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Polyvinyl alcohol- Poly-acrylic acid- Titanium Nanoparticles Nanocomposites: Optical Properties

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A R T I C L E I N F O

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A B S T R A C T

Polyvinyl alcohol- poly-acrylic acid- titanium nanoparticles nanocomposites have been prepared with different concentrations of titanium nanoparticles. The polymer matrix is ($PVA_{0.90}$-$PAA_{0.10}$); the titanium nanoparticles is added to polymer matrix with different weight percentages are (0, 2, 4 and 6) wt.%. The results show that the absorbance of (PVA-PAA-Ti) nanocomposites increases with the increase of titanium nanoparticles concentrations. The optical constants (absorption coefficient, extinction coefficient, refractive index, real and imaginary dielectric constants) of (PVA-PAA-Ti) nanocomposites are increasing with the increasing of titanium nanoparticles concentrations. The energy gap of (PVA-PAA-Ti) nanocomposites decreases with the increase of titanium nanoparticles concentrations.

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INTRODUCTION

The polymers embedded with metal nanoparticles are of current research interest because of their novel properties generated from quantum size effect of the embedded metal nanoparticles. Polymer metal nanocomposites with varying nano-particle size, shape and concentration are significantly used in many potential optical, electrical and optoelectronic applications. Many synthetic approaches have been applied to the preparation of metal/ polymer nanocomposites (Geethu Krishnan, P.M., *et al.*, 2014). There is increasing research interest in polymeric nanocomposites owing to improvements in electrical, thermal, optical, and mechanical properties and their great potential for highly functional materials. In particular, nanoparticles embedded in a transparent matrix have attracted attention as advanced technological materials because of their high transparency, high refractive index, and attractive electrical/electronic properties. Polymeric nanocomposites also demonstrate high thermal stability compared to virgin polymers (Chandrakala, H.N., *et al.*, 2014). The importance of polymers is mainly because polymers are still regarded as a cheap alternative material that is manufactured easily. The intensive use of polymer in broad use has led to the development of materials for specific applications namely composites (Al-Ramadhan, Z., *et al.*, 2010). The applications of nanocomposites are quite promising in the fields of microelectronic packaging, optical integrated circuits, automobiles, drug delivery, sensors, injection molded products, membranes, packaging materials, aerospace, coatings, adhesives, fire-retardants, medical devices, consumer goods, etc (Wasan Al-Taa'y, *et al.*, 2014). Poly vinyl alcohol (PVA) is a cheap polymer having excellent film forming and adhesive properties, good chemical and mechanical stability and high potential for chemical cross-linking. However, PVA has highly swelling and low proton conductivity (Abdol mohamad, *et al.*, 2013). In this paper, study the effect of titanium nanoparticles on structural and optical properties of (PVA-PAA) nanocomposites.

MATERIALS AND METHODS

The polymers (polyvinyl alcohol (90 wt.%), and poly-acrylic acid (10 wt.%)) as a dissolved in distill water by using magnetic stirrer. Titanium nanoparticles is added to solution with different concentrations are (0,2 ,4 and 6) wt.% . The samples are prepared by using casting technique. The optical properties of (PVA-PAA-Ti) nanocomposites are measured by using UV/1800/ Shimadzu spectrophotometer in range of wavelength (200-800) nm.

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Advances in Natural and Applied Sciences, 8(15) December 2014, Pages: 9-14

Absorption coefficient (α) of polymers has been determined by the absorbance (Jasim, F.A., *et al*., 2013):

$$\alpha=2.303A/t \quad (1)$$

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

The energy band gap of naocomposites has bee calculated by following equation (Jasim, F.A., *et al*., 2013):

$$\alpha h\upsilon = B(h\upsilon - E_g)^r \quad (2)$$

Where B is a constant, hυ is the photon energy, E_g is the optical energy band gap and r = 2 for allowed indirect transition and r = 3 for forbidden indirect transition.

The Refractive index (n) of nanocomposites has been calculated by using the reflectance spectra (Anees, A.,):

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

Where R is the reflectance of naocomposites.

