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OPTICAL CHARACTERIZATION OF BOUGAINVILLEA GLABRA LEAF EXTRACT FOR SOLAR CELL APPLICATIONS

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Abstract
This study explores the potential of Bougain Villea (BV) leaf extract as a natural material in dye-sensitized solar cells (DSSCs). There has been a lot of attention paid to solar cells and other renewable energy sources in recent times due to their capacity to reduce dependency on fossil fuels and alleviate the consequences of climate change. The optical characteristics of the BV leaf extract were studied to determine its suitability for use in DSSCs. UV-Vis spectroscopy was used to measure the optical properties of the BV extract. Absorption spectra were found to be in the range of 420 - 900 nm. The optical band gap of the Bougain Vilea (M) and (AE) extract was determined to be 1.8 eV and 1.9 eV respectively. The results indicate that Bougain Vilea extract can be a potential natural material for DSSCs, as it is affordable and easily accessible. This study presents an in-depth analysis of the optical characteristics of Bougain Vilea extract and demonstrates its potential application in DSSCs. Further research is needed to optimize Bougain Vilea extract for use in DSSCs.

Keywords: Bougain Villea, DSSCs, Absorbance, Transmittance, reflectance, optical bandgap

Introduction

Solar cells and other renewable energy sources have recently received a lot of attention for their ability to lessen reliance on fossil fuels and mitigate the effects of climate change (Tyan, 2011). Research conducted in 2019 by Nayak et al. suggests that dye-sensitized solar cells (DSSCs) might be a viable substitute for silica-based cell processes. How well and what kind of dye is used in DSSCs determines how efficient and effective the device is. One environmentally friendly and long-term option for dye sensitization is the use of natural dyes made from plant extracts (Kalyani & Dhoble, 2012). One easily available plant that shows promise as a natural dye for solar cell applications is Bougainvillea glabra. Although it has been produced, there is presently no comprehensive optical assessment of bougainvillea glabra leaf extract for DSSCs. As part of the optical characterization of bougainvillea glabra leaf extract, it is vital to study its absorption and fluorescence properties and efficient light-to-electric energy conversion. Researchers employ a range of techniques, including photovoltaic tests, fluorescence spectroscopy, and UV-Vis spectroscopy, to evaluate the dye's effectiveness in DSSCs (Richhariya et al., 2017). Due to a lack of substantial optical characterization data, bougainvillea glabra leaf extract cannot be utilized efficiently and effectively by DSSCs (Bekele & Sintayehu, 2022). A thorough familiarity with the optical properties of this natural dye, such as its absorbance, fluorescence, and transmittance, and its operational capabilities in various contexts, is necessary for an appropriate exploration of its potential (Garcia-Salines & Ariza, 2019). There has been a lot of effort to improve the efficiency of solar cells due to the increasing need for renewable energy sources. As a result of their reduced manufacturing costs, simplicity of fabrication, and potential for effective energy conversion, dye-sensitized solar cells, also known as DSSCs, have emerged as a viable alternative to traditional silicon-based solar cells on account of their potential for efficient energy conversion (Gedam et al., 2021). In 2020, Ali et al. found that plant-based natural dyes might be a good substitute for synthetic dyes in DSSCs due to their lower environmental impact. The majority of Bougainvillea Glabra plants cultivated nowadays are produced primarily for their aesthetic value (Shah et al., 2021). They are commonly used in landscaping and gardening to enhance the aesthetic value of outdoor spaces like gardens, parks, and other outdoor areas. The most striking feature of bougainvillea is its multi-coloured bracts, which are modified leaves that encircle the little, hardly perceptible blooms.

Materials and Methods

For this investigation, the solvent extraction approach was used. The initial stage in separating the desired natural products from the base materials is extraction. The following steps are taken when natural product extraction advances:

i. The solvent penetrates the solid matrix;
ii. The solute dissolves in the solvents;
iii. The solute is diffused out of the solid matrix;
iv. The extracted solutes are collected.

The leaves of Bougain Vilea were collected from the Bougain Vilea flower growing around Birabi Street, GRA, Port Harcourt, Rivers State. Using a smart Android phone and the Google photo search capability, the flowering plant was located. To get rid of the surface debris, the harvested flower plant leaves were rinsed twice with distilled water before being chopped into little pieces. For about two weeks, the leaves were allowed to dry in the shade.

