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Study the optical properties of the polymer (PMMA)composite to films Based on Malachite Green Dye

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Abstract

This study includes the preparation of a thin film of Malachite Green dye (MG) by casting method on a glass substrate. the polymethacrylate (PMMA) was applied (0.5ml) with the dye. to increase the adhesion of dye films, On the glass surface, The films were prepared with different concentrations (6mM, 8mM, 10mM, 12mM, and 16mM) to find a best optical property of the films. The linear optical Parameters such as extinction coefficient, refractive index, real and imaginary parts, Urbach energy and optical conductivity. The average refractive index by using the absorbance and transmittance measurement were studied by atomic force microscopy (AFM) study shows that the roughens of films increase with the increase of the dye concentration. Study of linear optical (UV-visible) Spectrophotometer (Shimadzu) the spectral range (200-1100nm) showed an increasing concentration of the dye. the energy gap was estimated in the range of (3.26 -2.64) eV for the different films.

Keywords

Organic dye, energy gap, linear properties, casting method.

1- Introduction

Organic semiconductors receive increasing attention because they have many properties, including their lightweight, low-cost preparation and production, their possibility of processing at low temperatures, mechanical flexibility, and their availability in nature compared to their conventional inorganic counterparts[1]. They have been applied across a variety of optoelectronic devices, including organic light-emitting diodes[2], and photo-catalysis, voltaic cells, transistors, laser applications[3], and light-emitting screens. Applications of organic semiconductors included chemical, physical and biological sensors, electronic and photonic devices, especially the use of organic dyes as active materials for the manufacture of sensors [4]. Organic

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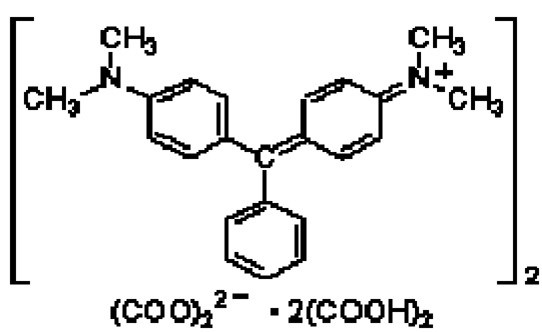
semiconductors are characterized by the possibility of manufacturing these devices at low cost using thermal evaporation, centrifugation, spin coating and casting techniques.

This study includes a description of the Malachite green dye (MG) is an organic dye used extensively as a fungicide and ectoparasiticide in the fish farming industry throughout much of the world On the other hand, it is also used as a food coloring agent, food additive, a medical disinfectant and anthelminthic [5], as we studying its chemical and physical properties, and then presenting methods and techniques of preparing the dye as films.

2-Experimental

Malachite green dye (MG) it also called china green or Benzaldehyde green[6,7],it has chemical formula ($C_{52}H_{54}N_4O_1$) and molar mass (927.03 gm/mol) as shown in figure(1), it supplied by Aldrich company with purity(96.3%.)poly Methyl methacrylate (PMMA) it has chemical formula (**$C_5H_8O_2$**),it supplied by Aldrich



$[(C_{23}H_{25}N_2)\cdot(C_2HO_4)]_2\cdot C_2H_2O_4$

Fig.1: The chemical structure and formula of MG.

The Malachite Green (MG)dye films was prepared as follows: (6mM,8mM,10mM, 12mM and 16mM) of the MG were dissolved in 10ml chloroform then the solutions were stirred at room temperature for 30min and then filtered. through 0.2mm syringe filter, and prepared (PMMA) dissolved (0.78gm) in 30 ml of chloroform. The films were prepared by the casting methods [18] on glass substrate. each concentration of the dye is mixed with 0.5ml of polymer then the solution were stirred ,then 1ml of the mixture is withdrawn on the substrate and left to dry at room temperature for 24hours.