The extinction coefficient (k) has been calculated by using the following equation (Anees, A.,):

$$K=\alpha\lambda/4\pi \quad (4)$$

The real and imaginary parts of dielectric constant (ε_1 and ε_2) for nanocomposites are calculated by using equations (Bishwajit, S., Chakrabarty, 2014):

$$\varepsilon_1=n^2-k^2 \text{ (real part)} \quad (5)$$

$$\varepsilon_2=2nk \text{ (imaginary part)} \quad (6)$$

RESULTS AND DISCUSSION

The absorbance spectra of (PVA-PAA-Ti) nanocomposites with wavelength range (200-800) nm is shown in figure 1. From the figure, we can see that absorbance of (PVA-PAA-Ti) nanocomposites is increased with the increase of concentrations of titanium nanoparticles, this is due to increase the number of free electrons which absorbs the incident light (Sreelalitha Kramadhati, K.Thyagarajan, 2013).

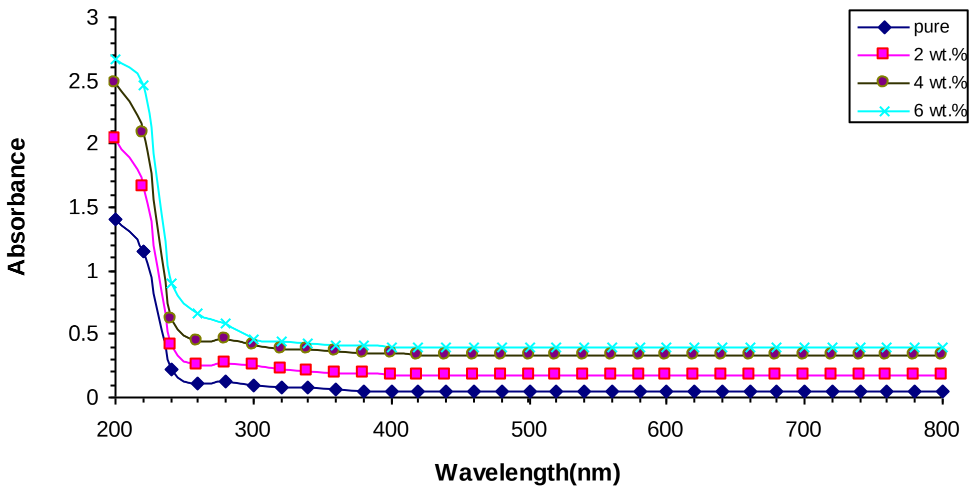

Fig. 1: The variation of optical absorbance for (PVA-PAA-Ti) nanocomposites with wavelength

Figure 2 shows the variation of absorption coefficient of (PVA-PAA-Ti) nanocomposites with the photon energy. The figure shows that the absorption coefficient of (PVA-PAA-Ti) nanocomposites is increased with the increase of titanium nanoparticles concentrations, this behavior attributed to increase the number of free electrons in nanocomposites. From the values of absorption coefficient, the nanocomposites have indirect energy gap. The figures (4 and 5) for allowed indirect and forbidden indirect transition of nanocompsites respectively. The energy gap of (PVA-PAA-Ti) nanocomposites is decreased with the increase of the titanium nanoparticles concentrations which attributed to increase of the localized level in energy band gap (Sreelalitha Kramadhati, K.Thyagarajan, 2013; Adnan KURT, 2010).

