Enhancement in Optical Properties of (PVA-PEG-PVP) Blend By the Addition of Titanium Oxide Nanoparticles For Biological Application

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ABSTRACT
In this paper, the effect of titanium oxide nanoparticles on optical properties for (PVA-PEG-PVP) blend has been studied. The titanium oxide nanoparticles was added to the (PVA-PEG-PVP) blend for different weight percentages are (2, 4, 6, 8) wt.%. The optical properties were measured in range of wavelength (220-800) nm. The experimental results show that the absorbance of (PVA-PEG-PVP) blend was increased with the increase of titanium oxide concentrations. The optical constants and energy gap were changed with the addition of titanium oxide nanoparticles concentrations. The gamma ray shielding application of (PVA-PEG-PVP-TiO$_2$) nanocomposites has been investigated.

KEYWORDS: optical properties, titanium oxide, blend, absorbance, nanoparticles

INTRODUCTION
The field of application of science and technology is one of the most areas for current research and development in basically all technical disciplines. This obviously includes polymer science and technology in this field the investigations a broad range of applications. This would includes microelectronics (which could now be referred to as nanoelectronics). Other areas include nanoparticle drug delivery, polymer-based biomaterials, miniemulsion particles; polymer bound catalysts, fuel cell electrode, layer-by-layer self-assembled polymer films, polymer blends, imprint lithography, and nanocomposites. In the field of nanocomposites, many diverse topics exist including bactericidal properties, composite reinforcement, flame resistance, barrier properties, cosmetic applications and electro-optical properties [1,2]. Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. Composites have good potential for various industrial fields because of their excellent properties such as high hardness, high melting point, low density, low coefficient of thermal expansion, high thermal conductivity. Polymer-based nanocomposite have many applications of because of their electron transport, mechanical and optical properties in medical and engineering technology. Polyvinyl alcohol (PVA) is a polymer with several interesting physical properties, which are very useful in technical application. PVA is a semi crystalline, water soluble and low electrical conductivity material with many technological, pharmaceutical and biomedical applications [3]. Optical spectroscopy is one of the most powerful techniques to determine the band structure of materials.
Currently, there has been considerable interest in the optical spectra because of both the interesting physics involved and potential applications in materials. Moreover, the changes in the electronic band structure of the crystal also can be investigated via optical spectroscopy. The optimization of devices is largely the results of improvement in material quality. Studying functional material requires the knowledge of the band gap of the material. Polyvinyl alcohol (PVA) polymers have attracted much attention in view of their variety applications in optical devices. PVA is a water soluble polymer which is important from an industrial viewpoint due to the role of the hydroxyl group and hydrogen bonds. Moreover, PVA is also nontoxic, high dielectric strength, and good charge storage capacity [4].

MATERIALS AND METHODS

The polymer blend consisting of (polyvinyl alcohol (90 wt.%), polyvinyl pyrrolidinone and (5 wt.%) polyethylene glycol (5 wt.% ) were prepared by using casting method. The nanocomposites were prepared with different concentrations of the titanium oxide nanoparticles are (0, 2, 4, 6 and 8) wt.%. The absorbance and transmittance spectra of (PVA-PEG-PVP-TiO$_2$) nanocomposites are recorded by using UV/1800/ Shimadzu spectrophotometer in range of wavelength (220-800) nm.

The absorption coefficient ($\alpha$) of (PVA-PEG-PVP-TiO$_2$) nanocomposites is given by using the following equation [5]:

$$\alpha = \frac{2.303A}{d}$$  \hspace{1cm} (1)

Where $A$: is the absorbance of nanocomposites and $d$: is the sample thickness.

The electronic transitions model for amorphous semiconductors is defined by using the equation [6]:

$$\alpha \nu = B(\nu - E_g)^n$$  \hspace{1cm} (2)

Where C: constant, $\nu$: photon energy , $E_g$: optical energy band gap, $n = 2$ for allowed indirect transition and $n = 3$ for forbidden indirect transition.

The extinction coefficient (k) of (PVA-PEG-PVP-TiO$_2$) nanocomposites was calculated by using the equation[6]:

$$K = \frac{\alpha \lambda}{4\pi}$$  \hspace{1cm} (3)

The refractive index (n) of (PVA-PEG-PVP-TiO$_2$) nanocomposites is defined by following equation for $k \rightarrow 0$ [7]:

$$n = (1 + R^{1/2}) / (1 - R^{1/2})$$  \hspace{1cm} (4)

Where $R$ is the reflectance.

The real ($\varepsilon_1$) and imaginary ($\varepsilon_2$) parts of dielectric constant of (PVA-PEG-PVP-TiO$_2$) nanocomposites were calculated by using equations[7]:

$$\varepsilon_1 = n^2 - k^2$$  \hspace{1cm} (5)

$$\varepsilon_2 = 2nk$$  \hspace{1cm} (6)

RESULTS AND DISCUSSION

The effect of titanium oxide nanoparticles on absorbance of (PVA-PEG-PVP) blend with wavelength range (220-800) nm is shown in Fig.1. The absorbance of (PVA-PEG-PVP) blend is increased with the increase of the concentration of titanium oxide nanoparticles, this behavior related to the increase of the charge carriers [8], as shown in figure 2.

