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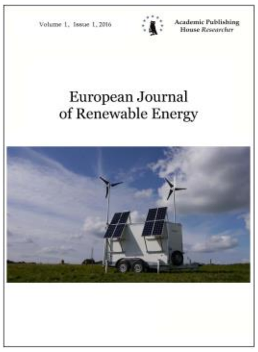

Extraction and Optical Characterization of the Active Ingredient in *Solanium Melongena* Extract

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Abstract

In carrying out the experiment, first liquid extract was obtained from *Solanium Melongena* leaves using solvent extraction method at room temperature of 300K with acetone solvent. The liquid extract was concentrated to a certain degree using a rotary evaporator and the concentrated extracts were afterwards analyzed using a Hewlett-Packard 6890 gas chromatography mass spectrometer. Following additional analysis of the extract, it was observed that *Solanium melongena* extract contains 2, 3, 5, 6-tetraisopropylpyrazine (5.15 %), 6-octadecenoic acid (33.84 %), 1-(hydroxymethyl)-1, 2-ethanediyl ester (2.60 %) and stearic acid (20.68 %) as the active ingredients. The result of optical characterization using a Jenway 6405 UV-Visible spectrophotometer revealed that Solanium Melongena extract has optical band gap range from 1.10eV to 1.20eV.

Keywords: Solanium, melongena, extract, active, Ingredients, optical.

1. Introduction

Dye-based solar cells have been established to represent a more cost-effective alternative to traditional solar cells. In these cells, a dye is used in place of a semiconductor to trap the light (Bach, 2012). Dye has received great attention due to its environment stability, ease of preparation and its optical and electrical properties. The dye's color result from absorbance of light in the visible region of the electromagnetic spectrum due to the delocalization of electrons (Aziz, El-Mallah, 2009). Another way to improve the light harvesting in thin films is to use natural dyes obtained from plant parts like leaves, flowers or fruits with high extinction coefficients (Schmidt-Mende et al., 2005; Ute, 2009). This was the motivation for analyzing the active ingredients in natural dye obtained from *Solanium melongena* leaves. Knowledge of the optical constants of the materials (optical band gap and extinction coefficient) is vital in order to scrutinize the atomic structure, electronic band structure and electrical properties of the dye. The refractive index provides information about the chemical bonding and electronic structure of the material (Al-Mansaf, 2011).

A brief note on *solanum melongena*

Solanum melongena belongs in the plant family Solanaceae (for which belongs tomato, potato, nicotine and the poisonous deadly nightshade plant) (Fern, 2019; Gowda, 2016). It is commonly known as eggplant or aubergine. *Melongena* is a Latin word derived from the Italian word 'melanzane', meaning 'mad apple' (KSP, 2019). This plant was first domesticated in India, but

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is now cultivated worldwide and is a popular ingredient in many traditional dishes. The Plant can grow up to 2 metres tall with a long taproot which extends deep into the ground (KSP, 2019). The stems and leaves are thickly covered with star-shaped hairs and sometimes they give tingling sensation of mild discomfort when touched. The leaves (which is between 6-10 cm long) are arranged alternately along the stem and that by nature. The plant is an important vegetable crop of tropical and temperate parts of the world (Randhawa, Singh, 2016).

Analytical methods

In carrying out the study, first literature review of the study was carried out, followed by preparation of the materials needed for the experiment. Afterwards, the extraction of dye pigment from *Solanium melongena* leafs was carried out following Rodney (1990) solvent extraction method. The extract from *Solanium melongena* (already mixed with acetone) was subjected to rotary evaporation for hours using a rotary evaporator. This was done to separate the solvent (acetone) from the extract. The evaporator operated by first raising the temperature of acetone to between 40°C and 45°C (which is the boiling point of acetone). The concentrated extract obtained was placed in a sealed sample bottle for analysis.

The next thing that was carried out in the experiment was the analysis of the concentrated extract. This analysis was performed using a Hewlett-Packard 6890 gas chromatograph equipped with a Hewlett-Packard 5973 mass selective detector. Identification of the active ingredients in the concentrated dye extract was done by comparison of their relative retention index and mass spectra with those of NIST05s library data (McNair, Bonelli, 1969).

