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Investigation of optical properties of a novel pyrene-aminoisophthalate thin film grown by the spin coating method

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Pyrene-aminoisophthalate (containing an pyrene-imine group) thin film was deposited on quartz glass substrate with spin coating method. UV absorption measurements of the fabricated organic film were evaluated as a function of energy. Transmittance (T) was decreased depending on the increasing energy in the energy range from 1.5 eV to 2.5 eV whereas the reflectance (R) increased and then T remains almost constant as R decreases. At 1.55 eV, the T, R, and absorbance (A) values were determined as 77.77, 6.78, and 0.11, respectively. The indirect and direct optical band gap (E_g) were calculated to be 1.84 eV and 2.51 eV, respectively. The results note that the organic compound is in the semiconductor class and promising material for optoelectronic and electronic devices.

Keywords: Organic compound, thin film, transmittance, reflectance, energy band gap

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1. Introduction

Organic compounds have distinctly reported very great potential in optoelectronic device such as photodetectors, organic light-emitting diodes (OLEDs), solar cells, as well as display systems [1-3]. Furthermore, organic materials have many advantages such as their remarkable optical/electrical properties, cost reduction and organic materials could also be fabricated in a low-cost method by the simply prepared device [4-7].

Several researchers have explored the optical parameters and properties of organic thin film deposited on the glass. [8-11]. Abuelwafa et al. [8] 4-phenylthiazol-2-yl-(phenylhydrazono) acetonitrile (PTPA) azo dye were synthesized and studied from optical and electrical properties. Spectrophotometric measurements of transmittance (T), reflectance (R), and absorbance (A) at normal incidence light in the range from 200 nm to 2500 nm were used by them to calculate the optical band gap. El- N-(4-methoxy-2-nitrophenyl) acetamide (4M2NPA) thin films using spin coating method were deposited by Mahalawy et al. [9]. They studied transmittance (T), reflectance (R), and absorbance (A) measurements in detail and calculated optical parameters such as energy band gap, extinction coefficient and refractive index of the produced films.

This study comprises of to fabricate spin coated dimethyl(E)-5-((pyren-1-ylmethylene) amino) isophthalate (DMPMAI) thin film on the glass and researched it the optical microscopy method. Thus, the optical energy band gap values of the organic compound were determined. Also, it is targeted that fabricated organic film are used in solar cell applications.

2. Experimental

In this work, the optical measurements of the DMPMAI film were taken on the Corning 1737 glass. The molecular structure of DMPMAI is shown in Fig. 1. The glass substrate was washed in detergent, acetone and propanol for 3 min in each stage with an ultrasonic cleaner and dried in nitrogen gas. The organic DMPMAI material was dissolved in cloroform with a concentration of 10 mg/ml and then the prepared solution was grown in film form on the glass substrate by spin coating (1000 rpm for 30 s). The optical properties of the fabricated thin films were investigated by the analysis of the measured transmission, T, and reflection, R. The T and R data were collected using a JASCO V-670 spectrophotometer in the spectral range from 1.5 eV to 6 eV at room temperature an in normal incident mode.

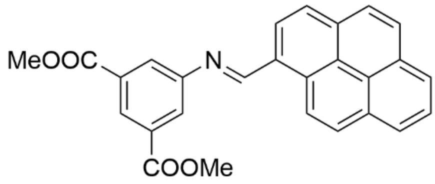

Figure 1: The molecular structure of dimethyl (E)-5-((pyren-1-ylmethylene)amino)isophthalate (DMPMAI).

3. Results

Fig. 2 displays the variation of the transmittance (T) with a photon energy in the UV and visible regions for DMPMAI thin film in the interval 1.55 eV < E < 6.0 eV. It is seen from Fig. 2 that T value of the deposited thin film decreases from 77% to 46% as the photon energy increases from 1.5 eV to 6.0 eV.

