Effect of dye variation on DSSC efficiency

Muhammad Ivan Bachtiar, Muhammad Nur Putra Agustina, Lia Wahyu Hariyani, Fahru Nurosyid
Physics Department, Universitas Sebelas Maret
Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, Indonesia
Email: nurosyid@yahoo.com

Abstract. DSSC is a solar cell that utilizes a dye to absorb light [1]. One of the components affecting DSSC performance is dye. Dye serves to absorb the energy of sunlight that produces electrons. Dye has a characteristic absorption area. Only solar radiation of a certain wavelength is converted into electrical energy [2]. The red color obtained from Hibiscus extract has an efficiency of 0.0341%. The blue color obtained from Telang flower extract has an efficiency of 0.0183%. The green color obtained from pteridophyta extract has an efficiency of 0.0513%. The yellow color obtained from chrysanthemum extract has an efficiency of 0.0414%. Then the image of Universitas Sebelas Maret logo will be made on the surface of DSSC so it can add aesthetic value.

1. Introduction
The DSSC component includes a semiconductor layer on a Transparent Conductive Oxide (TCO) substrate as anode, a catalyst in the opposing electrode as a cathode, a dye as a photosensitizer, and a redox electrolyte. One of the components affecting DSSC performance is dye. Dye serves to absorb the energy of sunlight that produces electrons [3].
Dye can be derived from natural materials and synthesis. Dye synthesis from ruthenium complex is able to produce an efficiency of 11%. Although it can provide high efficiency, but synthetic dye from ruthenium complex is very expensive. Natural dye provides a lower efficiency value compared to synthesis dye. But natural dye is cheaper, because it can be obtained from plant extracts [4].
Dye has a characteristic absorption area. Dye with a certain color has a different absorption area with other dye. So that only solar radiation with a certain wavelength is converted into electrical energy [1]. Dye used in this study can be seen in Figure 1. The red color obtained from Hibiscus extract. The blue color obtained from Telang flower extract. The green color obtained from pteridophyta extract. The yellow color obtained from chrysanthemum extract. Then the image of Universitas Sebelas Maret logo will be made on the surface of DSSC so it can add aesthetic value.
2. Experimental Methods

2.1 Preparation of TiO$_2$ paste
Titanium Dioxide (TiO$_2$) nano powder 1 gram dissolved in 8 ml ethanol. The solution was stirred with a magnetic stirrer at a rate of 300 rpm for 4 hours until homogeneous. The TiO$_2$ paste is shown in Figure 2.

![TiO$_2$ Paste](image)

**Figure 2. TiO$_2$ Paste**

2.2 Extraction method of natural dye
The red dye is made of 10 grams of hibiscus dissolved in 25 ml of methanol, 4 ml of acetic acid, and 21 ml of distilled water. Green Dye made from 10 grams of pteridophyta dissolved in 50 ml acetone. The yellow dye is made from 10 grams of chrysanthemum which is dissolved in 50 ml of N-Hexane. Blue Dye is made from 10 grams of telang flower dissolved in 50 ml of distilled water. Organic material crushing using mortar into small size. Then dissolved in a solvent and allowed to stand for 24 hours. After that stirred with a magnetic stirrer for 1 hour with a rotation speed of 300 rpm. The solution is filtered with filter paper. All these processes are shown in Figure 3.

![Extraction Natural Dye](image)

**Figure 3. Extraction Natural Dye**
2.3 Preparation of Fabricate DSSC Using Spin Coating

Stickers with Universitas Sebelas Maret logo are affixed to Transparent Conductive Oxide (TCO) glass. The TiO₂ paste is deposited on the substrate by using a spin coating method with a rotation speed of 1000 rpm for 1 minute. Then TiO₂ anealed using furnace with temperature 450 °C for 30 minutes with heating rates 15. After that, TiO₂ soaked in dye solution for 24 hours. For the opponent electrode is used platinum dissolved in ethanol. The platinum solution is applied to a TCO glass over a hot plate of 200 °C. Masking tape is used on the TCO glass to avoid contact between the working electrode and the opposing electrode. Electrolyte is applied to the opposing electrode. Working electrodes and opposing electrodes are combined using a binder clip and measured I–V characteristics. All such processes are shown in Figure 4.