Advances in Natural and Applied Sciences, 8(15) December 2014, Pages: 9-14

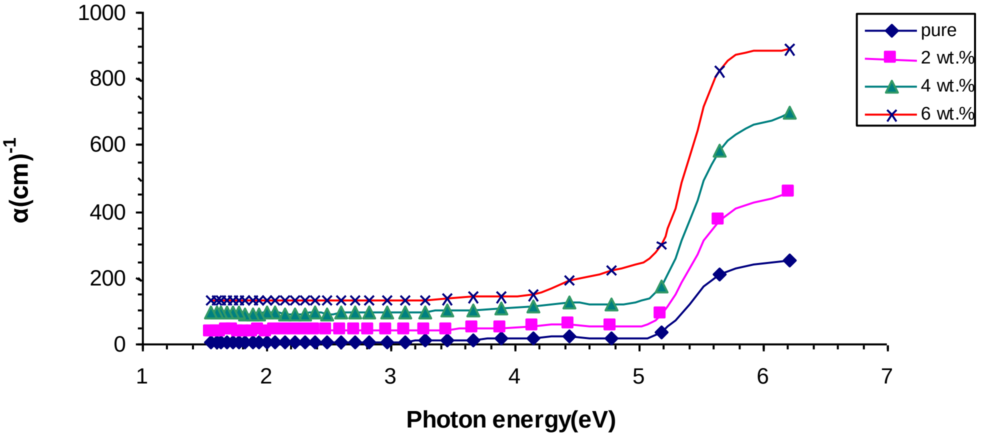

Fig. 2: The absorbance coefficient for (PVA-PAA-Ti) nanocomposites with various photon energy

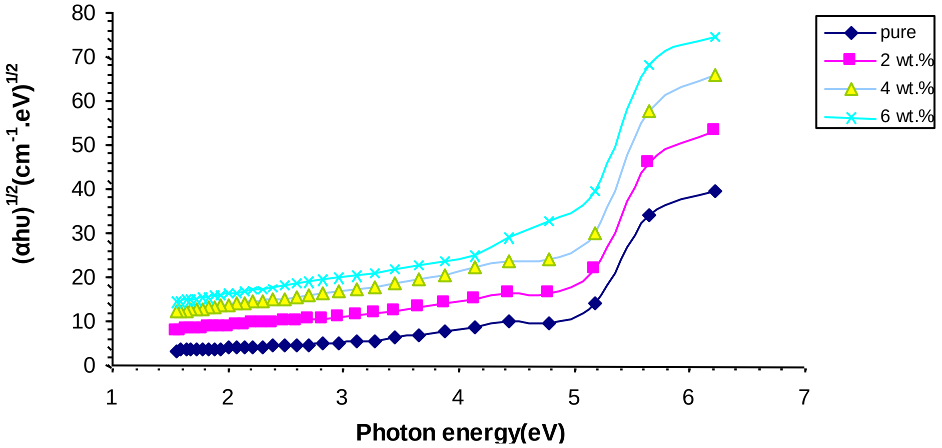

Fig. 3: The relationship between $(\alpha h\upsilon)^{1/2}$ $(cm^{-1}.\ eV^{1/2})$ and photon energy of (PVA-PAA-Ti) nanocomposites.

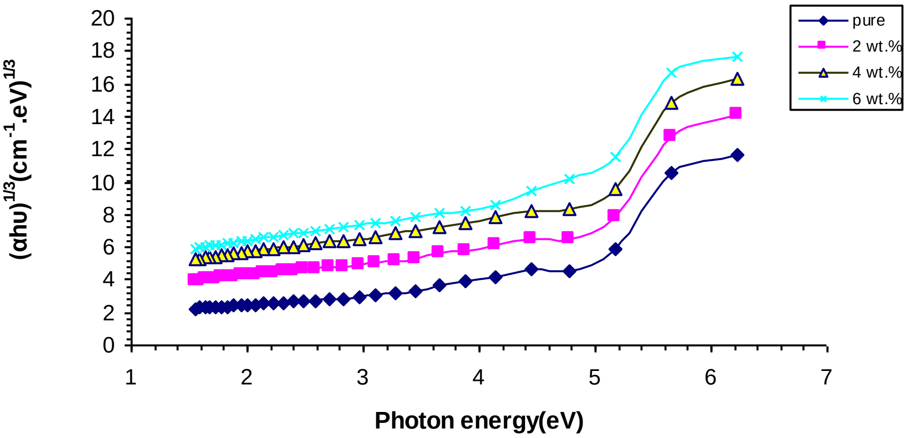

Fig. 4: The relationship between $(\alpha h\upsilon)^{1/3}$ $(cm^{-1}.\ eV)^{1/3}$ and photon energy of (PVA-PAA-Ti) nanocomposites.