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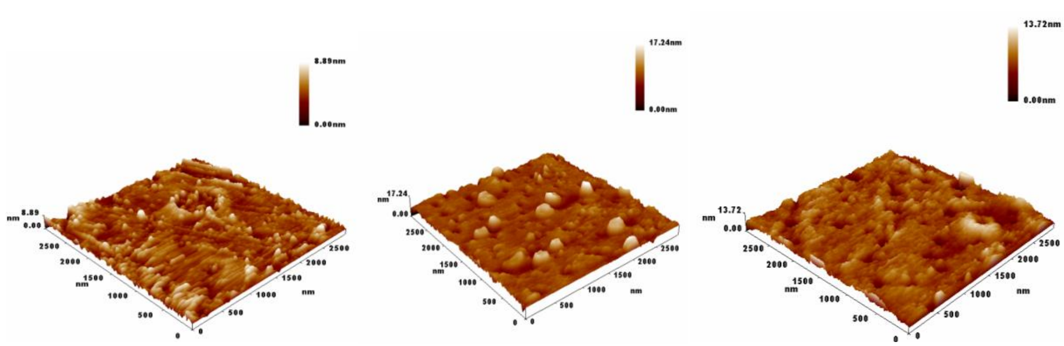
Thus,the film are ready for study optical properties. Thickness of all films was measured to be 2μm.

3- Results and discussion

(3-1)Topography discussion

The topography of the surfaces of films, was studied using the Atomic Force Microscope (AFM), as it has the ability to analyze the surfaces of the films and give statistical values depending on the square root of the average roughness and it was found that through figures (2) roughness values the surface area increases with the increase in the concentration of MG dye.



a b c

Fig.2. Surface topography of films (a)6mM,(b) 8mM and (c)10mM

(3-2) Study of the Optical properties

Figures3 and 4 show the visible and ultraviolet spectrum Absorption and Transmittance spectra of films. Absorption / Transmittance (MG) films spectra increase/decrease. Figure 3 shown the spectral distrbution from the absorption samples in the spectrum range (400-750nm.) and the peaks of the absorption spectra of the films of differents concentrations is at 630 nm.

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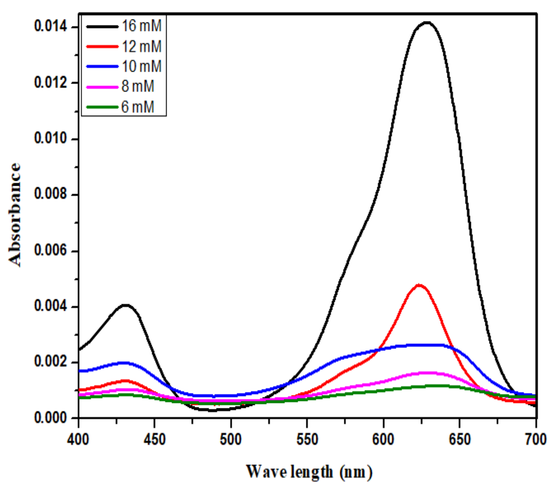

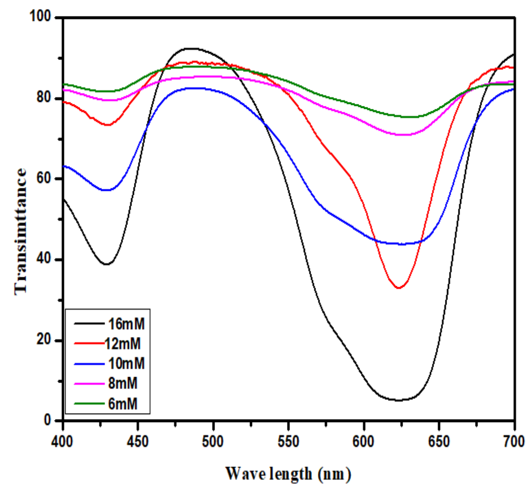

Fig.3Absorbance spectral of the Malachite Green films at deposited different concentration different Concentration.

Fig4.Transmitance spectral of Malachite Green films deposited' at .

