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The Effect of Aluminum Oxide Nanoparticles on Optical Properties of (Polyvinyl alcohol-Polyethylene glycol) Blend

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ABSTRACT

The effect of addition the aluminum oxide nanoparticles on optical properties of (polyvinyl alcohol- poly-ethylene glycol) composites has been studied . For this purpose , many samples have been prepared by adding Al2O3 nanoparticles to (poly-vinyl alcohol- poly-ethylene glycol) with different weight percentages by using casting method. The absorption spectra has been recorded at the wavelength ranges (220-800)nm . Results show that the (absorption coefficient, extinction coefficient, refractive index ,real and imaginary part of dielectric constant) have been increased with increasing the concentration of Al2O3 nanoparticles. The energy gap of the indirect transition decreases with the increasing concentration of Al2O3 nanoparticles. Keywords: Blend, Nanoparticles, Optical Properties

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INTRODUCTION

Polymer nanocomposites have unique properties such as light weight, high flexibility, and ability to be fabricated at low temperature and low cost[1].

In order to fulfill the requirements of polymer industry many developers usually blend polymers together in order to reach an optimum balance of properties [2].

In the recent years conducting polymers also known as conductive plastics are being developed for many uses such as corrosion inhibitors, compact capacitors, antistatic coating, electromagnetic shielding and smart windows [3,4]. Polymer composites are used as electrical conductive adhesives and circuit elements in microelectronics and have been reported to possess anticorrosive behavior as metal components coatings [3].

In this paper, we have used PVA as a host polymer because PVA is semi-crystalline polymer and has very important applications due to the role of OH group and hydrogen bonds [5]. Hence the assistance in the formation of polymer blends.

The aim of this paper, the effect Al_2O_3 nanoparticles on the optical properties of the (poly-vinyl alcohol and poly-ethylene glycol) blend.

Experiment:

The experiment was carried out at room temperature. 1 gm of (85% PVA and 15%PEG) was dissolved completely in distilled water under constant stirring for 1 hour while the mixture was heated up till 90^oC then the mixture was let to cool down to room temperature while the stirring of the mixture was carried out to ensure a homogenous composition. From the cooled mixture, 10 ml were sampled out and mixed with various concentrations of nanoparticles of Aluminum oxide (Al_2O_3) are (0,1,2,3) weight percentages. Were dissolved as stated above and in this way various samples were obtained. To cast the film, the mixture for each Al_2O_3 nanoparticles concentrations was poured in a casting glass plate and let it dry at room temperature for three days. At the expiry of this time, the films were ready which were peeled off the casting glass plate and cut into pieces. The transmission and absorption spectra of (PVA-PEG- Al_2O_3) nanocomposites have been recorded in the length range (220-800) nm using double-beams spectrophotometer.

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RESULTS AND DISCUSSIONS

The optical absorbance as a function of the wavelength of the incident light for PVA-PEG-Al_2O_3 nanocomposites of various filler contents is shown in figure (1). The figure shows that the absorbance increases as a result of filler addition but no shift in the peak position. The adding of different amounts of filler to polymers belend does not change the chemical structure of the material but new physical mixture is formed.