Advances in Natural and Applied Sciences, 8(15) December 2014, Pages: 9-14

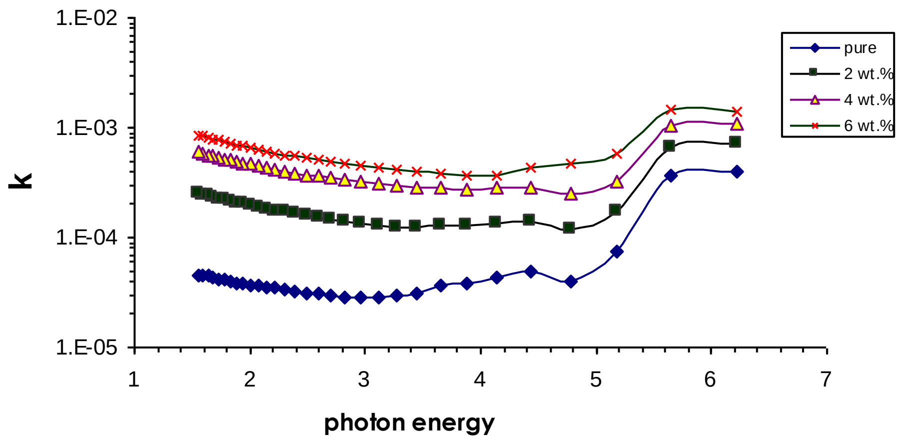

Fig. 5: The extinction coefficient for (PVA-PAA-Ti) nanocomposite with various photon energy.

The effect of titanium nanoparticles concentration on extinction coefficient of (PVA- -PAA-Ti) nanocomposites is shown in figure 5. The figure shows that the extinction coefficient increases with the increase of titanium nanoparticles concentrations, this behavior attributed to the increase the number of carries charges in nanocomposites (Adnan KURT, 2010).

Figure 6 shows the variation of refractive index for (PVA- -PAA-Ti) nanocomposites with photon energy. The increase of refractive index of (PVA- -PAA-Ti) nanocomposites attributed to increase the density of nanocomposite with the increase of titanium nanoparticles concentrations (Vijaya, S. *et al*., 2013).

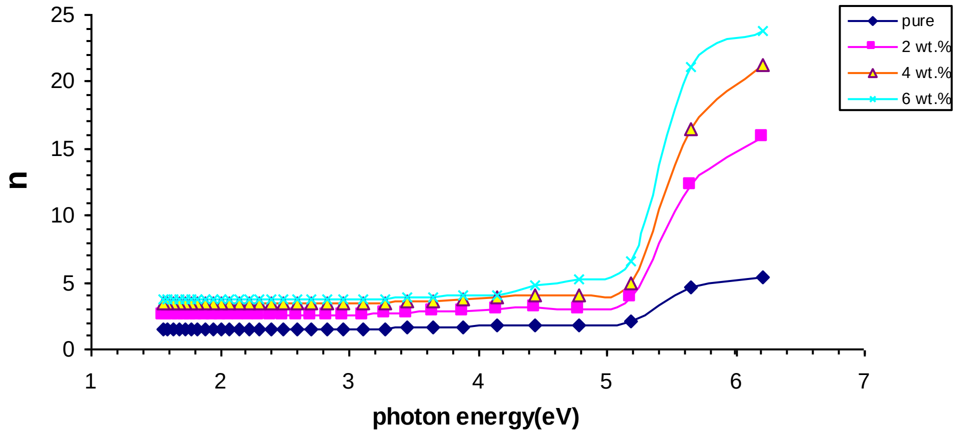

Fig. 6: The relationship between refractive index for (PVA-PAA-Ti) nanocomposite with photon energy.

Figures (7 and 8) show the variation of real and imaginary parts of dielectric constants of (PVA- -PAA-Ti) nanocompsites with photon energy for different weight percentages of titanium nanoparticles. The real part of dielectric constant of (PVA- -PAA-Ti) nanocomposites is increased with the increase of titanium nanoparticles concentrations which attributed to increase the scattering. Also, the imaginary part of dielectric constant absorption is increased with the increase of titanium nanoparticles concentrations which due to increase the absorption coefficient and refractive index of nanocomposites (Nahida, J.H. and R.F. Marwa, 2011).