The shade-dried flower leaves were crushed into a coarse powder using a blender, and the powder was stored in zip-top bags for later use. After being soaked for up to 12 hours at 25°C, 7.5 grams of the powder were weighed and dissolved in 150 ml of 80% methanol and 80% acidified ethanol, which served as an extraction solvent solution. After solute diffusion occurs, the extraction solvent is separated from the solid using a funnel and a filter (Griesbeck & Mattay, 2020). The leaf extract is then subjected to optical characterization using a UV-vis spectrophotometer in the form of a solution.

The optical investigation of the Bougain vilea glabra leaf extract was conducted using a UV-VIS-NI spectrophotometer (UV 752), measuring wavelengths from 230 nm to 1100 nm. The following equations were used to analyze optical parameters such as transmittance, reflectance, refractive index, extinction coefficient, and energy band gap, in addition to absorption values acquired from the spectrophotometer;

The transmittance (T) of the cells was evaluated using Equation (1)

$$T = 10^{-A} \quad 1$$

Reflectance was obtained using equation (2)

$$R = 1 - (A + T) \quad 2$$

The refractive index of the cells was calculated using Equation (3)

$$\eta = \frac{(1+\sqrt{R})}{(1-\sqrt{R})} \quad 3$$

The absorption coefficient was calculated from absorbance spectra using the Equation (4). Where *d* is the thickness and is measured in micrometre (µm), and *A* is the absorbance.

$$\alpha = \frac{2.303A}{d} \quad 4$$

The extinction coefficient was obtained using Equation (5)

$$k = \frac{\alpha\lambda}{4\pi} \quad 5$$

Optical conductivity was estimated using Equation (6).

$$\sigma_o = \frac{\alpha\eta c}{4\pi} \quad 6$$

Where c is the speed of light.

The energy band gap was estimated using Tauc's model given in Equation (7)

$$(\alpha hv)^n = \beta\left(hv - E_g\right) \quad 7$$

Where α is the absorption coefficient, *h* is the Planck constant, v is the photon's frequency, *E*g is the band gap energy and β is a constant. The *n* factor depends on the nature of the electron transition and is equal to ½ or 2 for the direct and indirect transition band gaps respectively.

