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RESEARCH ARTICLE

Influence of Silver Nanoparticles on Optical Properties for (PS-PMMA) Blend

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Abstract

The optical properties of poly (methyl metha acrylate) (PMMA) with polystyrene (PS) blend films doped with silver nanoparticles were studied. The blend films were prepared using solution casting technique different weight ratio (0, 2.0, 4.0, and 6.0 wt %) of the Ag nanoparticles, the optical properties of the prepared films were investigated. The optical absorption spectra of these films in the wavelength range from (320-1100 nm) were measured to investigate the influence of Ag nanoparticles on the optical properties of (PS-PMMA) blend. The results showed that energy gap of the blend films decreases with increasing Ag nanoparticles weight ratio. The absorbance, absorption coefficient, extinction coefficient, refractive index, parts dielectric constant (real and imaginary) of the prepared (PS- PMMA) blend films were found to be increased with increasing the weight ratio of Ag nanoparticles.

Keywords: *Nanoparticls, Optical properties, (ps-pmma) polymer.*

Introduction

Photochromic compounds are important compounds because of their potential applications in optical memories [1, 2]. 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 [3].

Experimental

Materials

Poly(methyl metha acrylate) (PMMA), and polystyrene(PS) blend films doped silver nanoparticles (size:20-30 nm, purity: 99.99%, Manufacturer Hongwu nanometer) were prepared by solution casting technique, mixtures of the(PS- PMMA) and Ag 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 cleaned with water using ultrasonic device). After evaporation of the solvent, samples were dried. The thicknesses of the dried samples were measured using micrometer. The spectra of absorption and transmittance were recorded for wavelength (320-1100 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 equation [4]:

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

Where t is the thickness of sample and (α) is the absorption coefficient (cm $^{-1)}$

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

The value of $\log \frac{I}{I_0}$ is the absorbance (A). The absorption coefficient can be calculated by [5].

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

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 [6].

$$\propto hv = A\ (hv - E_g)^m \quad (4)$$

Where hv is the photon energy, (A) is the proportional constant, E_g is the allowed or forbidden energy gap of direct transition and (m) is a constant.

The refraction index consists of real and imaginary parts ($N = n - i\,k$), the relation between reflectivity and refractive index is given by [7].

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

Where k is the extinction coefficient, R is reflectivity and n is refraction index.

The absorbance and transmittance can be calculated by the following equation.

$$R + A + T = 1 \quad (6)$$

Where T is transmittance.

The refractive index can be expressed by [8].

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

The extinction coefficient can be calculated by [8].

$$k = \frac{\propto \lambda}{4\pi} \quad (8)$$

Where λ is the wavelength of incident ray.

The relation between the complex dielectric constant and the complex refractive index N is expressed by [9]

$$\varepsilon = N^2 \quad (9)$$

It can be concluded that (5).

$$(n - i\,k)^2 = \varepsilon_1 - i\,\varepsilon_2 \quad (10)$$

The real and imaginary complex dielectric constant can be expressed by eq. (1) respectively:

$$\varepsilon_1 = n^2 - k^2\ , \varepsilon_2 = 2nk \quad (11)$$

Results and Discussion

Figure (1) shows the absorbance spectra as a function of the wavelength of incident light for (PS- PMMA) film with different weight ratio of Ag nanoparticles. It is clear that increasing the weight ratio leads to increasing the peak intensity and there is no any shift in the peak position for all amounts of added Ag nanoparticles weight ratio to the polymer that means there is no chemical interaction between the two components.

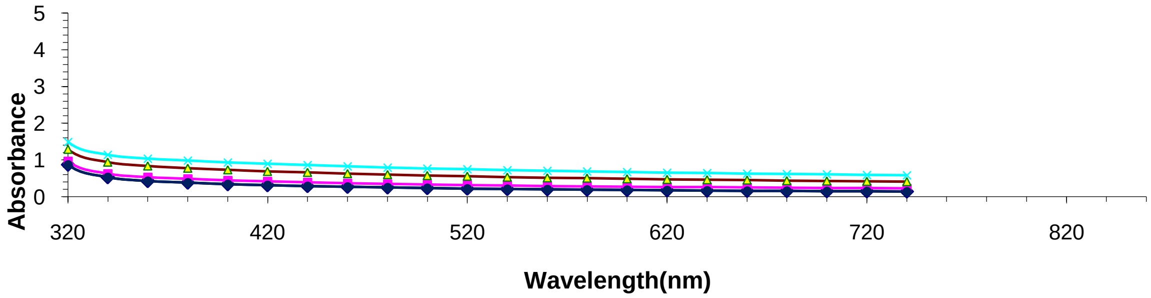

Figure 1: The absorbance spectra of (PS- PMMA- Ag) films. As function of incident light wavelength