![Fig. 1: variation of absorbance for (PVA-PEG-PVP-TiO$_2$) nanocomposites with wavelength.](image)

The variation of absorption coefficient of (PVA-PEG-PVP) blend with photon energy for different concentration of titanium oxide nanoparticles is shown in figure 3. From the figure, the absorption coefficient...
of (PVA-PEG-PVP) blend increases with the increase of the weight percentages of titanium oxide nanoparticles which due to the titanium oxide nanoparticles absorb the incident radiation by its free electrons. The values of absorption coefficient of (PVA-PEG-PVP-TiO$_2$) nanocomposites is less than $10^4$ cm$^{-1}$, this is mean the nanocomposites have indirect energy gap. The energy band gap for indirect allowed and indirect forbidden transition is decreased with the increase of the titanium oxide nanoparticles concentrations, this behavior attributed to creation of new levels in the band gap, lead to facilitate the crossing of electrons from the valence band to these local levels to the conduction band, consequently the conductivity increase and the band gap decreases [9], as shown in figure 4 and figure 5.

**Fig. 2:** photomicrographs (x20) for (PVA-PEG-PVP-TiO$_2$) nanocomposites: (A) for 2 wt.% TiO$_2$ (B) for 4 wt.% TiO$_2$ (C) for 6 wt.% TiO$_2$ (D) for 8 wt.% TiO$_2$.

**Fig. 3:** variation of absorption coefficient ($\alpha$) for (PVA-PEG-PVP-TiO$_2$) nanocomposites with photon energy.

**Fig. 4:** Variation of $(\alpha h\nu)^{1/2}$ for (PVA-PEG-PVP-TiO$_2$) nanocomposites with photon energy.
Figure 5: Variation of $(\alpha h \nu)^{1/3}$ for (PVA-PEG-PVP-TiO$_2$) nanocomposites with photon energy.

Figure 6 shows the effect of titanium oxide nanoparticles concentration on the extinction coefficient of (PVA-PEG-PVP) blend with different photon energy for incident light. As shown in figure, the extinction coefficient of (PVA-PEG-PVP) blend is increased with the increase of the titanium oxide nanoparticles concentration which due to the increase of the absorption coefficient [10].

Figure 6: Variation of extinction coefficient for (PVA-PEG-PVP-TiO$_2$) nanocomposites with wavelength.

Figure 7: Variation of refractive index for (PVA-PEG-PVP-TiO$_2$) nanocomposites with wavelength.
The variation of refractive index of (PVA-PEG-PVP) blend with incident photon energy for different concentration of titanium oxide nanoparticles is shown in figure 7. The refractive index of (PVA-PEG-PVP-TiO$_2$) nanocomposites increases with increasing of the titanium oxide nanoparticles concentrations which attributed to the increase of packing density as a result of titanium oxide nanoparticles content [10].

Figure 8 and figure 9 show the variation of the real and imaginary parts of dielectric constant for (PVA-PEG-PVP-TiO$_2$) nanocomposites for different concentration of titanium oxide nanoparticles with wavelength. From the figures, the real and imaginary parts of dielectric constant of (PVA-PEG-PVP-TiO$_2$) nanocomposites increase with the increase of the titanium oxide nanoparticles weight percentages which related to the increase of the refractive index (n) and extinction coefficient (k) [11].

The attenuation of gamma radiation for (PVA-PEG-PVP-TiO$_2$) nanocomposites is calculated by: $N = N_0 \exp (-\mu t)$ where $N_0$ is the number of particles of radiation counted during a certain time, $\mu$ is the attenuation coefficient of gamma radiation for (PVA-PEG-PVP-TiO$_2$) nanocomposites and $N$ is the number counted during the same time, with a thickness of sample is d [12]. The transmitted gamma ray fluxes through the (PVA-PEG-
PVP-TiO$_2$ nanocomposites were measured by the Geiger counter were used to estimate the linear attenuation coefficients. The variation of (N/N$_0$) for (PVA-PEG-PVP-TiO$_2$) nanocomposites is shown in figure 10 and figure 11. The transmission radiation is decreased with the increase of the weight percentages of titanium oxide nanoparticles which attributed to the increase of the attenuation radiation [12].

Fig. 11: variation of attenuation coefficients of gamma radiation for (PVA-PEG-PVP) blend as a function of TiO$_2$ nanoparticles concentration

Conclusions:
1- The absorbance of (PVA-PEG-PVP) blend increases with increasing of the titanium oxide nanoparticles concentration.
2- The absorption coefficient, extinction coefficient, refractive index and real and imaginary dielectric constants of (PVA-PEG-PVP) blend increase with the increase of the titanium oxide nanoparticles concentration.
3- The energy band gap of (PVA-PEG-PVP) blend is increased with the increasing of the titanium oxide nanoparticles concentration.
4- The (PVA-PEG-PVP-TiO$_2$) nanocomposites have been studied for gamma ray shielding.

REFERENCES