



Antigonon Leptopus Extract as a Renewable Energy Source Material for the Development of Dye-Sensitized Solar Cells (DSSC)

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Article Info	Abstract
Article History Received: 25 August 2025 Revised: 17 Oct 2025 Published: 31 Oct 2025	Antigonon Leptopus Extract as a Renewable Energy Source Material for the Development of Dye-Sensitized Solar Cells (DSSC). Solar cells are devices composed of solar panels that convert light into electrical energy. Conventionally, energy is primarily derived from fossil fuels, which are non-renewable resources. Consequently, many researchers have sought alternative sources of energy. One such innovation is the Dye-Sensitized Solar Cell (DSSC). This study aims to investigate the effect of Antigonon leptopus flower dye as an active material in Dye-Sensitized Solar Cells (DSSC). The absorbance testing was conducted using a UV-Visible Spectrophotometer (1601 PC), while current and voltage (<i>I–V</i>) measurements were carried out using a Keithley instrument. The results showed that the natural dye extracted from the leaves of Antigonon leptopus exhibited an absorbance spectrum in the range of 200–800 nm. These findings suggest that Antigonon leptopus has potential as a natural sensitizer material for application in Dye-Sensitized Solar Cells (DSSC).
Keywords Antigonon Leptopus; Dye Sensitized Solar Cells (DSSC); Efficiency	
Informasi Artikel	Abstrak
Sejarah Artikel Diterima: 25 Agustus 2025 Direvisi: 17 Okt 2025 Dipublikasi: 31 Okt 2025	Sel Surya adalah perangkat yang terdiri dari panel surya yang berfungsi mengubah cahaya menjadi energi listrik. Secara konvensional, energi umumnya diperoleh dari bahan bakar fosil yang merupakan sumber daya tak terbarukan. Oleh karena itu, banyak peneliti yang berupaya mencari sumber energi alternatif. Salah satu inovasi yang dikembangkan adalah Sel Surya Tersensitisasi Zat Pewarna (<i>Dye-Sensitized Solar Cell</i> atau DSSC). Penelitian ini bertujuan untuk mengkaji pengaruh zat pewarna bunga <i>Antigonon leptopus</i> sebagai material aktif dalam Sel Surya Tersensitisasi Zat Pewarna (DSSC). Pengujian absorbansi dilakukan menggunakan Spektrofotometer UV-Visible (1601 PC), sedangkan pengukuran arus dan tegangan (<i>I–V</i>) dilakukan dengan menggunakan instrumen Keithley. Hasil penelitian menunjukkan bahwa zat pewarna alami yang diekstrak dari daun <i>Antigonon leptopus</i> memiliki spektrum absorbansi dalam rentang 200–800 nm. Temuan ini mengindikasikan bahwa <i>Antigonon leptopus</i> memiliki potensi sebagai material fotosensitizer alami untuk diaplikasikan dalam Sel Surya Tersensitisasi Zat Pewarna (DSSC).
Kata kunci Antigonon Leptosus, Dye Sensitized Solar Cells (DSSC); Efisiensi	
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INTRODUCTION

The development of sensitization technology using natural organic materials is of considerable interest due to their abundant availability in nature. Dye-sensitizer molecules derived from natural compounds or plant pigments represent highly promising organic materials for the fabrication of third-generation solar cell devices. In order to function

effectively as a sensitizer, a dye must be capable of serving as a medium for charge carrier transfer as a result of absorbed photons (Brabec, 2004).

A solar panel is a device composed of solar cells that convert light into electricity. They are referred to as “solar” from the Sun or sol, as the sun is the most powerful natural source of usable light energy (Cari et al., 2013). Solar panels are often called photovoltaic cells, where photovoltaic means “light-electricity.” Solar cells rely on the photovoltaic effect to absorb solar energy and induce a current between two oppositely charged layers. Despite their potential, the global share of solar panels in electricity production remains small, mainly due to their relatively high cost per watt compared to fossil fuels—up to ten times higher, depending on circumstances (Nurussaniah et al., 2013). Currently, the cost of solar panels renders them impractical for everyday use in areas where grid electricity is readily available. Nevertheless, photovoltaic technology has made significant advancements in solar energy as an alternative and renewable energy source.

