. 2010).

DSSC is inseparable from dye, in this case, the dye has an important role as an absorber of sunlight and converts it into electrical energy. Chlorophyll is a leaf green substance that has the function to carry out carbon assimilation in photosynthesis. Chlorophyll has a green color and is present in cells, especially in the leaves of plants so that the color of the leaves turns green. The chlorophyll used is Amaranthus dye and Carica Papaya dye (Hadiat, 2000; Aziza, 2018; Agustini, 2013).

2. Experiments

Extraction of dye sensitization for Amaranthus dye and Carica papaya dye. Amaranthus and Carica papaya are used as extraction dyes. Amaranthus and Carica Fresh papayas are taken and washed properly in ionized water and dried at room temperature for 30 minutes. The leaves are then ground with mortar using ethanol solution as solvent extraction. Dye that has been given ethanol solution is stored in a beaker and then covered with aluminum foil to prevent direct sunlight.

The dye solution is stirred for 30 minutes at a speed of 300 rpm. Then it is prepared and stored in a dark room at room temperature. TiO_2 deposition on FTO substrate with an active area of 0.8 cm x 0.8 cm using the Spin Coating method (Iwantono, *et all.* 2016) and then furnished at 400^0C. Then immersed in a dye solution for 24 hours to find out the performance of the dye on DSSC. The characteristics will be measured using a Uv-Vis spectrophotometer, test dye solution to find out the peak of the wave and the energy gap. Characteristics of conductivity values using the Elkahfi 100 / I-V Meter. After DSSC is assembled, it is continued with the current-voltage characteristic test using Keithley 2602A (Stathatos, 2012; Alfa, 2012).

3. Results and Discussion

Dye solution extracted from Amaranthus chlorophyll and Carica Papaya with ethanol solvent can absorb and continue the visible light spectrum. Tests using a Visible 1601 Spectrophotometer using a wavelength range of 400 nm-800 nm. The results of absorbance wave peaks and absorbance spectrum characterization can be seen in Table 1 and Figure 1.

Table 1. Absorbance Spectrum of Materials

Dye	**λ (nm)**	**Spectrum Absorbance (a.u)**
Amaranthus	431, 661	2,2995 dan 1,2857
Carica papaya	433, 668	1,0853 dan 0,9415
Hybrid Amarantus + Carica papaya	417, 668	1,9060 dan 1,4630

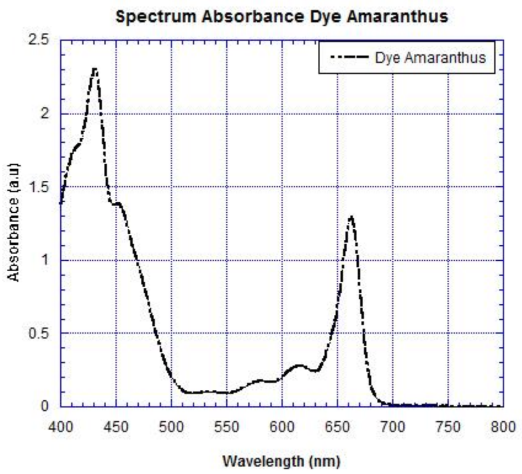
Table 2. Characterization of the Conductivity Values

Dye	**Conductivity in Dark conditions** $(\Omega^{-1}m^{-1})$	**Conductivity in Light conditions** $(\Omega^{-1}m^{-1})$	**Δ Conductivity** $(\Omega^{-1}m^{-1})$
Amaranthus Dye	$1.4\ x\ 10^{-2}$	$5.1\ x\ 10^{-2}$	$3.7\ x\ 10^{-2}$
Carica papaya Dye	$5.3\ x\ 10^{-2}$	$8.4\ x\ 10^{-2}$	$3.1\ x\ 10^{-2}$
Hybrid Amaranthus Dye + Carica papaya Dye	$5.0\ x\ 10^{-2}$	$10\ x\ 10^{-2}$	$5.0\ x\ 10^{-2}$

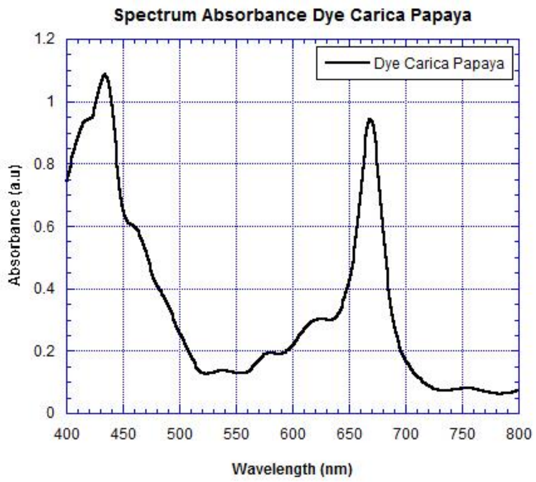
Table 3. Characterization of the Conductivity Values