Following the analysis (which was meant to determine the active ingredients in the dye extract) was the characterization of the liquid dye extract. The liquid extract was characterized for absorbance and transmittance using a Jenway 6405 UV-VIS spectrophotometer. Other properties which include absorption coefficient, extinction coefficient, refractive index, reflectance, band gap and optical conductivity were determined.

The following formulae were employed in the calculations:

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

Where R is the reflectance, A and T are the absorbance and transmittance respectively.

$$\alpha = \frac{A}{\lambda} \quad (2)$$

Where α is the absorption coefficient, A is the absorbance and λ is the wavelength of the incident radiation (Pankove, 1971).

$$K = \frac{\alpha}{4}\frac{\lambda}{\pi} \quad (3)$$

Where K is the extinction coefficient, α is absorption coefficient and λ is the wavelength of the incident radiation.

$$n = \frac{(1+\sqrt{R})}{(1-\sqrt{R})} \quad (4)$$

Where n is refractive index, R is the reflectance (Robinson, 1952).

$$\sigma(op) = \frac{\alpha.n.c}{4\pi} \quad (5)$$

Where σ is optical conductivity, n is the refractive index and c is the speed of light

2. Discussion and results

The result from extraction shows that the extract from: *Solanium melongena* possesses a green colour suggesting chlorophyll pigment present. The chromatogram of the *Solanium melongena* extract taken from the gas chromatograph-mass spectrometer is shown in Figure 1.

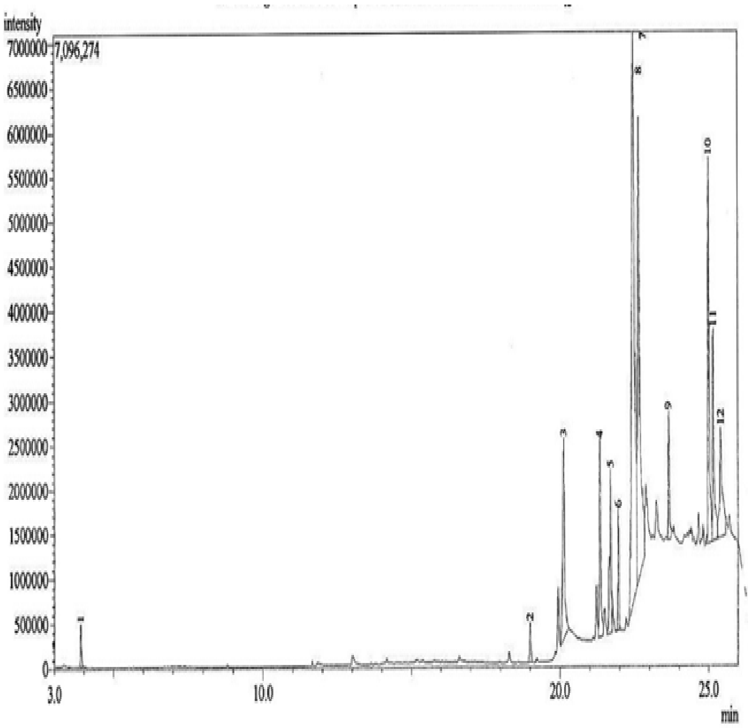
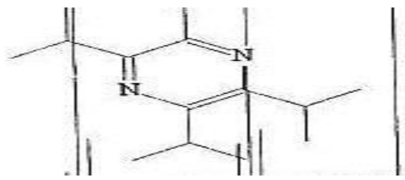


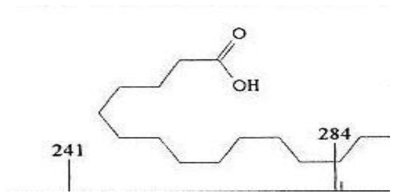
Fig. 1a. GC-MS chromatogram result of *Solanium melongena* extract

Figure 1a shows the chromatogram of *Solanium melongena* extract. Here, there were some minor unidentified peaks in the GC-MS spectrum but the compounds found in abundance were 2, 3, 5, 6-tetraisopropylpyrazine, 6-octadecenoic acid, 1-(hydroxymethyl)-1, 2-ethanediyl ester and octadecanoic acid (stearic acid).