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Results

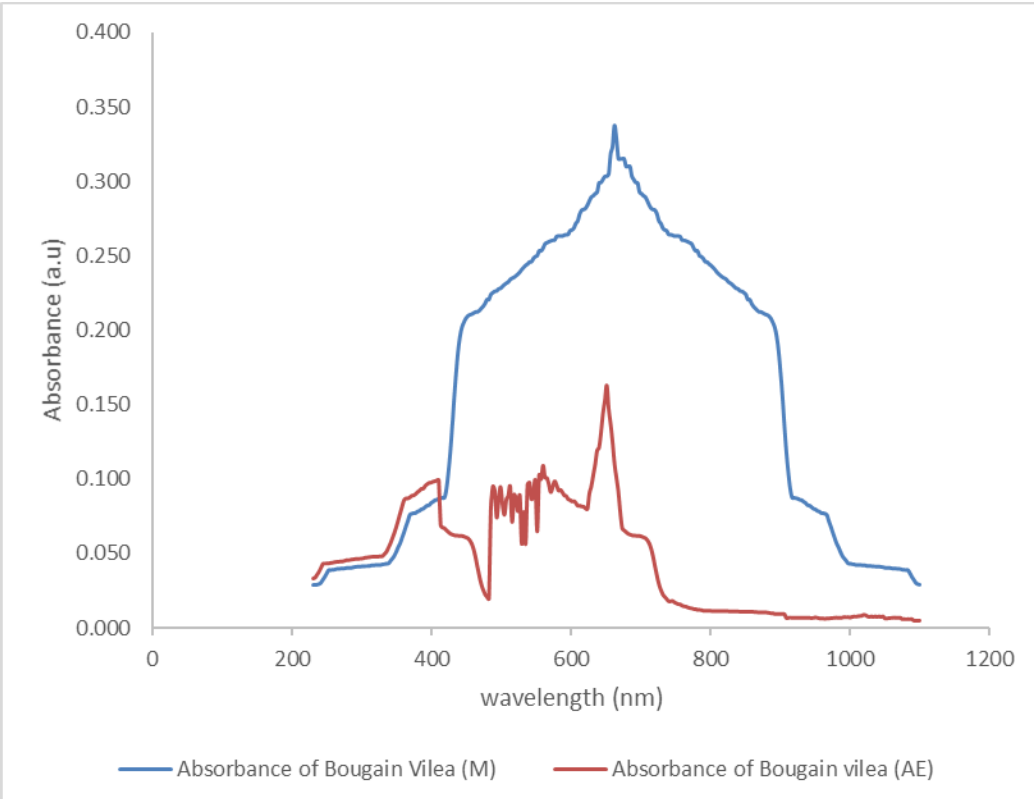

Figure 1: Uv-vis- Absorbance spectra of the Bougain Vilea leaf extracted with methanol (M) and acidified ethanol (AE).

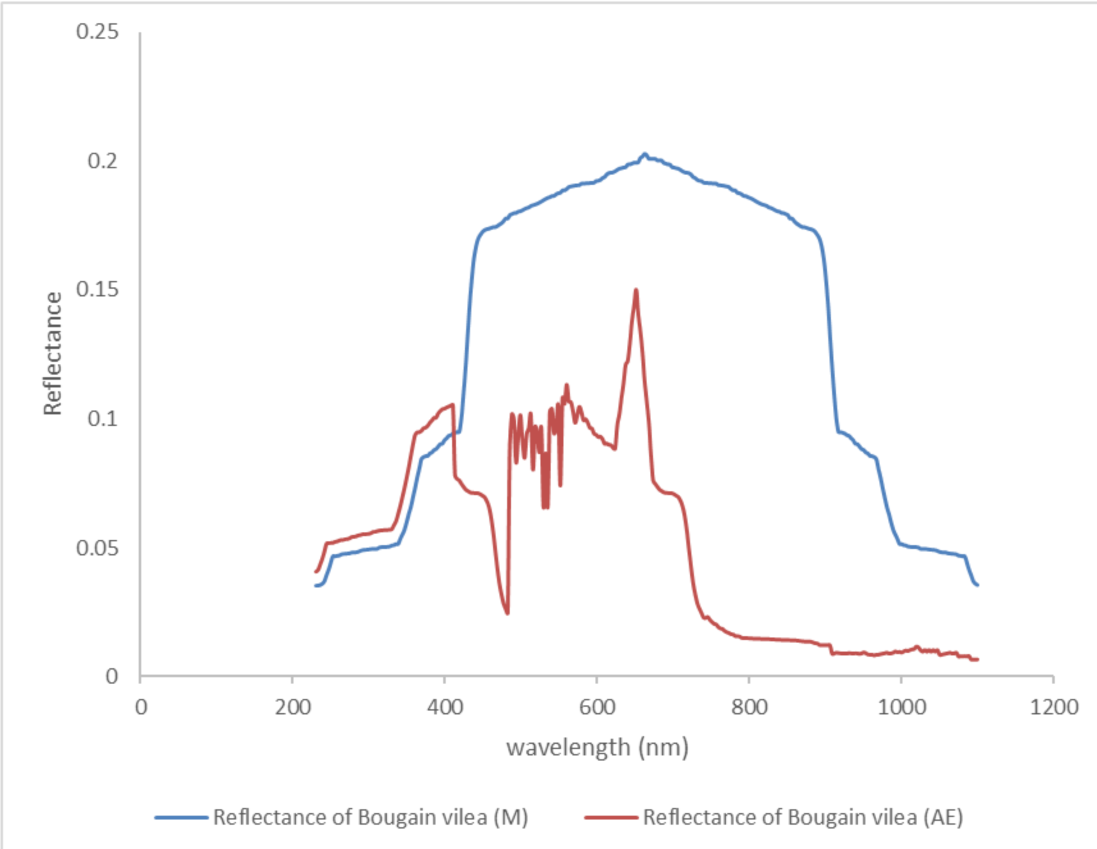

Figure 2: Uv-vis- Reflectance spectra of the Bougain Vilea leaf extracted with methanol (M) and acidified ethanol (AE).