Organic photovoltaics offer several attractive features, including the potential for flexible devices, and the possibility of low-cost fabrication using simple manufacturing techniques (Brabec, 2004). The dye-sensitized solar cell (DSSC) is a type of photoelectrochemical solar cell, primarily composed of a photoelectrode, an electrolyte, and a counter electrode. Titanium dioxide (TiO_2) has become the preferred semiconductor material in many studies; however, due to its wide band gap (3 to 3.2 eV), TiO_2 absorbs only the ultraviolet portion of sunlight, which results in relatively low conversion efficiency (Grätzel, 2001).

Over the past two decades, M. Grätzel has pioneered the development of Dye-Sensitized Solar Cells (DSSCs) as a novel photovoltaic device. DSSCs have garnered significant attention as energy converters, offering a viable alternative to conventional silicon-based solar cells (Green, 1982). A typical DSSC employs three main active materials: an organic dye that absorbs photons, a nanocrystalline metal oxide layer that facilitates electron transport, and a liquid or metal oxide-based hole transport material (HTM) (Hagfeldt & Grätzel, 2000).

DSSCs are highly attractive for further research due to their potential to achieve high efficiency at low production costs (Nurussaniah et al., 2013). Several studies have utilized platinum (Pt) as the counter electrode in DSSC configurations. Both platinum (Pt) and carbon (C) are commonly employed materials for counter electrodes (Cari et al., 2013). In this study, platinum (Pt) is used as the counter electrode in a DSSC incorporating an organic dye extracted from *Antigonon leptopus* (Hardani et al., 2025).

The working principle of a DSSC involves the conversion of light energy into electrical energy. When the dye adsorbed on the surface of TiO_2 absorbs photons from sunlight, electrons are excited into the conduction band of the TiO_2 . These electrons are collected within the TiO_2 , while the dye molecules, having lost electrons, remain in an oxidized state. The electrons then travel through the external circuit toward the counter electrode (Darmawan et al., 2023).

The performance of a solar cell refers to its ability to convert light into electrical energy. Figure 1 shows the I–V curve, which illustrates the cell's capability to produce current and voltage. The figure displays key parameters such as open-circuit voltage (V_{oc}), short-circuit current (I_{sc}), maximum power voltage and current, and the fill factor (FF). Under short-circuit conditions (I_{sc}), the cell delivers maximum current with zero voltage. In open-circuit conditions, no current flows, and the voltage reaches its maximum value, referred to as the open-circuit voltage. The fill factor is an indicator of the overall performance quality of a solar cell (Hardani et al., 2025).

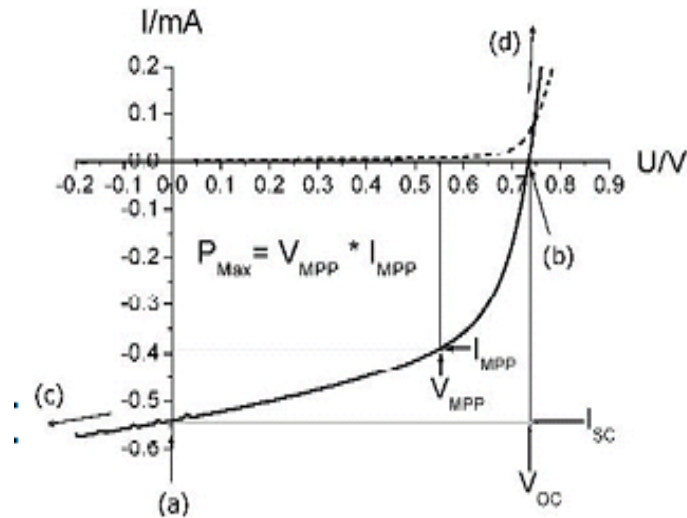


Figure 1. Schematic of the I–V Curve for Determining the Efficiency of DSSC (Hardani et al., 2020)

The Fill Factor (FF) is a quantitative measure of the quality of a solar cell and represents the rectangularity of the I–V curve. The Fill Factor can be calculated using Equation (1).