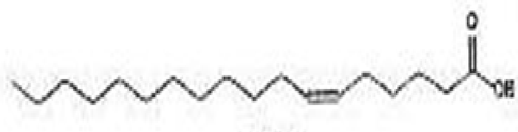
Figure 1b indicates the structure of the identified molecules and their percentage composition.



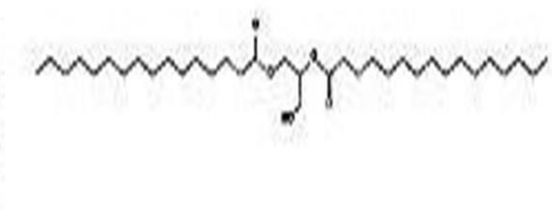
2, 3, 5, 6-tetraisopropylpyrazine (5.15 %)



Octadecanoic acid (stearic acid 20.68 %)



6 – Octadecenoic acid (33.84 %)



1-(hydroxymethyl)-1,2-ethanediyl ester (2.60 %)

Fig. 1b. the structure of the identified molecules

The optical absorbance/transmittance of the extract were studied in the wavelength range of 300-1000 nm.

Figure 2 shows a plot of absorbance versus wavelength for *Solanium melongena* extract. The plot reveals a high absorbance value of 0.9 throughout ultraviolet and Visible regions which later drop to approximately 0.68 at the near infrared region. The high absorbance value in the visible region makes solanium melongena extract useful as dye sensitizer for solar cell fabrication. This result is similar to those of the dye sensitizers by other natural dyes in previous works (Sofyan et al., 2013; Anthony et al., 2013).

Figure 3 shows the plot of spectral transmittance for *Solanium melongena* extract. The figure reveals a low transmittance of about 15 % throughout the ultraviolet and visible regions and a fairly moderate transmittance of about 22 % in the near infrared region at the peak of about 800 nm. The low transmittance in the visible region makes *Solanium melongena* extract useful for film application as window coating in cold region of the world.