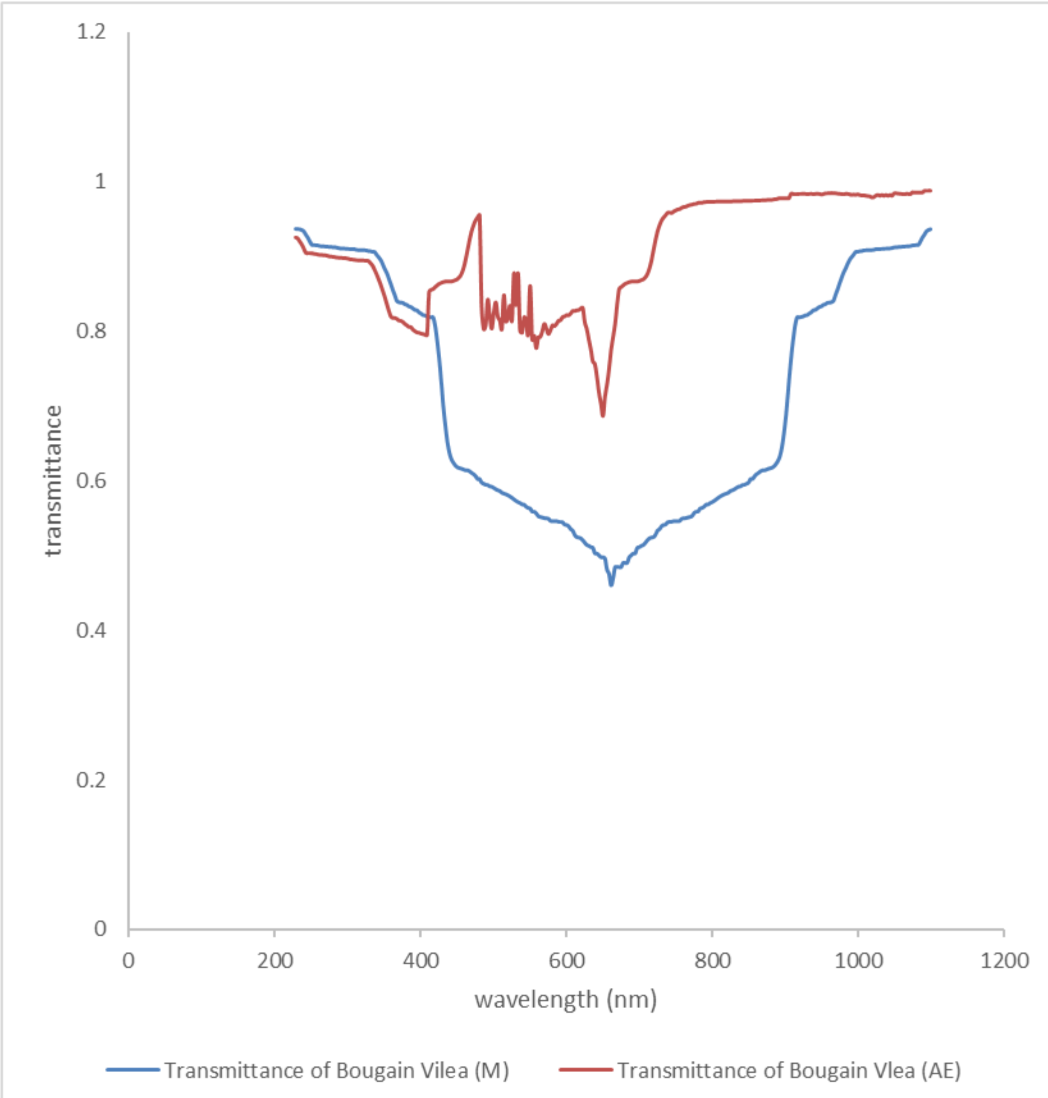

Figure 3: Uv-vis- Transmittance spectra of the Bougain Vilea leaf extracted with methanol (M) and acidified ethanol (AE).