$$FF = \frac{V_{maks} \times I_{maks}}{V_{oc} \times I_{sc}} \quad (1)$$

The maximum power output of a solar cell can be calculated using Equation (2):

$$P_{maks} = V_{oc} I_{sc} FF \quad (2)$$

The efficiency of the solar cell can be calculated using Equation (3):

$$\eta = \frac{P_{max}}{P_{in}} \quad (3)$$

Where:

I_{sc} = Short-circuit current density measured at each wavelength ($A \cdot cm^{-2}$)

P_{in} = Incident light power intensity on the DSSC per unit area ($W \cdot cm^{-2}$)

Efficiency serves as a global metric for assessing the overall quality of a solar cell. It is defined as the quantitative ratio between the maximum power output generated by the cell (P_{max}) and the power of the incident light (P_{in}), as expressed in Equation (3).

METHOD

The TiO_2 used in this study was Titanium (IV) Oxide, anatase-phase titanium dioxide powder, 99.8% trace metals basis. A total of 0.5 grams of TiO_2 was dissolved in 2 mL of ethanol and stirred for 30 minutes using a vortex stirrer. The TiO_2 suspension was deposited onto a Fluorine Tin Oxide (FTO) conductive glass substrate with a deposition area of $1.5 \text{ cm} \times 2 \text{ cm}$ using the spin coating method. The deposited TiO_2 layer was then annealed at $500^\circ C$ for 60 minutes on a hot plate.

In this study, the dye was obtained from the flower extract of *Antigonon leptopus* (commonly known as Coral Vine or Mexican Creeper). Two grams of *Antigonon leptopus* flowers were ground using a mortar until a fine consistency was achieved. The resulting powder was dissolved in 40 mL of ethanol and stirred continuously for 60 minutes.

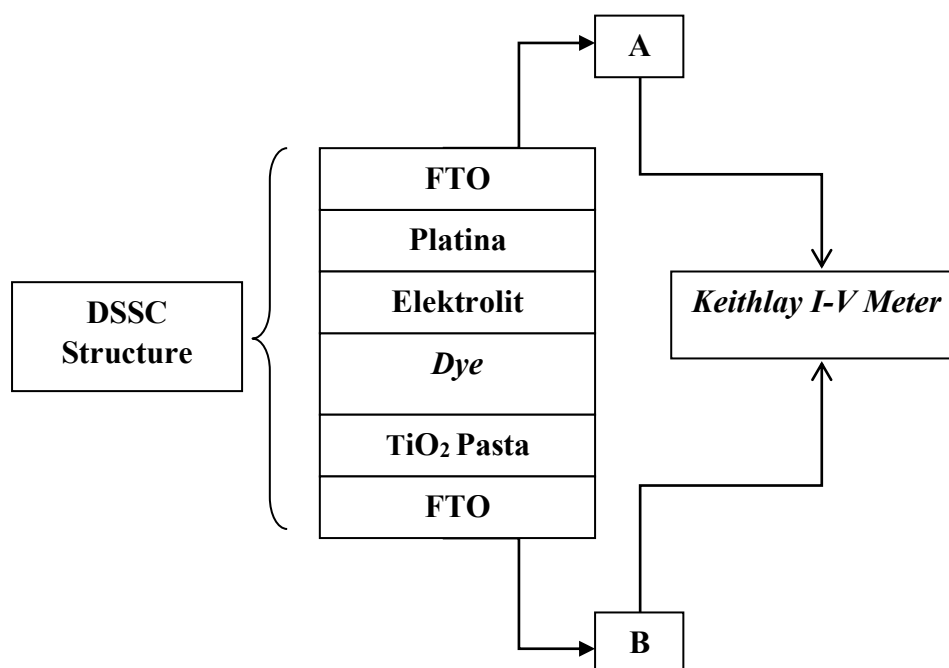


Figure 2. Schematic Diagram of I–V Measurement Setup for DSSC [9]

The DSSC constructed in this study employed a sandwich-type configuration. The working electrode consisted of FTO (Fluorine Tin Oxide) conductive glass coated with a TiO_2 layer that had been sensitized with Antigonon leptopus dye. The counter electrode was also made of FTO glass, coated with a thin layer of platinum (Pt), deposited using a 10% solution of hexachloroplatinic (IV) acid.