Dye	V_{oc} *(mV)*	I_{sc} *x* 10^1 *(mA)*	V_{max} *(mV)*	I_{max} *(mA)*	*FF*	*Efficiency (%)*
Amaranthus Dye	545	29.58	378	27.04	0.63	0.407
Carica papaya Dye	378	28.72	227	20.32	0.36	0.321
Hybrid Amaranthus Dye + Carica papaya Dye	469	28.53	303	22.22	0.50	0.526

The conductivity values can be seen in Table 2 and the Conductivity Characterization in the dark and light conditions can be seen in Figure 2. These results indicate that both in the dark or in the light condition can conduct electricity and electrons better.



(a)



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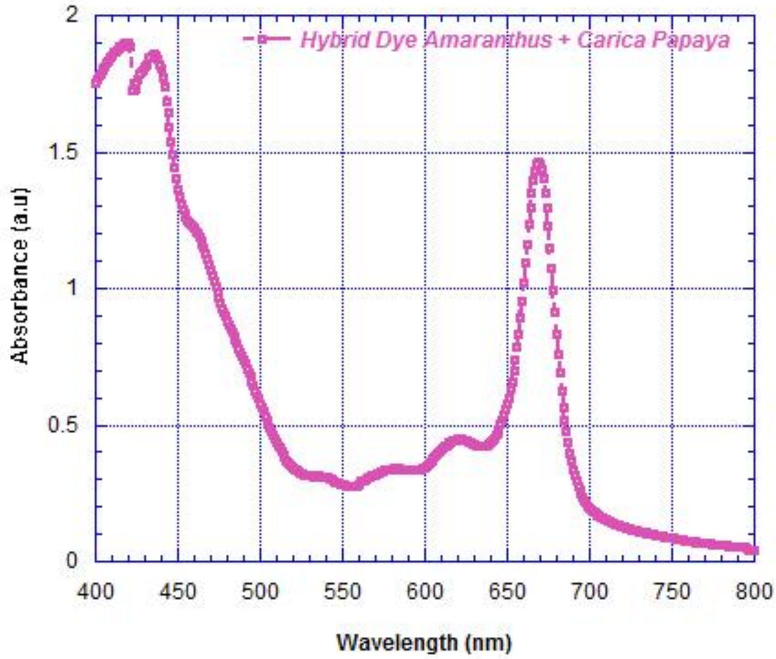

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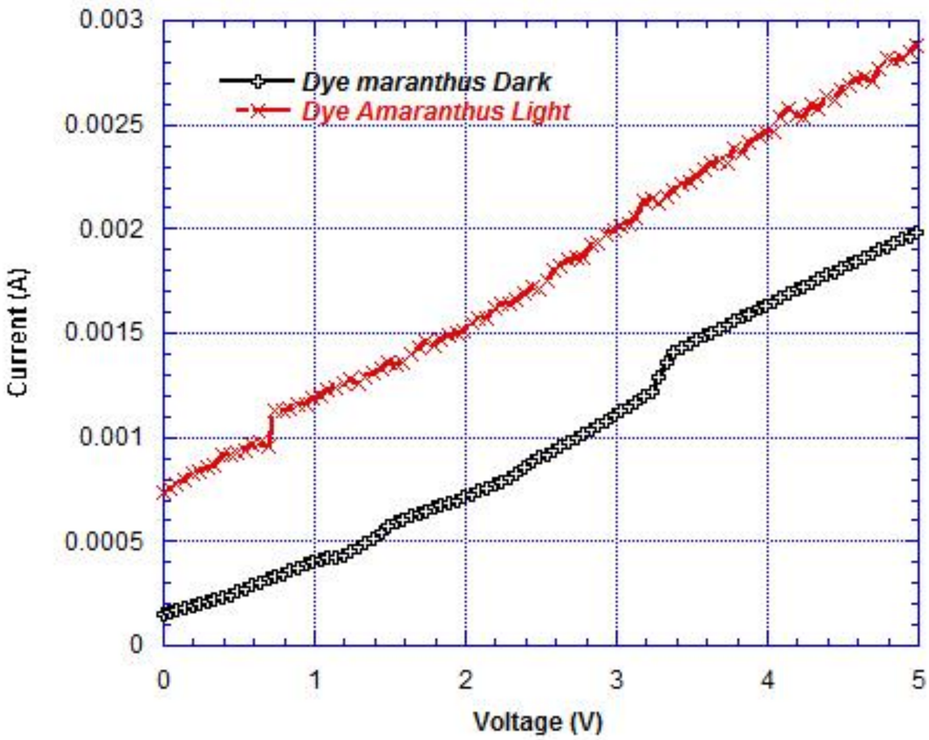
Figure 1. (a) Characterization spectrum absorbance of Amaranthus dye (b) Characterization spectrum absorbance of Carica Papaya dye (c) Characterization Absorbance Spectrum of Hybrid Amaranthus + Carica Papaya dye