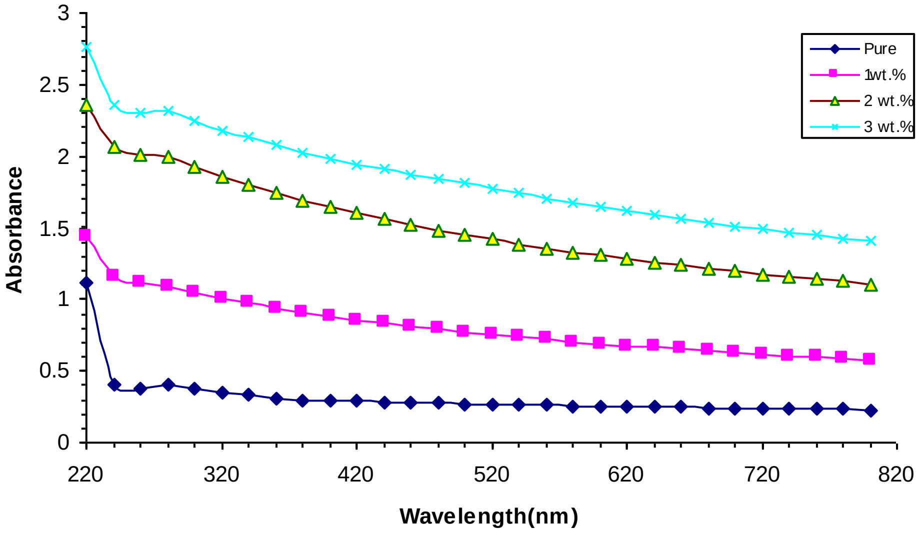

Fig. 1: Variation optical absorbance for PVA-PEG-Al_2O_3 nanocomposite with wavelength.

The absorption coefficient (α) was calculated in the fundamental absorption region from the following equation[6]:

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

Where: A is absorbance and t is the thickness of sample.

Figure (2) shows the relationship between the absorption coefficient and photon energy of the PVA-PEG-Al_2O_3 nanocomposites, we note that the change in the absorption coefficient is small at low energies this indicates the possibility of electronic transitions is a few. At high energy the change of absorption coefficient is large.

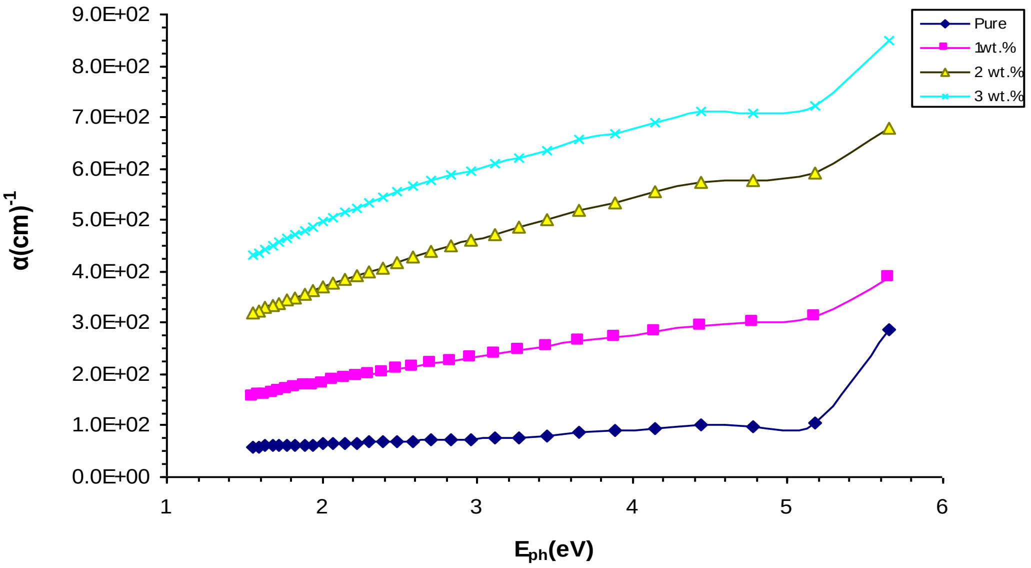

Fig. 2: Relationship between the absorption coefficient and photon energy of the PVA-PEG-Al_2O_3 nanocomposite

The absorption coefficient helps to know the nature of electronic transitions; when the high absorption coefficient values ($\alpha > 10^4 cm^{-1}$) at high energies, it is expected direct electronic transitions, and the energy and momentum preserve of the electron and photon, when the values of absorption coefficient is low($\alpha < 10^4 cm^{-1}$) at low energies, it is expected in this case an indirect electronic transitions, the momentum of the electron and photon preserves by phonon helps[7]. The results showed that the values of absorption coefficient of the PVA-PEG-Al_2O_3 nanocomposites less than $10^4 cm^{-1}$ which indicates the indirect electronic transition. The forbidden energy gap of indirect transition is calculated according to the relationship [8]:

$$\alpha h\nu = B(h\nu - E_g)^m .. \quad (2)$$

Where : hυ is the energy of photon , A is proportionality constant and Eg is forbidden energy gap of the indirect transition.