The electrolyte was prepared from an I_2/KI solution dissolved in polyethylene glycol (PEG), and applied between the working and counter electrodes. A keyboard protector was used as a spacer to prevent short circuits between the electrodes. The assembled electrodes and electrolyte were stacked and clamped together using a clipboard.

Following assembly, the DSSC device was subjected to current–voltage (I–V) characterization to evaluate its electrical performance (Yuniwati et al., n.d.).

RESULT AND DISCUSSION

The dye solution was prepared from the extract of Antigonon leptopus flowers, which is capable of absorbing and transmitting visible light spectra. This natural pigment serves as the dye sensitizer in the Dye-Sensitized Solar Cell (DSSC). The absorption characteristics of the Antigonon leptopus flower extract were analyzed using a UV-Visible Spectrophotometer (UV-Vis 1601 PC) to determine its absorbance across the visible wavelength range.

The absorbance spectrum was measured over the range of 200–800 nm. The characterization results, as shown in Figure 2, indicate that the Antigonon leptopus flower extract exhibits significant light absorption within the visible region.

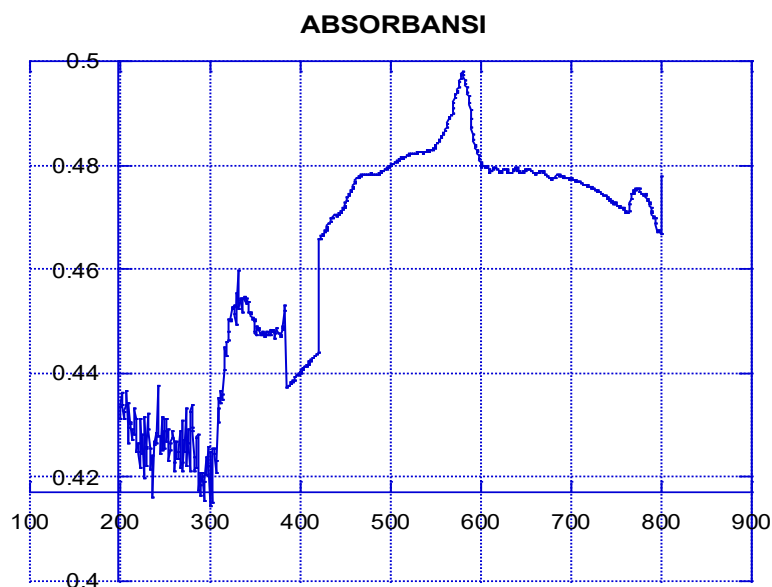


Figure 3. Absorbance Spectrum of Antigonon leptopus Extract

Current–voltage (I–V) characterization is a method used to evaluate the performance of Dye-Sensitized Solar Cells (DSSCs), specifically to determine their ability to convert light into electrical energy. The I–V measurements were conducted under both dark and illuminated conditions, with illumination provided by a halogen lamp at an intensity of 1991 W/m².

The conductivity and performance characteristics of the DSSC under these conditions are presented in the figure below.

