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Study of the Effect Magnetic Field on the Optical Properties of Poly(Methyl Metha Acrylate) Doped with Copper Nanoparticles

Zaid A. Hasan and Maryam F. Obayes
Department of Physics, College of Education for Pure Sciences, University of Babylon, Hillah, Iraq

Abstract: The optical characteristics of PolyMethyl Metha Acrylate (PMMA) films doped with copper nanopaticles were studied. The polymer films were prepared using solution casting technique different concentrations (0, 2.0, 4.0 and 6.0 wt.%) of the Cu nanoparticles, the optical properties of the prepared films were investigated. The optical absorption spectra of these films in the wavelength range from (190-1100 nm) were measured to investigate the influence of Cu nanoparticles on the optical properties of PMMA. The results showed that energy gap of the polymer films decreases with increasing Cu nanoparticles concentration. The absorbance, absorption coefficient, extinction coefficient, refractive index, parts dielectric constant (real and imaginary) of the prepared PMMA films were found to be increased with increasing the concentration of Cu nanoparticles. The magnetic field gives a better chance of all optical properties.

Key words: Spectra, wavelength range, energy, extinction coefficient, refractive index, PMMA

INTRODUCTION

Photochromic compounds are important compounds because of their potential applications in optical memories (Irie, 2000; Pu *et al*., 2006). The development in this field is continuant, therefore, need the optical devices such as computers. Photochromic polymers are favoured over low molecular weight monomeric compounds accordingly. The photochromic polymers became interesting materials (Luo *et al*., 2011). The PMMA films can be prepared by spin coating technique or by making a solution of mixture of the PMMA and the photochromic followed by casting the mixture on coer glass and drying (Fukaminato *et al*., 2007).

MATERIALS AND METHODS

Experimental: PolyMethyl Metha Acrylate (PMMA) films doped copper nanoparticles (size: 20-30 nm, purity: 99.99%, manufacturer Hongwu nanometer) were prepared by solution casting technique, mixtures of the PMMA and Cu nanoparticles in (0, 2.0, 4.0 and 6.0 wt.%) were dissolved in glass beaker (30 mL) by chloroform using magnetic stirrer and placed in petri dish 5 cm diameter (the petri dishes were cleand with water using ultrasonic device). After evaporation of the solvent, samples were dried. The thickness of the dried samles were measured using micrometer.

The spectra of absorption and transmittance were recorded for wavelength (190-1100 nm) using double beam spectrophotometer UV-Vis (1800) provided by (Shimadzu).

Theoretical: The relationship between incident Intensity (I_O) and penetrating light Intensity (I) is given by this Eq. 5:

$$I = I_0 e^{-\propto t} \quad (1)$$

Where:

t = The thickness of sample
$\propto$ = The absorption coefficient (cm^{-1})

$$\propto t = 2.303 \log \frac{I}{I_0} \quad (2)$$

The value of log I/I_0 is the Absorbance (A). The absorption coefficient can be calculated by Srivastava *et al.* (2008):

$$\propto = 2.303 \left(\frac{A}{t} \right) \quad (3)$$

If the value of absorption is $\propto \geq 10^4 cm^{-1}$ the electronic transitions are direct and the optical energy gap from this region can be evaluated by the relation:

$$\propto h\upsilon = A\left(h\upsilon - E_g\right)^m \quad (4)$$

Corresponding Author: Zaid A. Hasan, Department of Physics, College of Education for Pure Sciences, University of Babylon, Hillah, Iraq

Where:

hν = The photon energy
A = The proportional constant
E_g = The allowed or forbidden Energy gap of direct transition
m = The constant

The refraction index consists of real and imaginary parts (N = n-ik), the relation between reflectivity and refractive index is given by Sharafudeen *et al*.:

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2} \tag{5}$$

Where:

k = The extinction coefficient
R = The Reflectivity
n = The refraction index

The absorbance and transmittance can be calculated by the following Eq. 6:

$$R+A+T = 1 \tag{6}$$

where, T is Transmittance. The refractive index can be expressed by Shanshool *et al*. (2015):

$$n = \sqrt{\frac{4R-k^2}{(R-1)^2}} - \frac{(R+1)}{(R-1)} \tag{7}$$

The extinction coefficient can be calculated by Haider *et al*.:

$$k = \frac{\propto \lambda}{4\pi} \tag{8}$$

where, λ is the wavelength of incident ray. The relation between the complex dielectric constant and the complex refractive index N is expressed by Hasan (2018):

$$\varepsilon = N^2 \tag{9}$$

It can be concluded that (Pu *et al*., 2010):

$$(n-ik)^2 = \varepsilon_1 - i\varepsilon_2 \tag{10}$$

The real and imaginary complex dielectric constant can be expressed by Eq. 1, respectively:

$$\varepsilon_1 = n^2 - k^2,\ \varepsilon_2 = 2nk \tag{11}$$

RESULTS AND DISCUSSION

Increasing the value of the magnetic field leads to a better alignments of the dipoles of the molecules this is clear from Fig. 1.