The theory of optical absorptiongives the relationship between the absorption coefficient (α) and the photon energy (hv) is given by [8-11]:

$$\alpha hv = \beta\left(hv - E_g\right)^n \qquad (1)$$

Where (α) is the absorption coefficient,(hv) is the photon energy, E_g is the optical band gap and β is the constant equation. The (n) assumes values of (1/2, 2, 3/2 and3)for allowed direct, allowed indirect, forbidden direct and forbidden indirect transitions, respectively. For allowed direct types of transitions.

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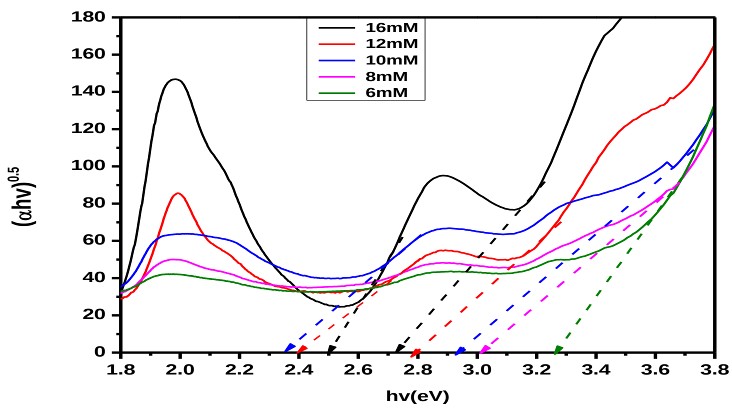

Fig.5 ($\alpha h\nu)^{0.5}$ vs. photon energy for different construction of MG

From the figure.5 of the relationship between $(\alpha h\nu)^{0.5}$ and (hv)it's observed that 'the values of the energy gap (E_g) decreases. with the increases in the concentration of MG dye and this is due to the formation of local levels within the energy gap near From the conductive band .The values of band gaps (E_g) calculated from the figure.5 are listed' in the Table.1.

Table.1.bandgap values.

Sample	Energy gap1(eV)	Energy gap2(eV)
6mM	**3.26**	**2.51**
8mM	**3.01**	**2.40**
10mM	**2.93**	**2.35**
12mM	**2.72**	**2.33**
16mM	**2.64**	**2.28**

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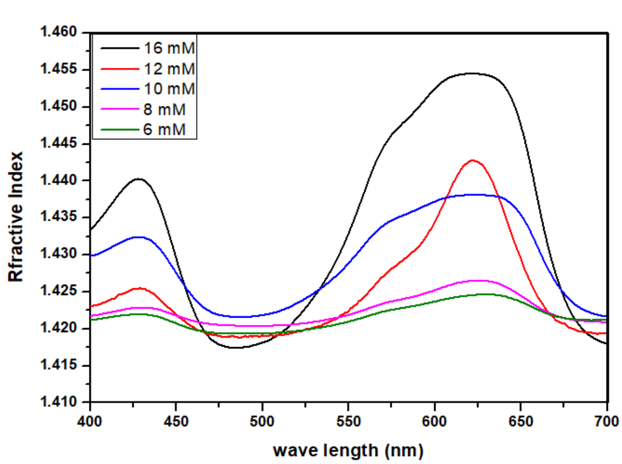
(3-3)The refractive index (n)

The calculated n from the relation 2 shown to the (n) index values of the thin film was increasing with the hv. The refractive index was observed that the refractive index spectrum behaves like a reflectivity spectrum and that the general was calculated based on the equation behavior of the refractive index curves was increasing with the energy of the incident photon (hv), We calculated the refractive index (n)values of the film's using the following equation[11-13]:

$$n = \sqrt{\frac{4R}{(1-R)^2} - k^2} + \frac{1+R}{1-R} \qquad (2)$$

Where (R)is the Reflction and k=$(\frac{\alpha\ \lambda}{4\pi})$ is the extinction. Coeffcient. As shown in Figures.6 and7, refractive *and* extinction coefficient values are influenced. by the increasing concentrations and decrease with increasing the wavelngth(λ) up to 620 . Therfore, they shown the normal e disprion.