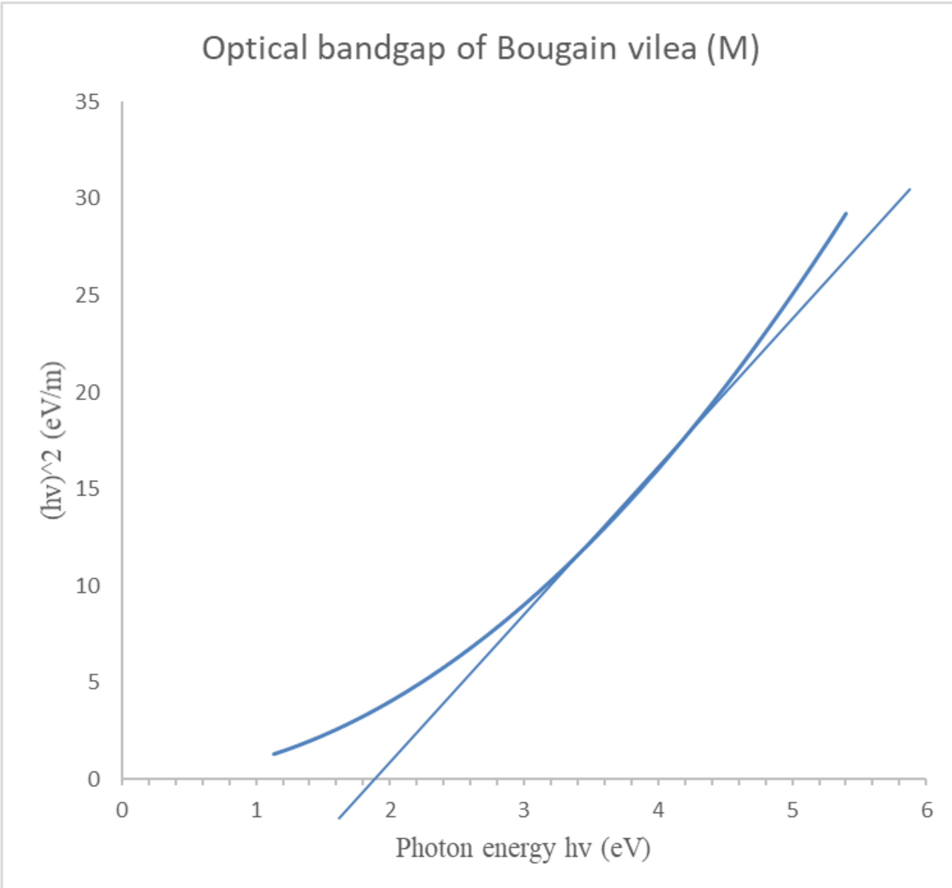

Figure 4: Uv-vis- optical bandgap of the Bougain Vilea leaf extracted with methanol (M)