Figure (2) shows the optical transmittance spectra as function of wavelength of incident light for several weight ratios of added Ag nanoparticles. The polymer transmittance decrease with the increasing the weight ratio of Ag nanoparticles, this is due to the added nanoparticles molecules that contains in it is outer orbits, these electrons absorb the electromagnetic energy of the incident light, then as a result electrons excited to higher energy levels, this process is not accompainied by of radiation because the electron that moved to higher levels have occupied vacant positions of energy bands, thus part of the incident light is absorbed by the substance and dose not penetrate through it. On the other hand the pure poly (Methyl Meth Acrylate) (PMMA) and the polystyrene (PS) blend have high transmittance because there are no free electron (i.e electrons are strongly linked to them atoms through convalent bands), i.e. the breaking of electron linkage and moving to the conduction band need high energy [9].

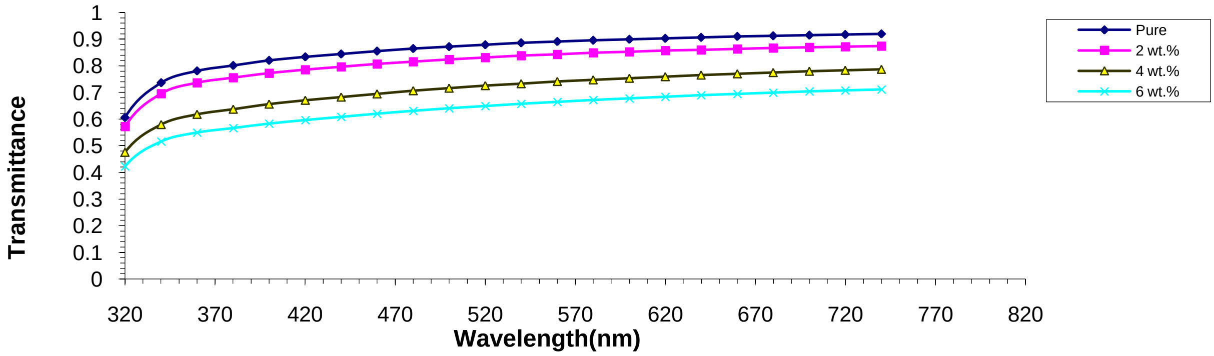

Figure 2: The transmittance spectra of (PS-PMMA–Ag $_{nano}$) blend as a function of incident light wavelength

The absorption coefficient (α) is calculated using equation (3) shows the absorption coefficient as a function of the photon energy, it can be noted that absorption is relatively small at low energy. This means that the possibility of electron transition is low, because the energy of the incident photon is not sufficient to move the electron from the valence band to the conduction band ($h\nu < E_g$). At high energies, absorption is high, this means that there is a great possibility for electron transitions consequently, where the energy of icident photon is enough to move the electron from the valence band to conduction band, this means that the energy of the incident photon is greater than the forbidden energy gap [9, 10]. This shows that the absorption coefficient assists is figuring out the nature of electron transition, when the values of the absorption coefficient is high ($\alpha > 10^4$) cm^{-1}at high energies, it is expected that direct transition of electron occur, the energy and moment are maintained by the electrons and photons, on the other hand when the values of the absorption coefficient is low ($\alpha < 10^4 \, cm^{-1}$) at low energies, it is expected that indirect transition of electron occur, and the electronic momentum is maintained with the assistance of the photon . Among other result the is that the coefficient of absorption for the (PS-PMMA) blend in the presence (Ag) nanoparticles as dopant is less than (10^4 cm^{-1}). This explains that the electron transition is indirect.