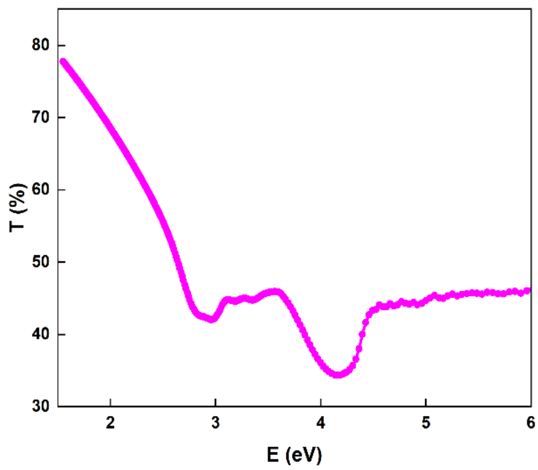

Figure 2: Transmittance spectrum of DMPMAI thin film

Fig. 3 indicates the measurement of the absorbance (A) with a photon energy in the UV and visible regions for DMPMAI thin film in the interval 1.55 eV < E < 6.0 eV. It is seen from Fig. 3 that A value of the deposited thin film has two absorption peaks and its values are 2.98 eV and 4.16 eV.

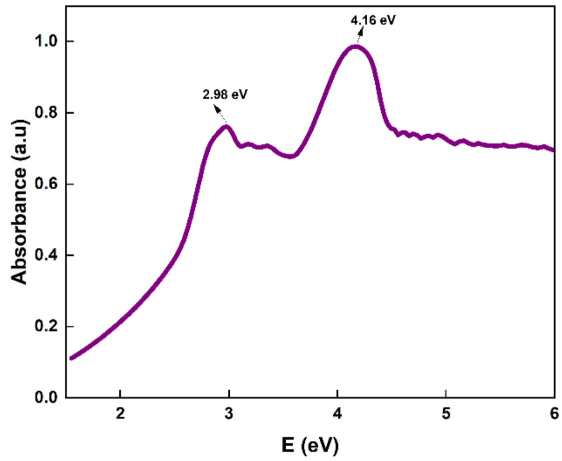

Figure 3: Absorbance spectrum of DMPMAI thin film

The reflectance (R) values are determined from the formula ($R = 1 - T - A$) as is described in [12,13]. Fig. 4 shows the variation of the transmittance (T) with a photon energy in the UV and visible regions for DMPMAI thin film in the interval 1.55 eV < E < 6.0 eV. It is seen from Fig. 4 that R value of the deposited thin film decreases from 6.78% to 3.82% as the photon energy increases from 1.5 eV to 6.0 eV. In addition, R value of the deposited thin film increases from 6.78% to 9.44% as the photon energy increases from 1.5 eV to 2.6 eV.

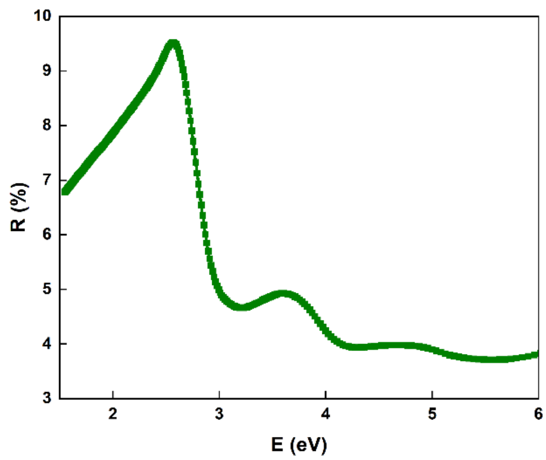

Figure 4: Reflectance spectrum of DMPMAI thin film

The parameter of absorption coefficient (α) is determined as [14-16]:

$$\alpha = \frac{2.303A}{d} \quad (1)$$

where A and d are the absorbance and the film thickness, respectively.