If the value of (m=2) this indicates an allowed indirect transition. When the value of (m=3), this indicates forbidden indirect transition. The value of the straight line cut oriented axis at the point $(\alpha h\nu)^{1/2} = 0$ will get the value of forbidden energy gap of the allowed indirect transition. It is noted that the value of the forbidden energy gap decreases with increasing Al_2O_3 nanoparticles concentration [9].

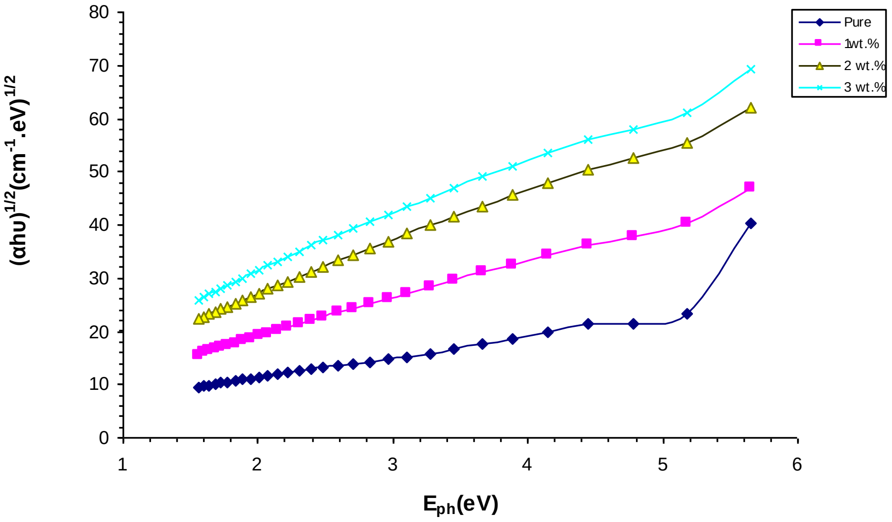

Fig. 3: Relationship between $(\alpha h\nu)^{1/2}$ and photon energy of PVA-PEG-Al_2O_3 nanocomposite.

Figure (4): shows the variations of extinction coefficient (k) with wavelength of PVA-PEG-Al_2O_3 nanocomposite. k ($k=\alpha\lambda/4\pi$). The figure shows an increase with increasing fillers. The behavior of (k) can be ascribed to high absorption coefficient. This result indicates that the Al_2O_3 nanoparticles will modify the structure of the host polymer blend. An interesting result that when the concentration of Al_2O_3 nanoparticles increases the absorbance in the visible region increases [10].

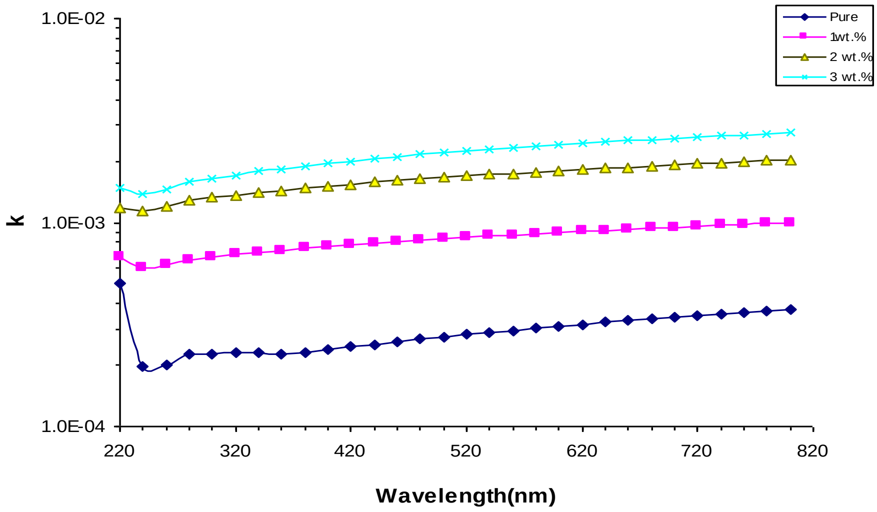

Fig. 4: Variation of extinction coefficient (k) for (PVA-PEG-Al_2O_3) nanocomposite with wavelength.