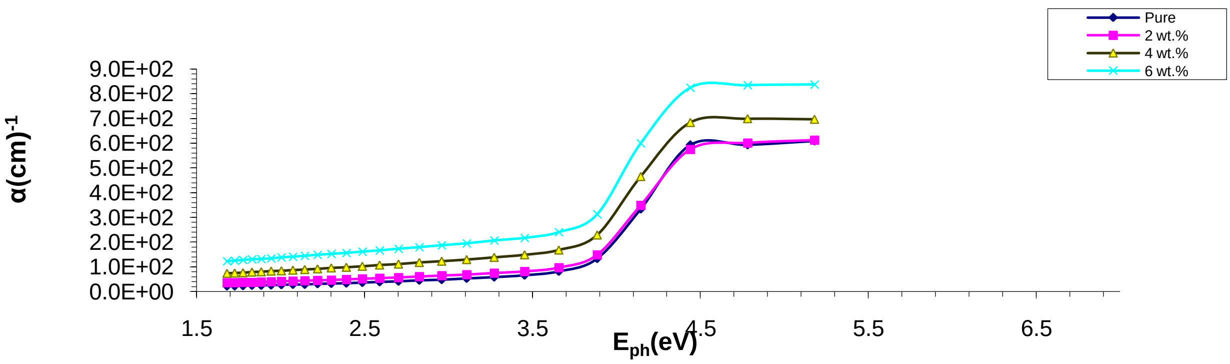

Figure 3: The absorption coefficient of (PS-PMMA –Ag $_{nano}$) blend as a function of photon energy

Figure (4) shows the relationship between absorption edges $(\alpha\ h\nu)^{1/2}$ for casting material as a function of photon energy. At extension of the curve to values of $(\alpha\ h\nu)^{-1/2} = 0$, get indirect allowed gap transition.

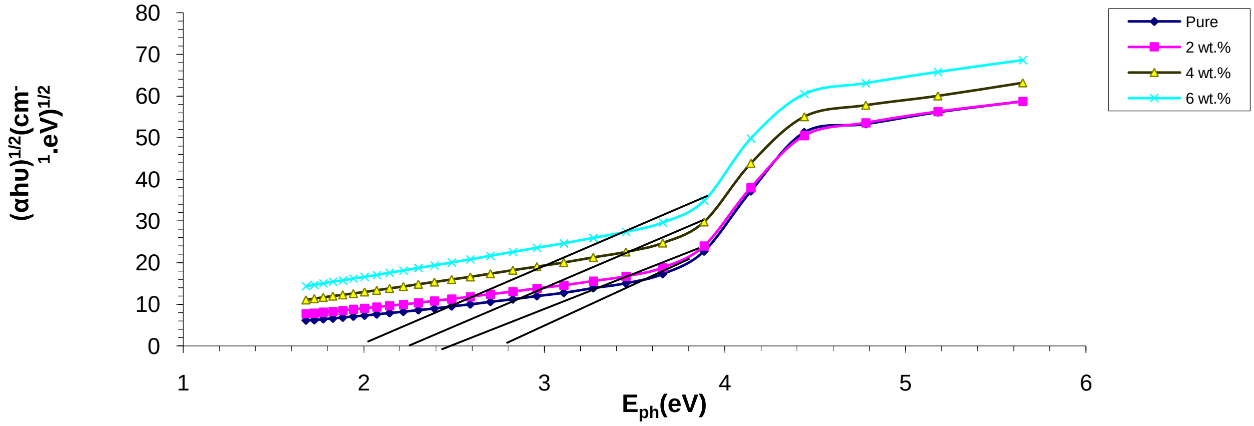

Figure 4: $(\alpha\ h\nu)^{1/2}$vs.hv plot of doped (PS- PMMA) blend films for different dopent weight ratio with energy of allowed indirection transitions

From Figure (5), noted that values of energy gap decrease with increase of weight percentage of nanoparticls. These attributes to the creation of the site levels in forbidden indirect energy gap lead to facilitate the crossing of electron from the valence band to the local levels to conduction depends on added impurities.