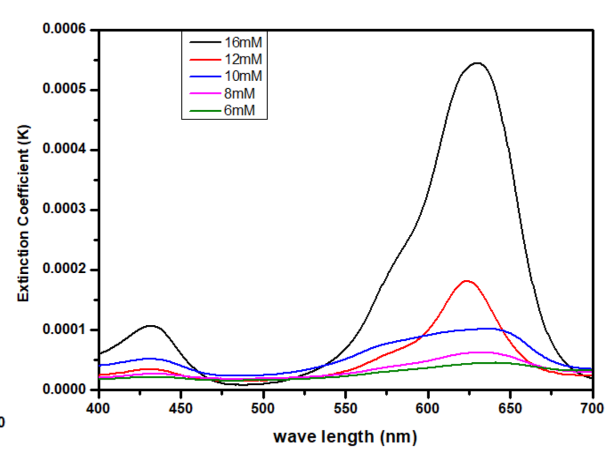


Fig.6.the relationship between refractive Fig.7. The relationship between extinction

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Index and wavelength (λ) for different concentration of MG dye.

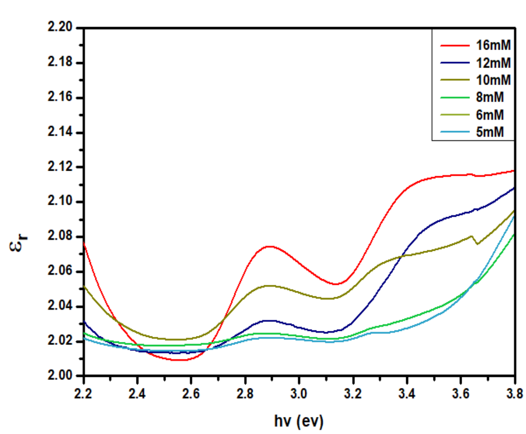
coefficient and wave length for different Concentration of MG dye.

(3-4)Dielectric characteristic

The dielectric constant describes the response of electrons to the electromagnetic field and the dielectric constant is represented by its real and imaginary parts and is given by the equation [12-17] ,the real dielectric constant present the speed of the speed of the propagating wave ,while the imaginary dielectric constant represents the energy loss. Where the n represent the refractive index and k indicator to the extinction coefficient .

$$\varepsilon_r = n^2 - k^2 \quad (3) \qquad\qquad \varepsilon_i = 2n\,k \quad (4)$$

Figures 8 and 9 show the relationship between the real and imaginary dielectric constant with the energy of the incident photon respectively.it can be seen from the figures that the real dielectric constant behave as refractive index, and the imaginary dielectric constant behaves as extinction coefficient.



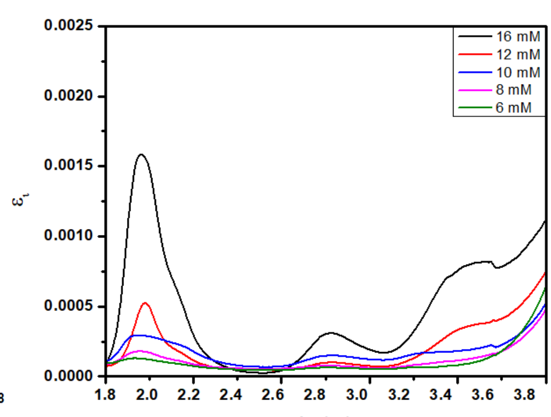


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Fig. 8. The real dielectic constant ($\square_r$) Fig.9. The imaginary dielectic constant of
($\square_{\square}\square$with with the photon energy for different the photon energy for different
concentration concentration of MG dye of MG dye

(3- 5)Conclusion

From the above results can be withdrawn the following conclusion, the films with different concentrations were deposited on glass substrate using casting method [18], and the topography of the films surfaces was studied and it was found that the surface area increases with increasing dye concentrations, in addition to that, the effect of increasing the concentration of dye on optical properties was studied. The indirect optical energy gaps of the films were determined in the range of the 3.26eV to 2.64eV for the films concentrations in the range of (6mM to 16mM) respectively.

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