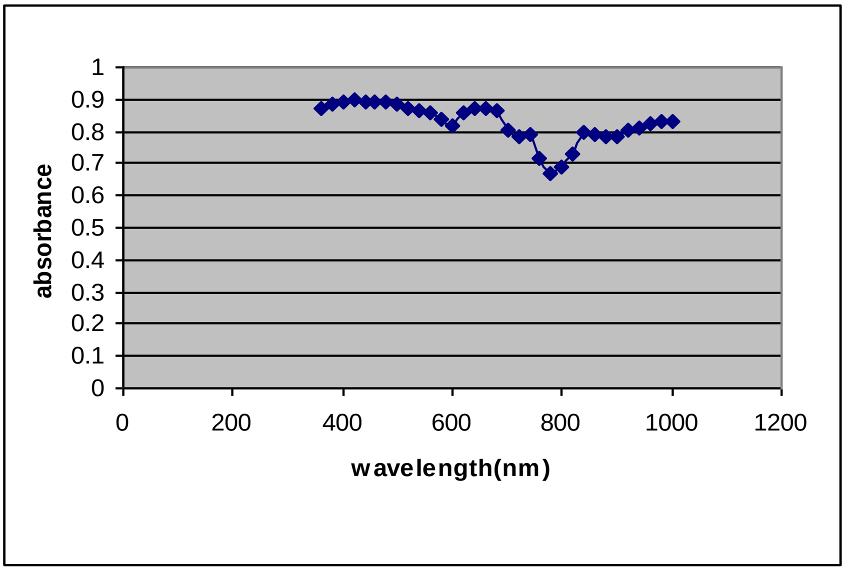


Fig. 2. Plot of absorbance against wavelength for *Solanium melongena* extract

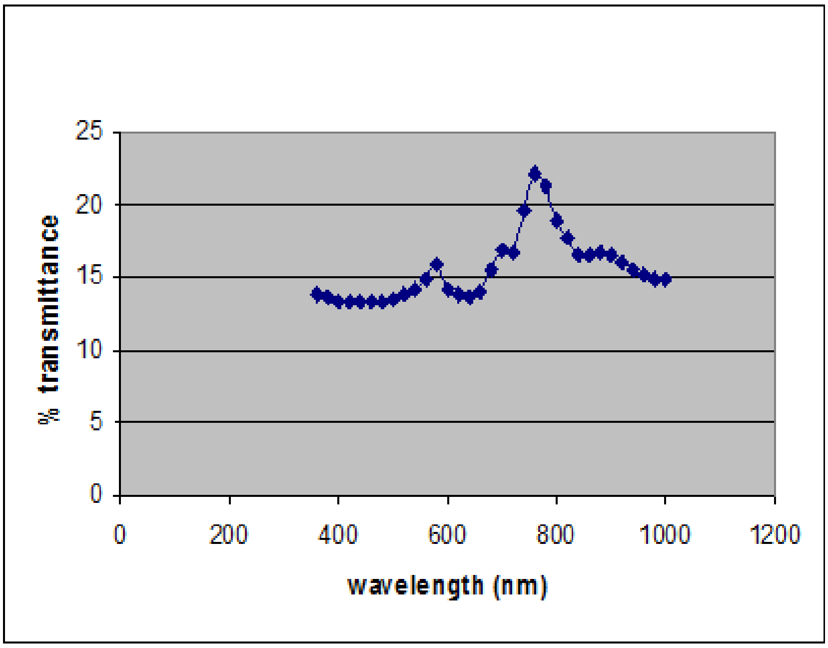


Fig. 3. Plot of transmittance against wavelength for *Solanium melongena* extract

Figure 4 indicates the extract reflectance (R) as a function of wavelength λ. A close observation of the graph shows that solanium melongena extract has very low reflectance value of about 0.04 in the visible region and 0.12 in the near infrared region. This makes it useful in thin film application as anti-reflection coatings.

The plot of absorption coefficient squared α^2 versus photon energy for *Solanium melongena* extract is shown in Figure 5. From the graph, the value of the band gap energy was found to be 1.20eV. This was obtained by extrapolating the straight part of the graph to a point where $\alpha^2 = 0$. It is in close agreement with the result of In Chung (2012) who reported a band gap range of 1.30eV for ruthenium dye.

Figure 6 shows a plot of the extinction coefficient (K) against wavelength. From the graph *Solanium melongena* shows a high extinction coefficient value of about 0.070 throughout the ultraviolet and the visible region. This high extinction coefficient value makes it useful for dye sensitizers. This agrees well with Schmidt-Mende, and Grätzel (2005) and Ute (2011) that a dye to be used in the fabrication of DSSC must have a high extinction coefficient.