The refractive index as a function of wavelength can be determined from the reflection coefficient data R and the extinction coefficient k using equation:

$$n = (\frac{4R}{(1-R)^2} - K^2)^{1/2} - \frac{(R+1)}{(R-1)}.. \quad (3)$$

The increase of extinction coefficient at high wavelengths (Fig 4) is related to the higher concentration of Aluminum oxide (Al_2O_3) nanoparticles (from 1 to 3 wt.%) and thus more scattering of photons are occurred with the added Aluminum oxide (Al_2O_3) nanoparticles.

The knowledge of real part and imaginary part of the dielectric constant provide information about the loss factor.

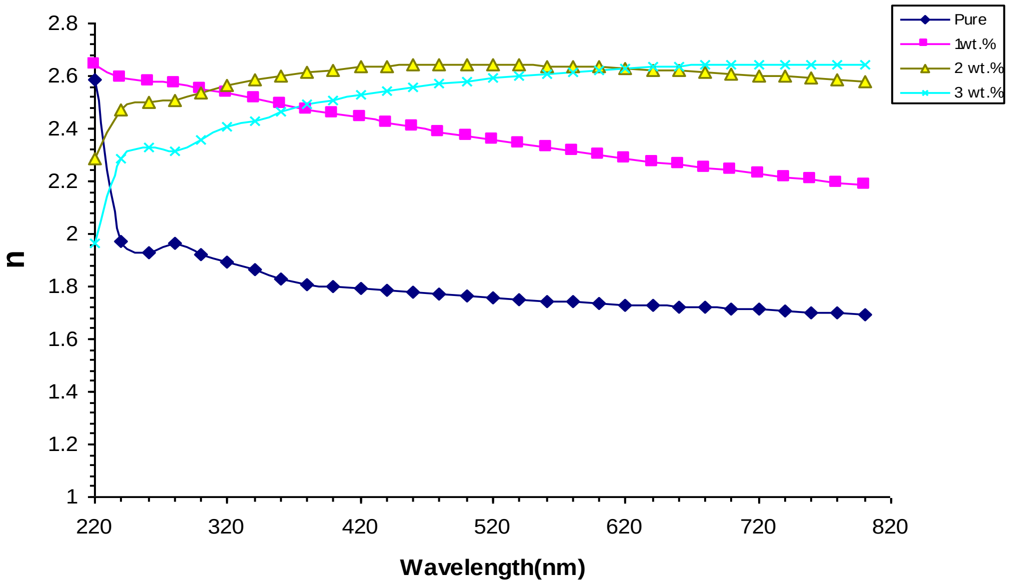

Fig. 5: Variation refractive index for (PVA-PEG-Al_2O_3) nanocomposite with wavelength.

The real part of the dielectric constant is associated with the term that shows how much it will slow down the speed of light in the material, can be calculated by using the relation:

$$\varepsilon_r = n^2 - k^2. \quad (4)$$

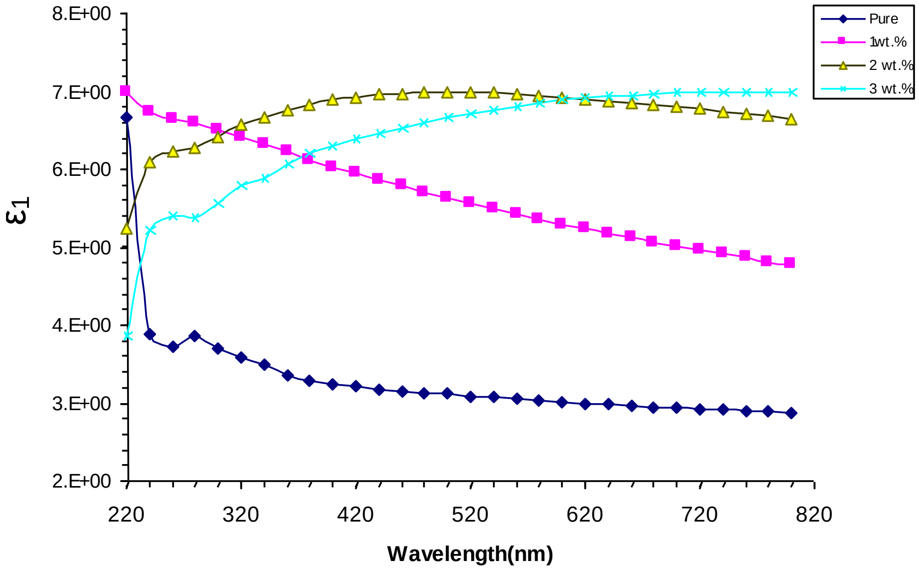

Fig. 6: Variation real dielectric constant for PVA-PEG-Al_2O_3 nanocomposite with wavelength.

The imaginary part shows how a dielectric absorbs energy from an electric field due to dipole motion. The dielectric loss (ε_i) has been determined from the relation [8]

$$\varepsilon_i = 2nk \tag{5}$$

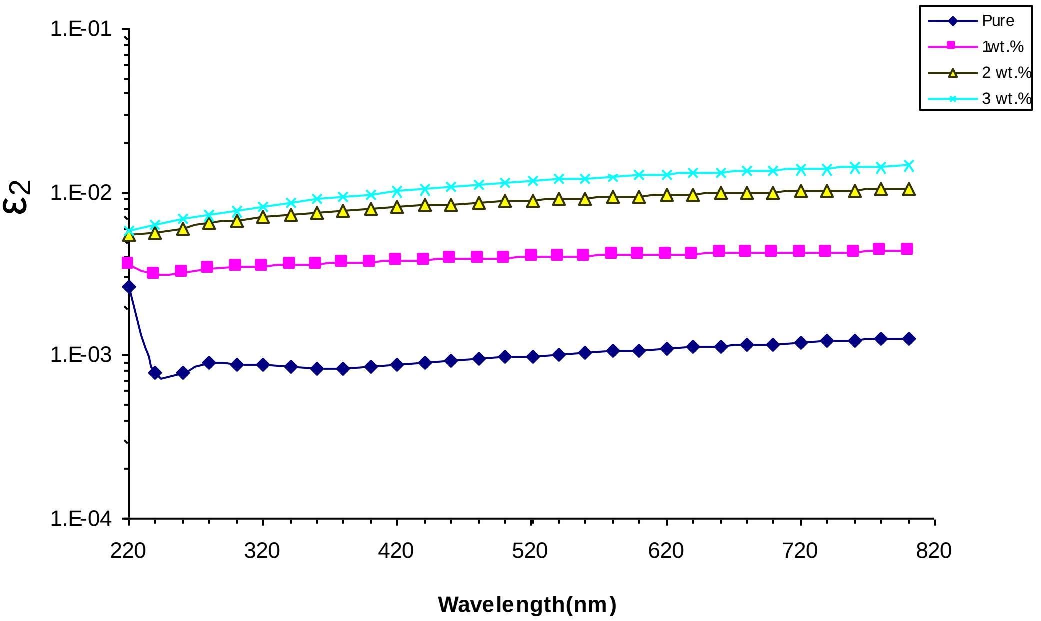

Fig. 7: Variation imaginary dielectric constant for PVA-PEG-Al_2O_3 nanocomposites with wavelength.

Conclusion:

The absorption increases with increasing of the Al_2O_3. nanoparticles concentrations. The experimental results showed that the absorption coefficient less than $10^4 cm^{-1}$, this indicates to indirect electronic transitions. The addition of Al_2O_3 nanoparticles concentrations to the (PVA-PEG) blend causes shift the optical energy gab from (4.54 eV) to (1.9eV) for 3 wt%. The (extinction coefficient, refractive index, real part and imaginary part of the dielectric constant) are increase with increasing the Al_2O_3 nanoparticles concentrations.

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