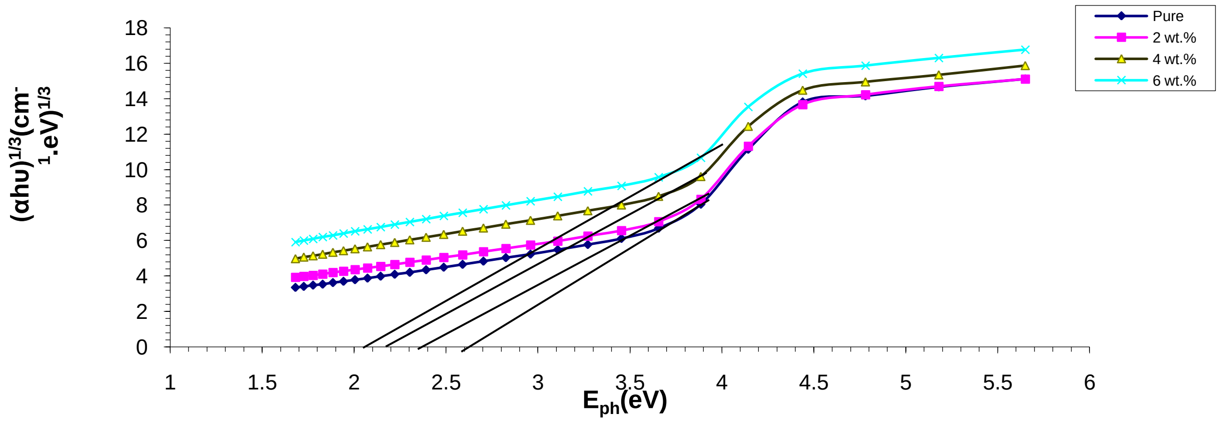

Figure 5: $(\alpha\ h\nu)^{1/3}$ vs. hv plot of doped (PS- PMMA) blend films for different Weight ratio with energy of forbidden indirection transitions

Figure (6) describes the change in refraction index for (PS - PMMA-Ag $_{nano.}$) as afunction of wavelength that has occur red due to an increase in (n) with icreasing the doping percentage. This is because pure (PS- PMMA) blend is an amorphous crystalline substance with low density that increases with increasing the weight ratio of Ag nanoparticles. The refraction index decreases at the greatest wavelengths and increases at greatest dopant weight ratio, because the transmission of the longest wavelength is more.

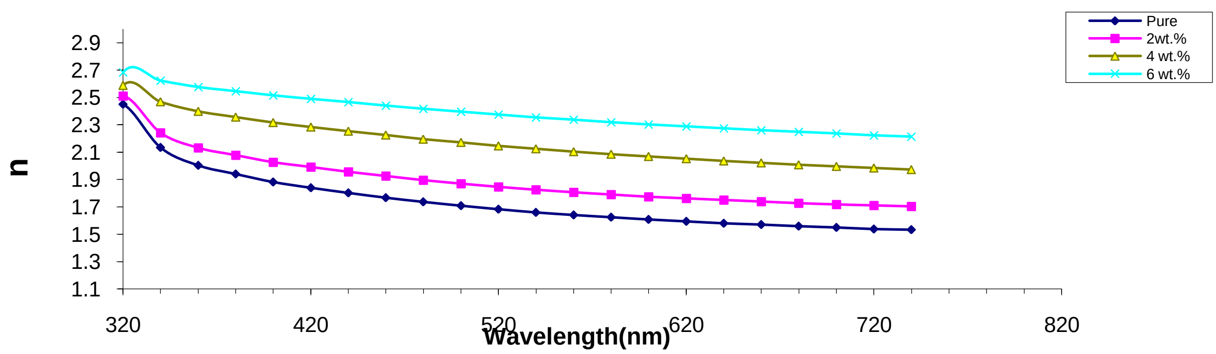

Figure 6: The refraction index of (PS - PMMA – Ag $_{nano.}$) blend films as a function wavelength at different weight ratio

The change of extinction coefficient as a function of wavelength is shown in Figure (7). It was noted that k has lower value at low weight ratio, and this is attributed to increase in the absorption coefficient with increased doping percentages of added nanoparticles. The extinction coefficient is high at the longest wavelength and high weight ratio.

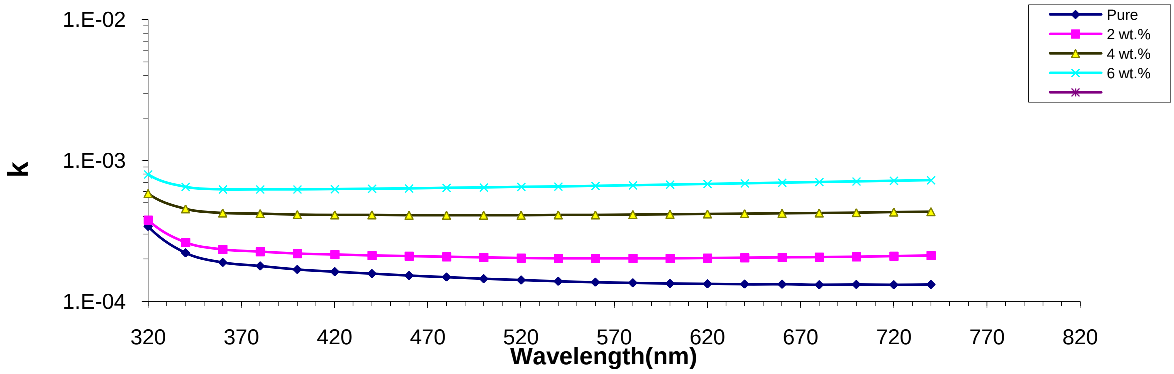

Figure 7: The extinction coefficient of (PS- PMMA – Ag $_{nano.}$) blend films as a function wavelength at different weight ratio