The transmittance value increases as the magnetic field applied, therefore, the molecules is affected by the magnetic field and polarized to word it this means that the wave vector (k) takes the same direction of field (Hasan *et al*., 2016). The absorptauce value can be obtain from Eq. 9:

$$A = -\text{Log}_{10}T$$

By applying these values of transmittance from this equation found the indirect proportionality between the Absorptauce (A) and the Transmittance (T). From Fig. 2, the direct proportionality between the Absorptauce (A) and the concentration (c).

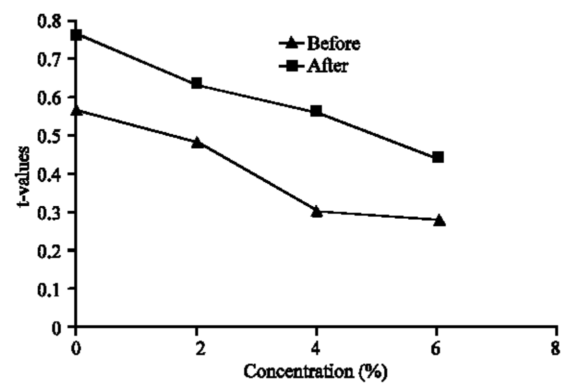

Fig. 1: The relation between Transmittance (T) and the concentration at magnetic field (B) (250 mT) and wavelength (540 nm)

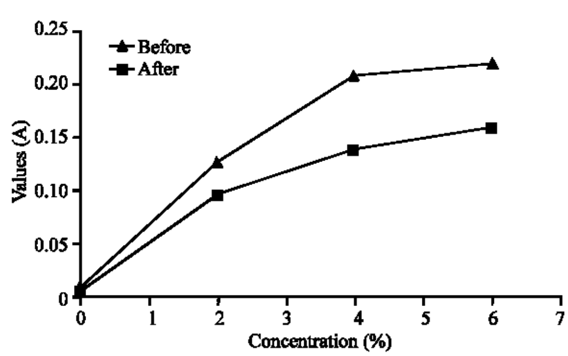

Fig. 2: The relation between Absorptauce (A) and the concentration at magnetic field (250 mT) and wavelength (540 nm)

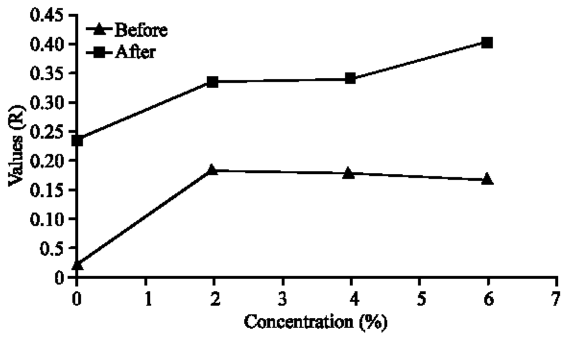

Fig. 3: The relation between Reflectance (R) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

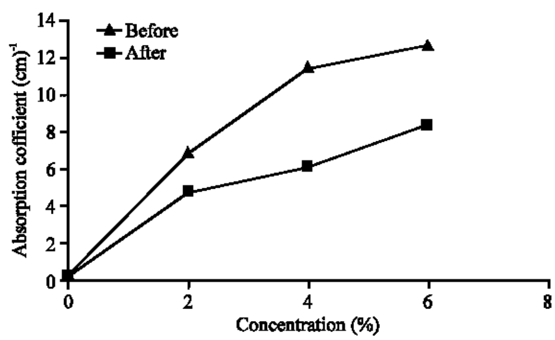

Fig. 4: The relation between the absorption coefficient (∝) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

From Fig. 3, the reflectance is increases as the concentration increased. Additionally, the magnetic field is arrange the molecules, therefore, the reflectance increases.

The relation between the concentration the absorption coefficient is direct proportionality as shown in Fig. 4 and the magnetic field causes better alignment of the dipoles, therefore, the absorption coefficient values are decreased. Additionally, to the relation between the absorption concentration and the Absorptance (A).

The extinction coefficient value was calculated from Eq. 8, the behavior shows direct proportionality as it in illustrated in Fig. 5 between the extinction coefficient and the concentration the magnetic field affected on the molecules, therefore the absorption coefficient decreases and caused to extinction coefficient value decreased.

From Fig. 6 and 7, the relation between the refractive index and the concentration is direct proportionality the magnetic field causes better alignment of dipoles, therefore, the refractive index value decreased. The complex dielectric function is:

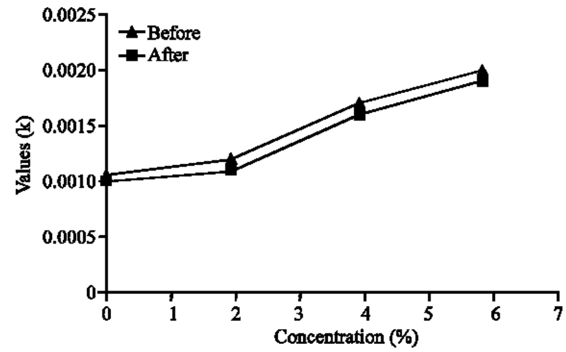

Fig. 5: The relation between the extinction coefficient (k) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