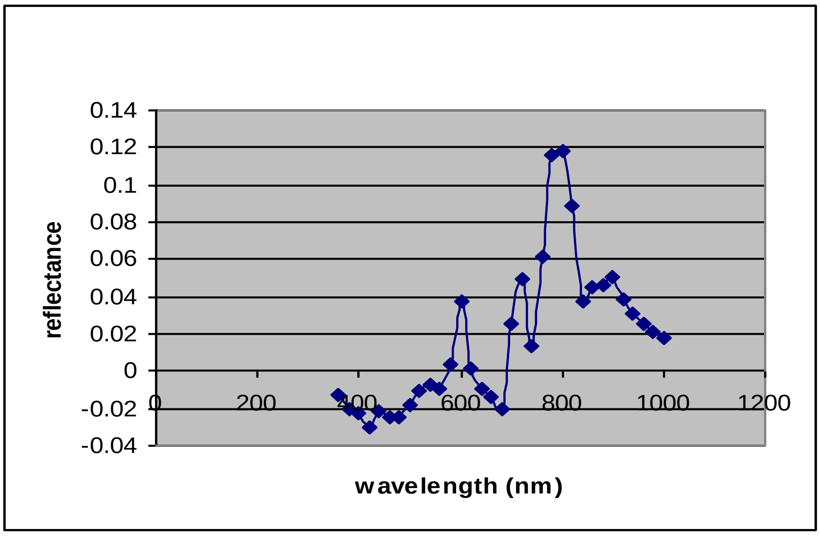


Fig. 4. Plot of reflectance against wavelength for *Solanium melongena* extract

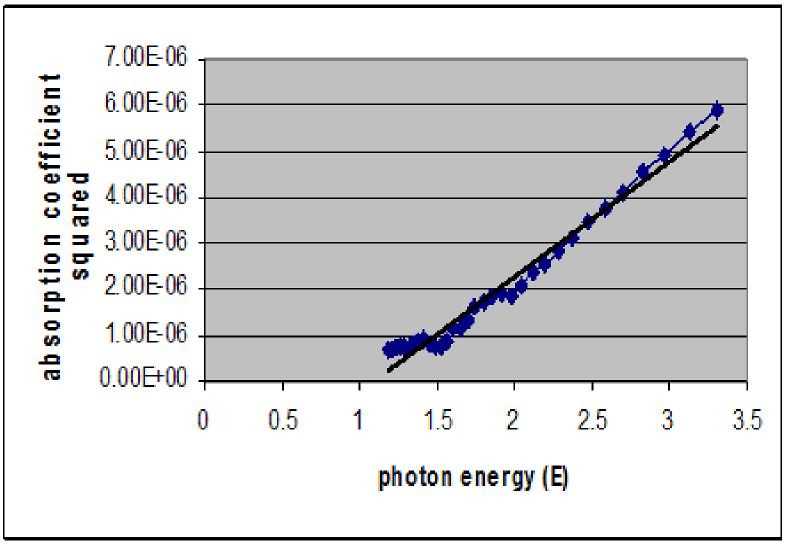


Fig. 5. Plot of absorption coefficient squared α^2 against photon energy E (hV) for *Solanium melongena* extract

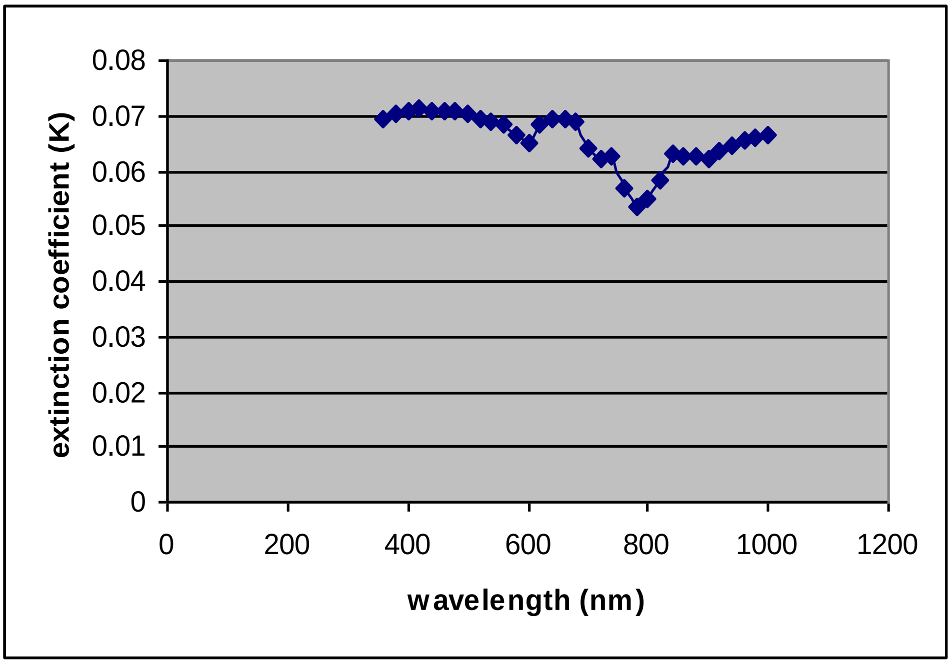


Fig. 6. Plot of extinction coefficient vs wavelength for *Solanium melongena* extract

Figure 7 is a plot of refractive index versus photon energy for *Solanium melongena* extract. From the graph it is indicated that the refractive index increases as photon energy increases. A peak value of 2.0 is observed at 1.5eV and 2.0eV respectively. This high refractive index makes *Solanium melongena* extract useful in solar cell and anti-dazzling coatings.

Figure 8 shows the plot of optical conductivity versus photon energy for *Solanium melongena*. From the graph it is observed that the optical conductivity increases with increasing photon energy. A further observation reveals that the optical conductivity of *Solanium melongena* extract when photon energy is 2.0eV it increases from 0.0004 at 1.5eV to 0.0005 which later drop to zero at 2.3eV. This is in agreement with the theory of semiconductor which explains that optical conductivity of a doped semiconductor increases as photon energy increases (Sze, 1969).