The real dielectrics depend on n^2 and k^2, but the imaginary dielectric depend on k and n. The real and imaginary dielectric constant (ε_1 ,ε_2) for (PS - PMMA–Ag $_{nano}$) Blend films have been calculated from equation (11).

Figures (8) and (9) show the change of these constants with wavelengths. The values of the real dielectric constant are high with respect to the imaginary dielectric constant, because they are dependent on n and k values.

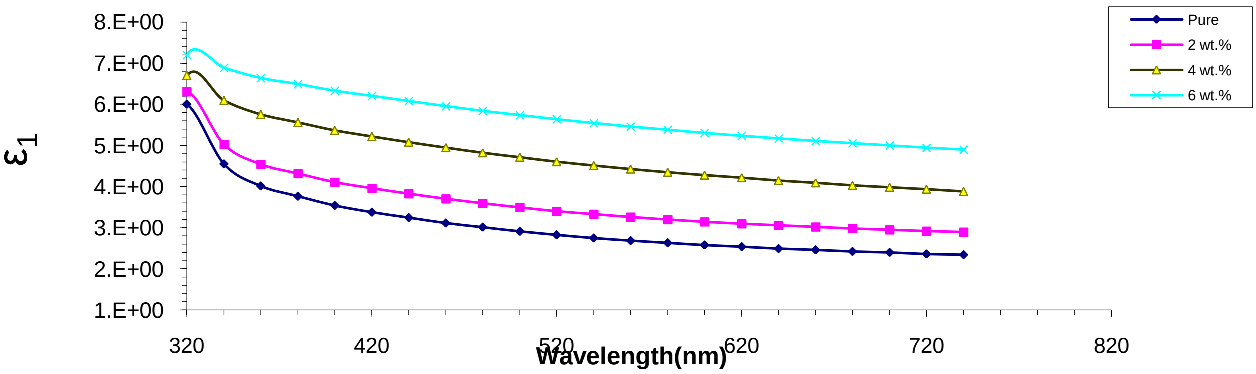

Figure 8: The real dielectric constant of (PS -PMMA- Ag $_{nano.}$) blend films as a function wavelength at different weight ratio

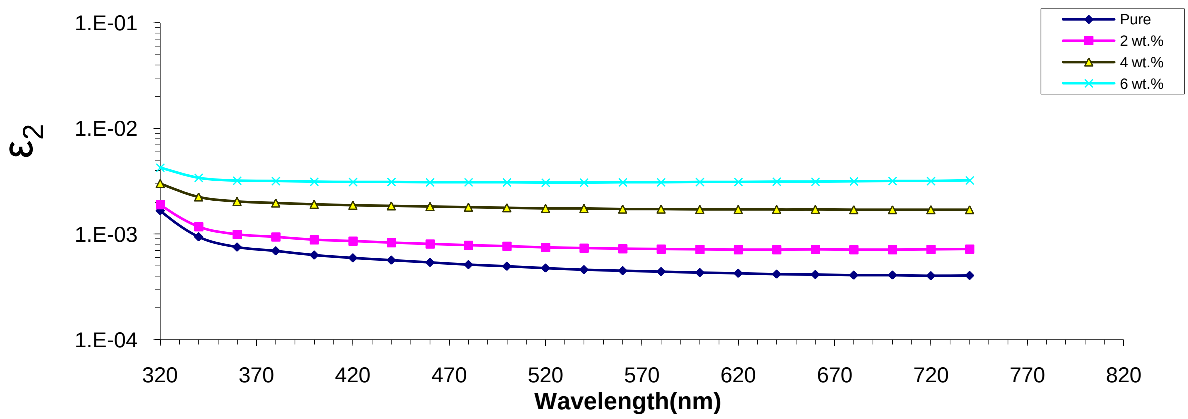

Figure 9: The imaginary dielectric constant of (PS - PMMA – Ag $_{nano.}$) blend films as a function wavelength at different weight ratio

The optical conductivity decreases suddenly after (320 nm) wavelength as a shown in Figure (10). It was observed on increase in optical conductivity as increasing in doping percentages. This means that the generation of (Ag) nanoparticle, percentages increases the contribution of electron transitions between the valence and conduction bands, which lead to reduction of energy gap as a result of, sit level generation. This optical conductivity becomes constant after (800 nm).