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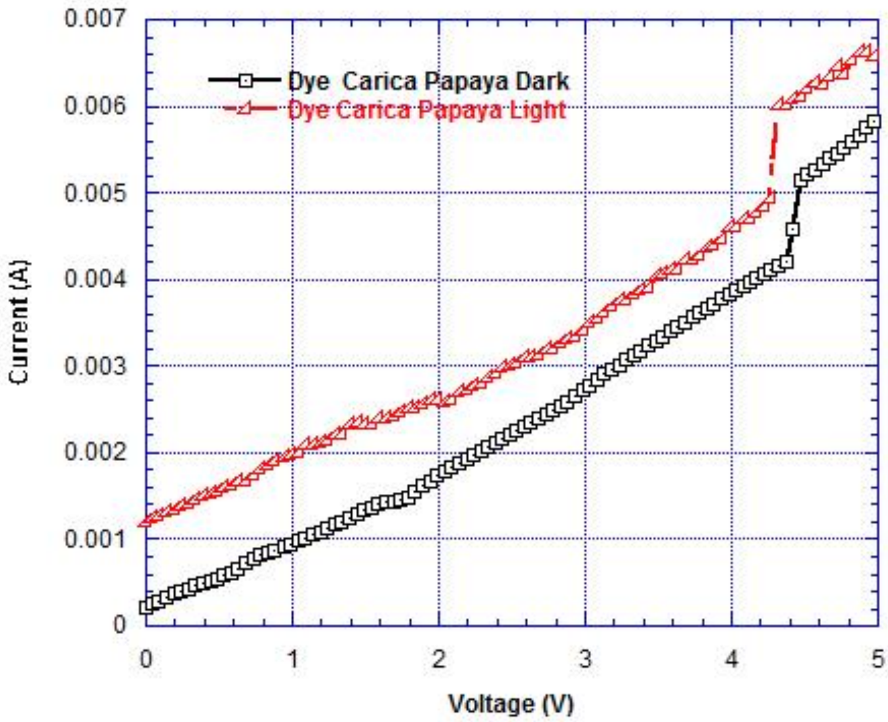

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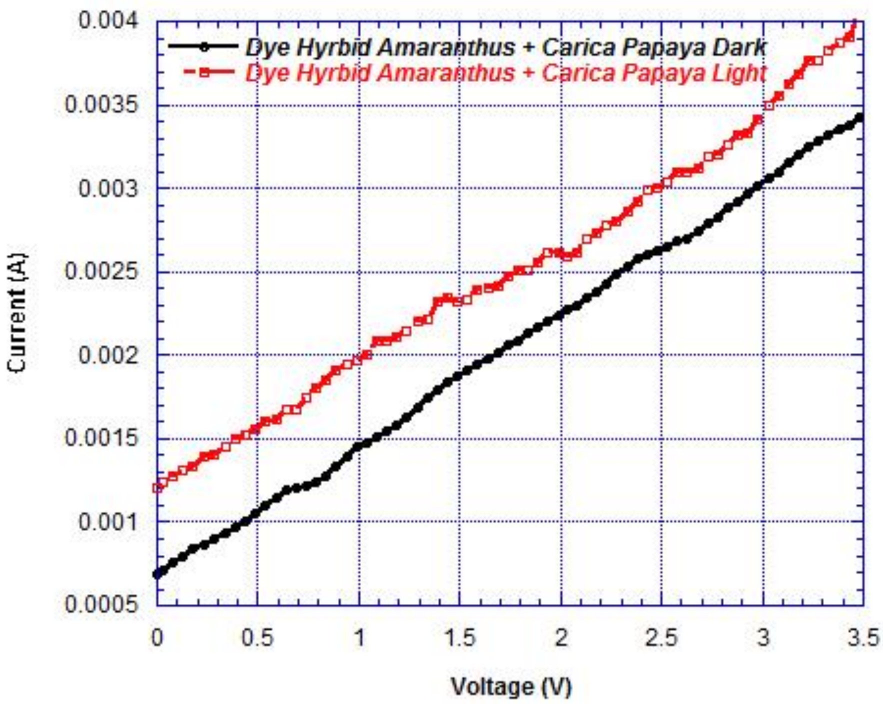