Advances in Natural and Applied Sciences, 8(15) December 2014, Pages: 9-14

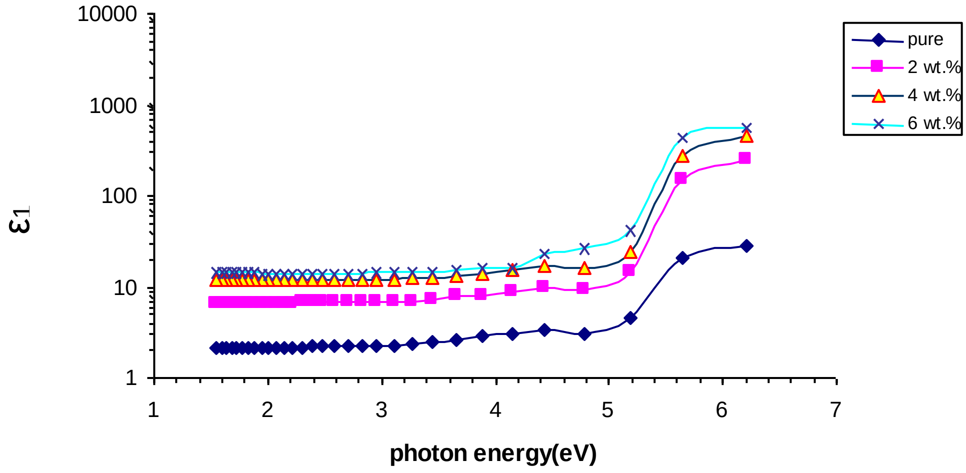

Fig. 7: The variation of real part of dielectric constant of (PVA-PAA-Ti) nanocomposite with photon energy.

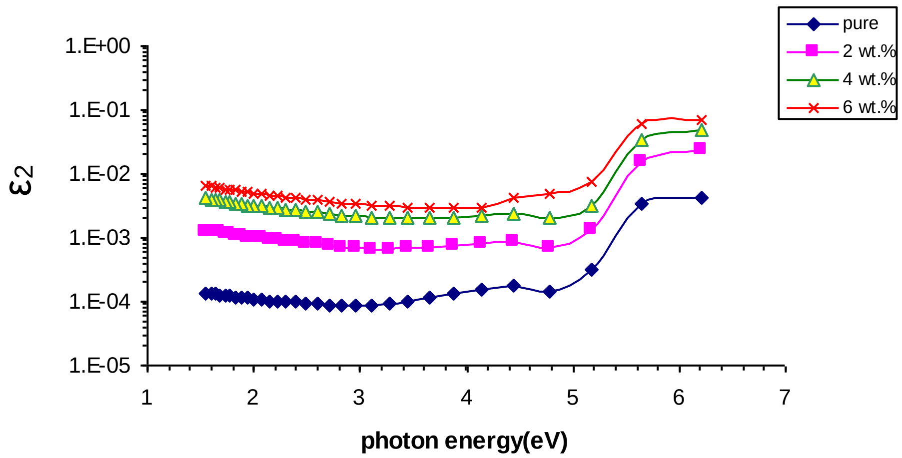

Fig. 7: The variation of imaginary part of dielectric constant of (PVA-PAA-Ti) nanocomposite with photon energy.

Conclusions:

1- The absorbance of (PVA- -PAA-Ti) nanocomposites is increased with the increase of titanium nanoparticles concentrations.

2- The optical constants of (PVA- -PAA-Ti) nanocomposites (absorption coefficient (α), extinction coefficient (k), refractive index (n), real and imaginary dielectric constants are increasing with the increase of concentrations for titanium nanoparticles.

3- The energy band gap of (PVA- -PAA-Ti) nanocomposites is decreased with the increase of titanium nanoparticles concentrations.

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