![Figure 4](image)

Figure 4. (a) Layer of TiO₂ in Yellow Dye (b) Layer of TiO₂ in Red Dye (c) Layer of TiO₂ in Blue Dye (d) Layer TiO₂ in Blue Dye (e) Opponent Electrode

2.4 Characterization

The quality of solar cells is often expressed with fill factor values (FF). These values indicate the great ability of solar cells to absorb the light that hit it. Fill factor (FF) is obtained from the solar cell characteristic curve expressed in terms of the equation:

\[ FF = \frac{I_m V_m}{I_{SC} V_{OC}} \]  \hspace{1cm} (1)

where \( I_m \) is the current when the maximum power, \( V_m \) is the voltage when the maximum power, \( I_{SC} \) is the current when the short circuit, \( V_{OC} \) is the voltage when there is no current flow.

The solar cell when it receives the light intensity will produce voltage (V) and current (I). The efficiency of solar cells can be obtained from the following equations:

\[ \eta = \frac{FF I_{SC} V_{OC}}{P_{in}} \times 100 \% \]  \hspace{1cm} (2)

where \( P_{in} \) is the power that goes into solar cells and FF is the fill factor in the I–V characteristics of the solar cells. \( P_{in} \) is obtained from the multiplication of radiation intensity that concerns the surface of solar cells with the extent of solar cells (Chen et al., 2009).

3. Results and Discussion

3.1 Absorption Spectra

Figure 5 shows the absorbance spectrum of hibiscus, talang flower, chrysanthemum and pteridophyta. From the absorbance chart, it can be seen that chrysanthemum flowers have a peak in the area of 450 nm. This shows that chrysanthemum flowers contain carotenoids that produce a yellow color. Hibiscus have a peak in the area of 500-550 nm. This shows that hibiscus contain anthocyanins that produce red. Telang flower has a peak in the area of 600 nm and 550 nm. This shows that the flower of the telang contains phycocyanin which produces blue. Nail plants have peaks in areas of 650 nm and 450 nm. This
shows that nail plants contain chlorophyll A which produces a green color.

![Absorption spectra](image)

**Figure 5.** Absorption spectra Natural Dye Solvent

### 3.2 I–V Characterization

Characterization of Current and Voltage is done using keithley I–V meter. Characterization uses white lights with 1000 W/m² power. The measured DSSC performance can be seen in table 1.

| Dye               | Solvent                  | Vmax   | Imax   | Pin  | Efficiency   |
|-------------------|--------------------------|--------|--------|------|--------------|
| Hibiscus          | Acetic acid, metanol,    | 0.24   | -0.0007| 0.50 | 0.0341       |
|                   | distilled water          |        |        |      |              |
| Chrysanthemum     | N-Hexane                 | 0.21   | -0.0009| 0.50 | 0.0414       |
| flower            |                          |        |        |      |              |
| Pteridophyta      | Acetone                  | 0.19   | -0.001 | 0.50 | 0.0513       |
| Telang flower     | distilled water          | 0.33   | -0.0002| 0.50 | 0.0183       |

From the table, the greatest efficiency to the smallest is as follows. Pteridophyta has an efficiency of 0.0513%, chrysanthemum has an efficiency of 0.0414%, hibiscus has an efficiency of 0.0341%, and Telang flower has an efficiency of 0.0183%. The characteristic data of I–V can be seen in Figure 6.
4. Conclusion
From UV Vis and Keithley data can be proved the theory that the wavelength is inversely proportional to energy. Telang flower has an absorbance to the highest wavelength of 650 nm and has the lowest efficiency of 0.0183%. Pteridophyta has the absorbance to the lowest wavelength of 450 nm and has the highest efficiency of 0.0513%.

5. References
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