(c)

Figure 2. (a) The conductivity Characterization of Amaranthus dye (b) The conductivity Characterization of Carica Papaya dye (c) The conductivity Characterization of Hybrid Amaranthus + Carica Papaya dye

Voltage-current characterization is a method to determine the performance of Dye-Sensitized Solar Cells how much DSSC's ability can convert solar energy into electrical energy in dark and light conditions under halogen lighting. The results obtained with good efficiency can be seen in Table 3 and Figure 3. The immersion time of the FTO substrate which produces the highest efficiency value is Amaranthus dye during 24 hours immersion. Carica Papaya dye obtained an efficiency value of 0.321% and Hybrid Amaranthus + Carica papaya obtained an efficiency value of 0.526%.

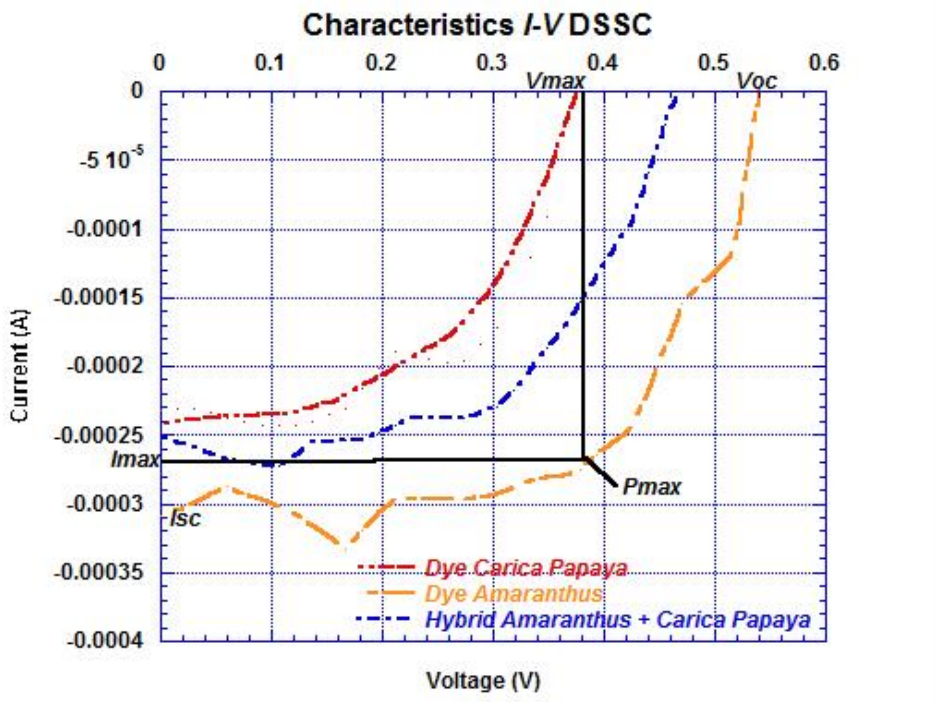

Figure 3. Characteristics of DSSC Amaranthus dye, Carica Papaya dye, and Hybrid Amaranthus dye + Carica Papaya dye

Electrolytes used are liquid electrolytes, quick to evaporate and quickly oxidized can produce catalyst transfers that are less than the maximum. So in the use of electrolytes must be carefully considered the cleanliness of pipettes and how to drip electrolytes in the FTO substrate (Arifin, *et all.* 2018).

4. Conclusion

The absorbance spectrum results obtained were light absorption in the wavelength range of 400 nm-800 nm is Amaranthus dye 431-663 nm and Carica Papaya dye 433-668 nm and Hybrid Amaranthus + Carica Papaya dye is 417-668 nm.

Carica Papaya dye absorption is more effective than Amaranthus dye. The value of the conductivity test results which have more conductive properties is Amaranthus dye. While the Keithley test value with the greatest efficiency is the Amaranthus dye of 0.407%. Soaking time for chlorophyll dye for 24 hours resulted in good performance of dye sensitivity in DSSC (Arifin, *et all.* 2019).

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