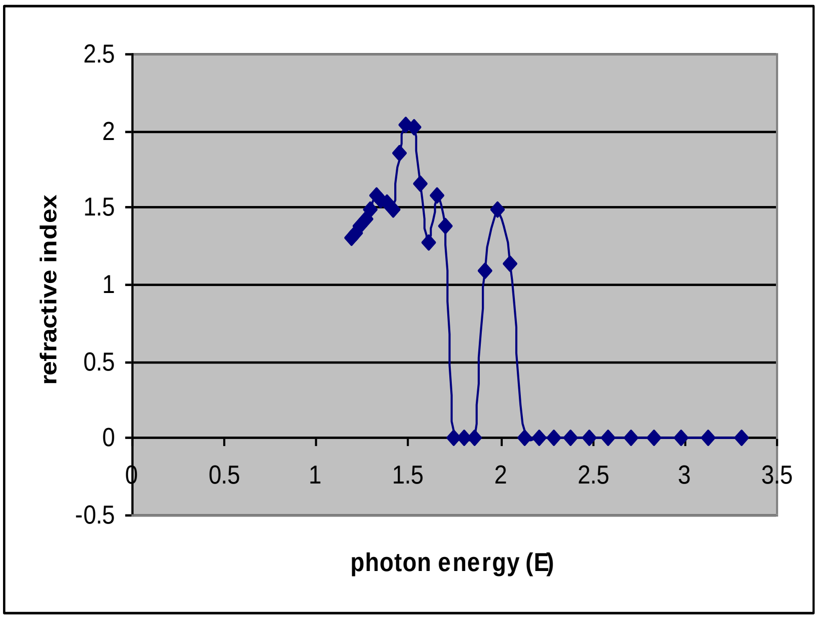


Fig. 7. Plot of refractive index vs photon energy for *Solanium melongena* extract

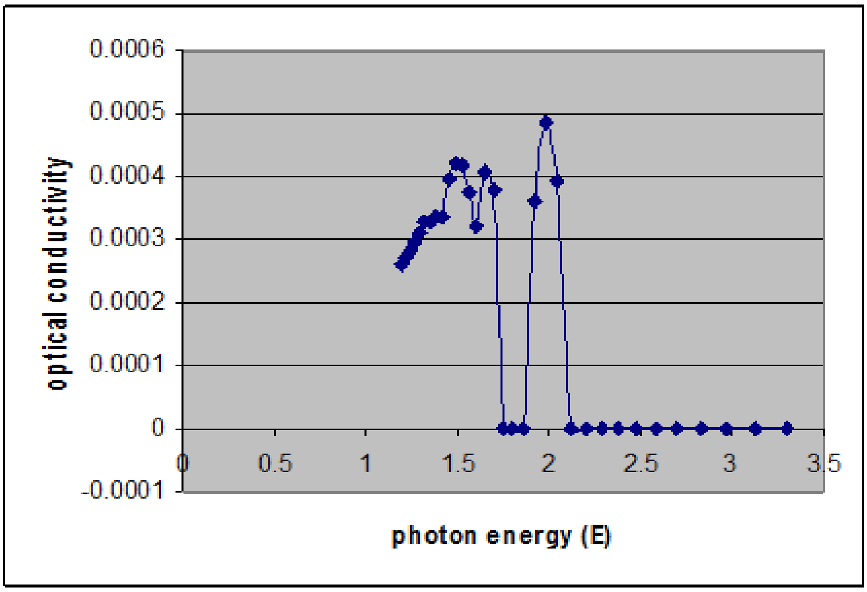


Fig. 8. Plot of optical conductivity against photon energy for *Solanium melongena* extract

3. Conclusion

Based on the results of research and discussion on the extraction and optical characterization of the active ingredient in *Solanium melongena*, it can be concluded that the extract from *Solanium melongena* contain pyrazine dye, 6-octadecenoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester and stearic acid as the active ingredients. These active ingredients composition portray the leaf extract as good source of dye for dye-sensitized solar cells (DSSCs). From the optical characterization, the extract showed very high absorbance, low transmittance, low reflectance, and high extinction coefficient. These makes it further useful as dye sensitizer material (and it can be employed in the fabrication of dye-sensitized solar cell). The extract can also be used in warm-coating and as anti-reflection coating. A band gap range of about 1.20eV was obtained from *Solanium melongena* extract and as a result, it can serve as semiconductor with high electrical properties.

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