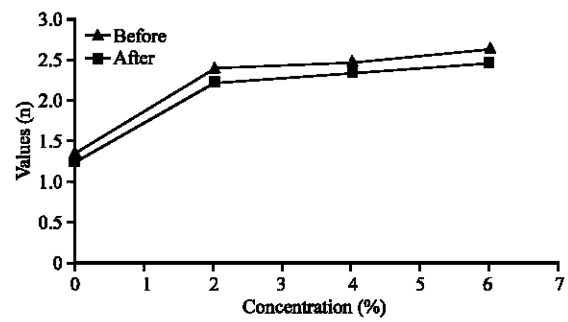

Fig. 6: The relation between the refractive index (n) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

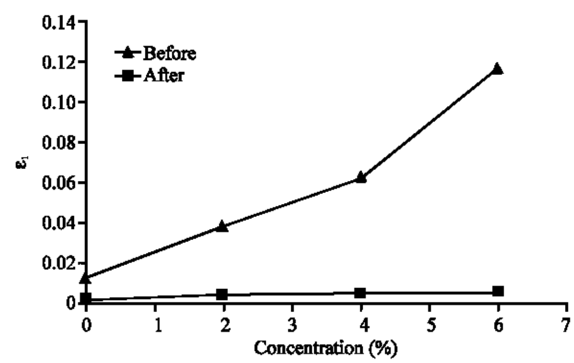

Fig. 7: The relation between the real dielectric constant (ε_1) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

$$\varepsilon = \varepsilon_1 + \varepsilon_2$$

The real of dielectric constant is related to the dispersion in order to explain the dispersion it is

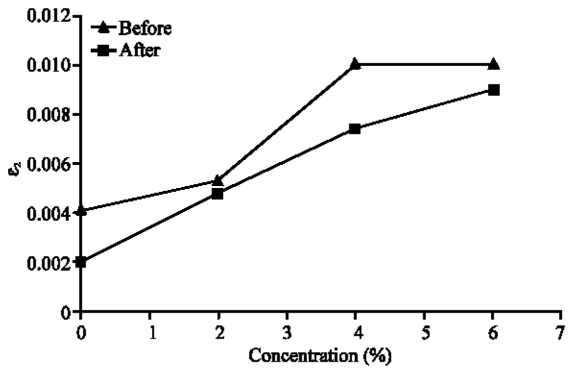

Fig. 8: The relation between the imaginary dielectric (ε_2) and the concentration (c) at magnetic field (250 mT) and wavelength (540 nm)

necessary to take into account, the actual motion of the electrons in the optical medium through which the light is traveling.

The imaginary part represent the dissipative rate electromagnetic ware propagation in the medium. The real and imaginary parts dependence on photon energy of samples and also dependences on refractive index, clue to the magnetic field make the decrease (n), therefore, the real and imaginary dielectric constant are decreased as shown in Fig. 7 and 8.

CONCLUSION

The absorbance, absorption coefficient, extinction coefficient and refraction index of the (PMMA) doped with a Cu nanoparticles where found to be increasing with increasing the concentration. The dielectric constant (real and imaginary) was also found to be increasing with increasing the concentrations of the dopant. The magnetic field gives a better chance of all optical properties.

REFERENCES

Fukaminato, T., T. Umemoto, Y. Iwata, S. Yokojima and M. Yoneyama *et al.*, 2007. Photochromism of diarylethene single molecules in polymer matrices. J. Am. Chem. Soc., 129: 5932-5938.

Hasan, Z.A., 2018. Influence the temperature on optical properties for (5PCH) liquid crystal. Res. J. Pharm. Technol., 11: 1137-1139.

Hasan, Z.A., S.S. Al-azzawi and M.M. Abdullah, 2016. Magnetic field effect on refractive indices for high birefringence liquid crystal (UCF). J. Babylon Univ. Pure Appl. Sci., 2: 409-417.

Irie, M., 2000. Diarylethenes for memories and switches. Chem. Rev., 100: 1685-1716.

Luo, Q., H. Cheng and H. Tian, 2011. Recent progress on photochromic diarylethene polymers. Polym. Chem., 2: 2435-2443.

Pu, S., F. Zhang, J. Xu, L. Shen and Q. Xiao *et al.*, 2006. Photochromic diarylethenes for three-wavelength optical memory. Mater. Lett., 60: 485-489.

Pu, S., W. Liu and G. Liu, 2010. The photochromism of unsymmetrical diarylethene isomers with an electron-withdrawing cyano substituent. Dyes Pigm., 87: 1-9.

Shanshool, H.M., M. Yahaya, W.M.M. Yunus and I.Y. Abdullah, 2015. Optical properties of PMMA/ZnO nanocomposites as foils prepared by casting method. Aust. J. Basic Appl. Sci., 5: 401-409.

Srivastava, S., M. Haridas and J.K. Basu, 2008. Optical properties of polymer nanocomposites. Bull. Mater. Sci., 31: 213-217.