The absorption coefficient of the produced film as a function of photon energy ($E = h\nu$) is plotted in Fig. 5. The main feature observed in this curve are the absorption peaks at 2.98 eV and 4.16 eV.

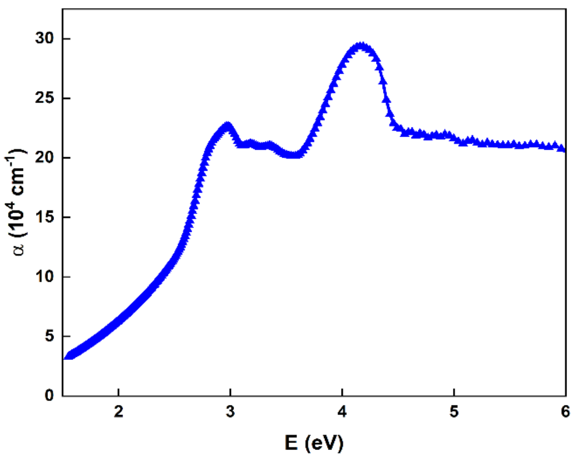

Figure 5: Absorption coefficient spectrum of DMPMAI thin film.

To determination the optical band gap and to investigate transition type, the analysis of the optical absorption edge is a acceptable method. The optical band gap Eg of the produced filmwhich can be determined from Tauc's relationship according to the following equation [17-20]:

$$\alpha h v = A\left(h v - E_g\right)^m \quad (2)$$

where A is a constant and m is 3, 2, 3/2 and 1/2 for transitions being indirect and forbidden, indirect and allowed, direct and forbidden, and direct and allowed, respectively. Thus, the value of optical band gap energy (E_g)of the film can be determined by extrapolating the absorption coefficient to zero absorption in the $(\alpha h v)^{1/m}$ against photon energy ($E = hv$) plot. Figure 6 shows plots of $(\alpha h v)^{1/2}$vs. E and $(\alpha h v)^2$ vs. E of DMPMAI thin film. According to Fig 6, the energy band gap values of direct and indirect allowed transition type for organic compound was calculated as 2.51 eV and 1.84 eV, respectively.

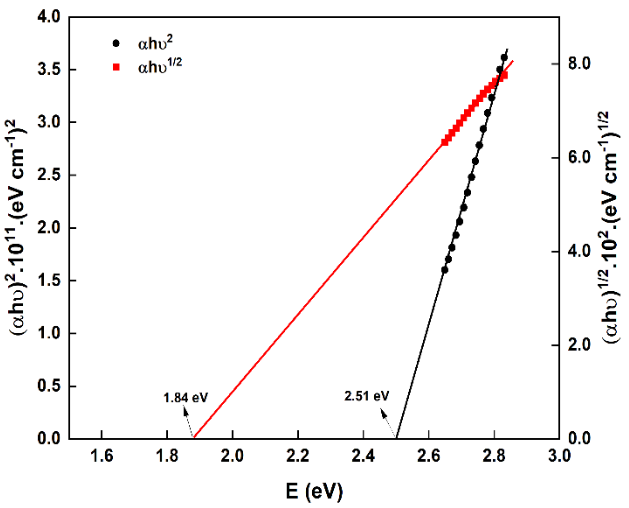

Figure 6: Plots of $(\alpha h v)^{1/2}$vs. E and $(\alpha h v)^2$ vs. E of DMPMAI thin film.

4. Conclusion

A thin film of DMPMAI was fabricated by using spin coating and its UV–Vis spectroscopy were taken to discover the optic properties. Due to the increase in photon energy up to 2.7 eV, the reflectance increased while the transmittance values decreased. At 1.55 eV, the transmittance value is 77%, while the reflectance value is 6.7%. The energy band gap values of direct and indirect allowed transition type for organic compound was calculated as 2.51 eV and 1.84 eV, respectively. It can be concluded from all calculations that the DMPMAI may replace in the semiconductor class and get a role in the several electro-optical applications

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