Performance of Cosmos caudatus chlorophyll dye on TiO$_2$ nano particles coating in the manufacture of Dye-Sensitized Solar Cells (DSSC)

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Abstract. Energy derived from fossils is diminishing and cannot be renewed. Therefore many experts are looking for other alternatives to create new renewable energy, and Dye-sensitized solar cells (DSSC) are one of them. This study aims to know the characterization of the electrical properties of dye cosmos caudatus material. The research was conducted at the UNS FMIPA Materials Laboratory. This research uses the TiO$_2$ deposition method with the spin coating technique. Absorbance test using PC UV Visible Spectrophotometer 1601 and Current and voltage test (I-V) using Keithley. The efficiency produced by the Cosmos caudatus chlorophyll dye was $8.3 \times 10^{-3}$ %. These results show that some natural dyes from natural organic material extraction have an absorbance spectrum range of 300-800 nm, which has the potential as DSSC.

1. Introduction
Currently, photovoltaic technology has very much progress in the field of solar energy as an alternative and renewable energy. To produce solar cells at a low cost, there have been many models with new structures and materials currently being developed [1]. Solar panels are often called photovoltaic cells. Photovoltaics can be interpreted as “electric light” [2].

Solar energy is one of the energies that is being developed [3]. One of the applications of solar energy is its utilization in the conversion of light energy into electricity i.e. solar cells. Thus, the term "solar power” means to convert sunlight directly into heat energy or electrical energy [4]. Many ways to harness the energy coming from the sun are abundant. As seen in plants convert sunlight into chemical energy in the process of photosynthesis [5].

Now the cost of solar panels makes it impractical for everyday use where electric power “cables” are available. Currently, photovoltaic technology has great progress in the field of solar energy as an alternative and renewable energy [6]. Solar cells of this type or commonly known as photovoltaic devices work by converting photons from solar energy into electrical energy are based on the energy band gaps of semiconductors, dyes, and electrolytes [7].
Organic photovoltaics have many attractive features, among them, the potential to be flexible can be produced with simple and inexpensive techniques in terms of the cost of making them [8]. In the last two decades, M. Gratzel has invented the Dye-Sensitized Solar Cell (DSSC) as a photovoltaic device [9]. Dye-Sensitized Solar Cells have attracted attention as an energy converter compared to silicon solar cells. DSSC uses three active materials: organic dye as material that absorbs photons, nanocrystal layer of metal oxide as an electron transporting material, and liquid or metal oxide coating as a hole transporting material (HTM) [10].

One of the dyes often used as a photosensitizer material is chlorophyll [11,12,13] chlorophyll is widely found in almost all kinds of green plants. This study used the dye Cosmos caudatus. There have been many previous studies using chlorophyll dye in DSSC and the resulting efficiency is still low, to fill this problem gap, this paper attempts to present the results of research using chlorophyll dye from Cosmos caudatus with a combination of TiO$_2$ nanoparticles and platinum as control of the opposing electrode. The DSSC operation scheme is generally presented in Figure 1.

Semiconductors TiO$_2$ DSSC not only acts as a support for dye sensitizers but also serve as electron acceptance and electronic conductors [15]. The performance of Dye-Sensitized Solar Cells (DSSC) based solar cells can be seen based on the conversion efficiency of electrical energy. Efficiency can be known through the current-voltage curve (I-V) produced by the solar cell. Figure 2, showing the I-V curve of the solar cell.

In open-circuit conditions, the resulting current is zero, resulting in maximum voltage or open-circuit voltage (Voc). Pmaks is a point where the maximum power is generated by a solar cell. Fill Factor (FF) is a quantitative measure of the quality of a solar cell and is the outer size of the I-V curve square, the Fill Factor can be obtained using equations [16].
\[ FF = \frac{V_{\text{max}}I_{\text{max}}}{V_{\text{oce}}I_{\text{sc}}} \]  

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

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

This efficiency value is a global measure in determining the performance quality of a solar cell. This study aims to know the characterization of the electrical properties of dye cosmos caudatus material.

2. Research methods

TiO$_2$ used in this study is Titanium dioxide (nanopowder) with a size of 21 nm. TiO$_2$ as much as 0.5 grams dissolved in 1.5 ml of ethanol stirred for 30 minutes using vortex stirrer. TiO$_2$ is coated on fluorine tin oxide (FTO) conductive glass with a deposition area of 2 cm x 2 cm using the spin coating method. The deposition TiO$_2$ coating is heated at 500°C for 60 minutes on a hot plate.