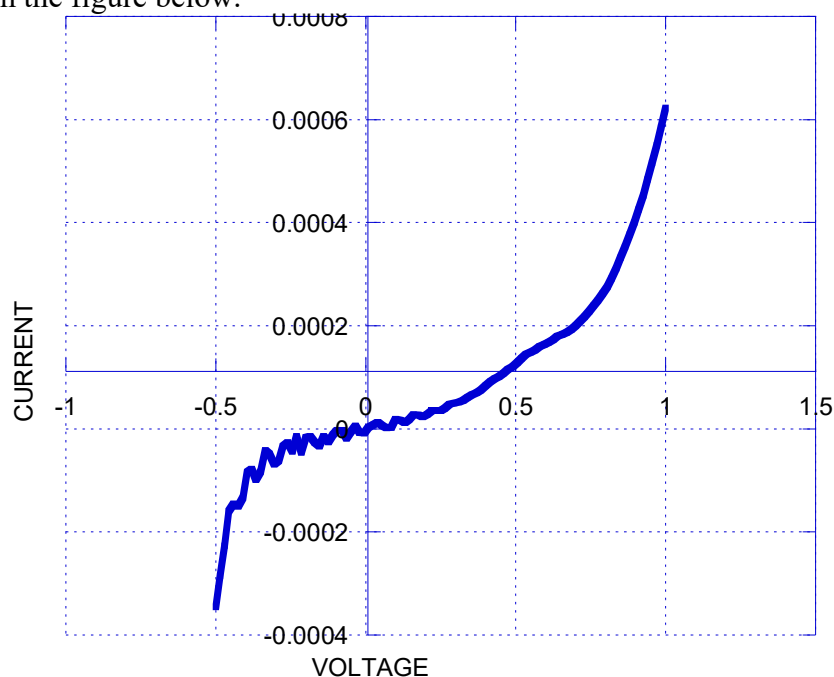


Figure 4. Conductivity Curve of Antigonon leptopus Extract

Figure 4 presents the I–V curve, showing that the conductivity of the electrolyte under illumination is higher than under dark conditions. The efficiency values obtained from DSSCs using Antigonon leptopus extract with different TiO₂ treatments are summarized in Table 1. DSSCs fabricated using the immersion method demonstrated higher efficiency compared to those prepared using the drop-casting method.

The solar cell in this study was assembled using a sandwich-type configuration. The working electrode consisted of a TiO_2 layer sensitized with the organic dye extracted from *Antigonon leptopus*, followed by the application of a redox electrolyte containing the I^-/I_3^- couple and KI. The counter electrode was placed on top of the working electrode and the applied electrolyte. The two electrodes were then clamped together using a clipboard to ensure proper contact and stability.

To prevent short circuits, an insulating spacer was placed between the electrodes. Figure 5 illustrates the assembly configuration of the solar cell.



Figure 5. Assembled DSSC with Dye, Ready for Testing

Table 1. Efficiency of DSSCs with Different Dye Application Methods

Antigonon Leptopus	Voc (mV)	Isc (μA)	Pmax	η (%)
Rendam (soak)	3.9×10^{-2}	1.86×10^{-3}	1×10^{-2}	6×10^{-2}
Tetes (drobs)	2.4×10^{-5}	6.85×10^{-4}	3.7×10^{-2}	3×10^{-2}

The power conversion efficiency is significantly influenced by the magnitude of the short-circuit current (I_{sc}). A higher I_{sc} generally results in increased efficiency. The I_{sc} represents the current density generated by the solar cell device when it is exposed to light without any applied forward or reverse bias, typically operating in the fourth quadrant (IV) of the I–V curve.

In this study, DSSC devices fabricated using different methods yielded a short-circuit current I_{sc} of $1.86 \times 10^{-3} \text{ mA}$ and an open-circuit voltage (V_{oc}) of $3.9 \times 10^{-2} \text{ mV}$. The corresponding power conversion efficiency was $6 \times 10^{-2} \%$ with a fill factor of 4.9×10^{-7} .

The efficiency achieved in this research remains relatively low. This is attributed to the inherent limitations of organic materials, such as low charge carrier mobility, high recombination rates, and significant internal resistance faced by electrons injected into the semiconductor layer during the assembly process (Darmawan et al., 2023). As a result, the number of electrons successfully transported to the external circuit is limited.

To improve DSSC performance, one approach is to dope the photoactive materials to widen the absorption spectrum and enhance charge generation and carrier mobility. Additionally, optimizing the structural configuration of each DSSC component is crucial. Improved interface engineering can reduce defects at the material interfaces and ensure better electronic contact, thereby enhancing the overall device efficiency (Hardani et al., 2025).

CONCLUSION

Dye-Sensitized Solar Cells (DSSCs) utilizing *Antigonon leptopus* flower extract with different treatment methods have been investigated. The presence of generated current and voltage confirms the photoelectrical activity of the devices. The area under the I–V curve indicates that the DSSC fabricated using the immersion method exhibited superior current–voltage (I–V) performance compared to the device prepared using the drop-casting method.

The counter electrode is a critical component in the DSSC structure. The application of platinum (Pt) using a 10% hexachloroplatinic (IV) acid solution on the counter electrode enhanced the overall performance of the device. Pt acts as a catalyst to accelerate redox reactions with the electrolyte, thereby improving charge transfer kinetics. The efficiency achieved using the immersion method was $6 \times 10^{-2} \%$, whereas the drop-casting method yielded a lower efficiency of $3 \times 10^{-2} \%$.

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