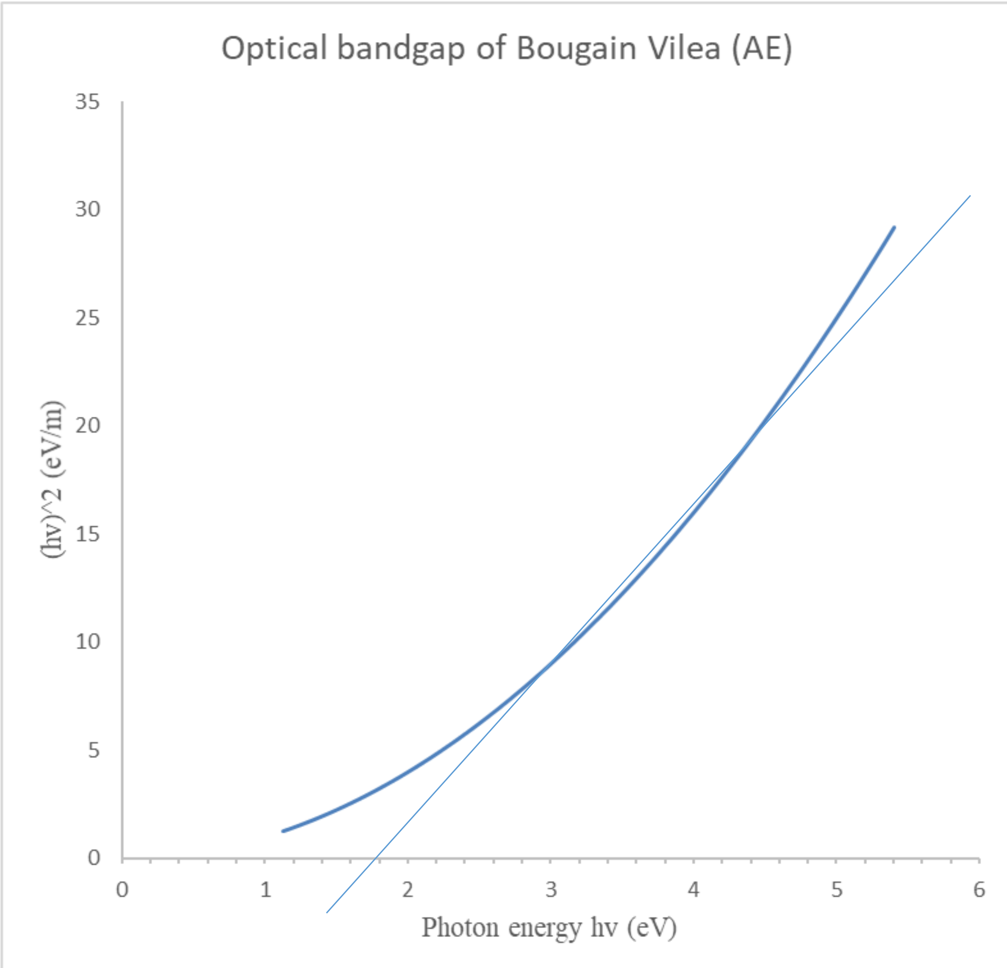

Figure 5: Uv-vis- optical bandgap of the Bougain Vilea leaf extracted with acidified ethanol (AE).

Discussions

Figure 1 displays the greatest absorbance values for Bougainvillea (AE) and (M) at various wavelengths, 666 nm and 605.8 nm, respectively. These values are 0.157 and 0.32, respectively. According to the absorbance values, the substance (M) is more effective at absorbing light at 605.8 nm than the substance (AE) at 666 nm. In other words, the amount of light that is absorbed by (M) at its corresponding wavelength is more than that of (AE). The amount of light that a material can absorb at a certain wavelength is referred to as its absorbance, and greater absorbance levels often indicate a larger concentration of absorbing species. The proportion of incident light that is reflected by a sample is referred to as the reflectance (R) of the sample, whereas the transmittance (T) of a sample is the fraction of incident light that is allowed to pass through itself. There is a correlation between the absorbance values and the amount of light that is absorbed by (M) at 605.8 nm and (AE) at 666 nm. This suggests that the two samples have distinct optical characteristics and most likely include different absorbing species or concentrations of absorbing species and that these differences are reflected in the samples. These distinctions are further illustrated by the transmittance and reflectance values as seen in Figures 2 and 3, with (AE) allowing a greater amount of light to flow through and reflecting less light than (M).

It is the amount of energy that is necessary to transport an electron from the valence band to the conduction band that is represented by the optical bandgap. Within the context of this scenario, the bandgap energy of (AE) is marginally higher than that of (M) as shown in Figures 4 and 5. According to the findings, the Bougain vilea leaf that was extracted using methanol had a high level of absorption in the visible spectrum, namely between 420 and 900 nanometers. However, the results also revealed that the absorption in the ultraviolet and infrared regions was marginally reduced. Furthermore, the results demonstrated that the samples exhibited a good light response not only in the ultraviolet region but also in the visible range, which indicated that there was tremendous potential for a variety of applications in the field of optoelectronics.

Conclusion

In conclusion, optical characterization of Bougainvillea leaf extract entails analyzing the extract's light interactions using different methodologies. This analysis sheds light on the extract's optical characteristics and possible uses. The extract's absorption and transmission of UV and visible light were investigated using UV-Vis spectroscopy. This showed that the extract included some chemicals that absorbed light, such as pigments or flavonoids. To further understand the optical behaviour of the Bougain vilea glabra leaf extract and its possible uses in dye-sensitive solar cells, this optical characterization approach is quite beneficial. Using a (UV 752) ultraviolet-visible near infra-red (UV-VIS-NI) spectrophotometer, the optical bandgap, absorbance spectra, transmittance spectra, and reflectance spectra of two samples of Bougain vilea leaf extracts were determined. The samples were prepared using two different solvents, acidified ethanol, and methanol, respectively. Bougain vilea leaf extract with methanol showed high absorption in the visible range (420~900 nm), according to the results. However, there was a minor decrease in absorption in the ultraviolet and infra-red regions. The samples exhibited excellent light sensitivity in both the UV and visible ranges, suggesting great promise for a variety of optoelectronics uses, according to the research.

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