This study used dye from Cosmos caudatus which is dissolved with ethanol. The DSSC construction used is a sandwich system. Working electrodes in the form of FTO conductive glass that has been coated TiO$_2$ that has been soaked with dye Cosmos caudatus. The opposing electrodes are FTO conductive glass that has been coated in a thin layer pt (Hexachloroplatinic (IV) acid 10%). Electrolytes made of KI 0.8 gr added I$_2$ 0.127 gr dissolved with 10 ml PEG, which is dripped between the opponent’s electrode and the working electrode is given a limiter using the keyboard protector so as not to occur short-circuit.

3. Results and discussion

Dye solutions are made from extracts that can absorb and pass on the visible spectrum of light [8]. The dye solution is made from cosmos caudatus leaf extract that can absorb and pass on the spectrum of visible light [17]. This color substance serves as Dye-Sensitized Solar Cells using the extraction of Cosmos caudatus leaves as a dye sensitizer has been done testing the extraction of Cosmos caudatus leaves using a UV Visible spectrophotometer 1601 PC to find out the absorbance of Cosmos caudatus leaf extract against visible wavelengths. Spectrum absorbance is measured in the range of 200-800 nm [18]. The rubberization of spectrum absorbance figure 3 shows that the absorption spectrum of Cosmos caudatus leaf extract is 340-800 nm. This color substance serves as a DSSC using organic material extraction as dye sensitizer has done, organic material extraction testing using UV Visible spectrophotometer 1601 PC to know the absorbance of organic material extraction against visible wavelengths. Cosmos caudatus dye absorbance chart can be seen in Figure 3.

![Cosmos Caudatus Absorbance Graph](image-url)
Based on Figure 3, we can see that the absorbance graph of the dye before and after mixing with TiO$_2$. The absorbance of the dye before mixing with TiO$_2$ resulted in a higher absorption, which was at a wavelength of 328 nm with an amplitude of 1.24. Meanwhile, the absorbance of dye after being mixed with TiO$_2$ resulted in low absorption at a wavelength of 320 nm with an amplitude of 1.12. This is because many of the dye particles are not completely bound by TiO$_2$ particles. Current-voltage characterization (I-V) is a method of knowing the Performance of Dye-Sensitized Solar Cells which is how much ability DSSC can convert light into electrical energy. I-V measurements are carried out in dark and light conditions that are under the exposure of halogen lamps with an intensity of 1000 W/m$^2$. For conductivity values from DSSC can be seen in figure 4.

![Figure 4. Organic material I-V curve.](image)

Figure 4 shows the I-V curve of the characterization value of organic matter at a light current greater than in dark currents. The efficiency produced by DSSC using organic extracts combined with Cosmos caudatus treatment differences in TiO$_2$ is presented in table 1. This study using electrode counter Pt (Hexachloroplatinic (IV) acid 10%).

| Dye                  | $V_{max}$ (Volt) | $I_{sc}$ (Ampere) | $P_{max}$ (Volt) | $E_t$ (%) |
|----------------------|------------------|-------------------|------------------|-----------|
| Cosmos caudatus      | 3.5 x10$^{-6}$   | 2 x10$^{-5}$      | 1 x 10$^{-6}$    | 8.3x10$^{-3}$ |

The efficiency produced in this study is still relatively low. This is because organic materials have low mobility properties and are easily combined as well as the use of liquid electrolytes, where the longer they are used because they evaporate and produce less maximum transfer catalysts. According to the function of the electrode/charge. If the electrolyte runs out or does not even exist then the electron transfer activity will be reduced/ none.

4. Conclusion
Dye-Sensitized Solar Cells (DSSC) using organic material extraction materials have been fabricated. With the current and voltage generated. The area of the curve indicates the DSSC of the organic material extract with the immersion method resulting in a good I-V curve. The opposing electrode is one of the most important components not usually released in the DSSC structure. Administration Pt (Hexachloroplatinic (IV) acid 10%) the opponent's electrodes provide better performance on the DSSC. Pt (Hexachloroplatinic (IV) acid 10%) catalyzes accelerating redox reactions with electrolytes. The efficiency is produced by each organic material. What needs to be suggested for further research is to improve the structure of DSSC to produce better synergy and efficiency. Using opposing electrodes from other materials that have better conductivity and catalyst properties.
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