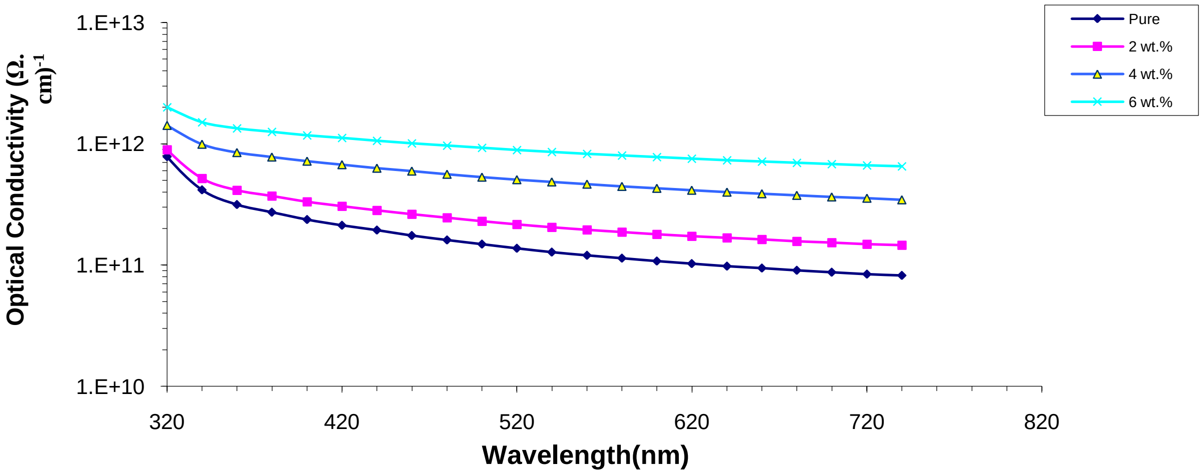

Figure 10: The optical conductivity as a function of wavelength for (PS - PMMA – Ag nano.) blend films

Conclusion

The absorbance, absorption coefficient, extinction coefficient and refraction index of the (PS-PMMA) blend doped with an Ag nanoparticles where found to be increasing with increasing the weight ratio. The energy gap of indirect transition decreases with increasing the weight ratio of the dopant. The dielectric constant (real and imaginary) was also found to be increasing with increasing the weight ratio of the dopant.

References

1. Irie M (2000) Chem. Rev., 100: 1685-1716.
2. Pu S, Zhang F, Xu J, Shen Xiao Q, Chen B (2006) Mate. Lett., 60: 485-489.
3. Luo Q, Cheng H, Tian H (2011) Polym. Chem., 2: 2435-2443.
4. Fukaminato T, Umemoto T, Iwata Y, Yokojima S, Yoneyama M, Nakamura S, Irie M (2007) J. Am. Chem. Soc., 129: 5932-5938.
5. Pu S, Liu W, Liu G (2010) Dyes Pigments, 87: 1-9.
6. Srivastava S, Haridas M, Basu JK (2008) Bull. Mater. Sci., 31 (3): 213-217.
7. Sharafudeen KM, Sudheesh P, Reddy GRC, Ghandrasekharan K (2009) International Conference on Optics and Photonics , CSIO , Chandigarh, India, 30: 1.
8. Zaid A Hasan, Maryam F Obayes (2018) Study of the Effect Magnetic Field on the Optical Properties of Poly(Methyl Metha Acrylate) Doped with Copper Nanoparticles, J. Eng. Applied Sci., 13 (13): 10551-10554.
9. Zaid A. Hasan (2018) Influence the Temperature on Optical Properties for (5PCH) Liquid Crystal, Research J. Pharm. And Tech., Marh, 11: 3.
10. Mohammed Alsawafta, Simouo Badilescu, Abhilash Paneri, Vo-Vau Truoug and Muthu Kumaram Packirisamy (2011) Polymers, 3: 1833 1848.