Enhancement of Structural and Optical Properties of (PVA-PVP- TiO$_2$) Nanocomposites

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ABSTRACT

In this paper, polymer- ceramic nanocomposites have been investigated. The (PVA-PVP-TiO$_2$) nanocomposites are prepared by using casting technique. The experimental results show that the absorbance of (PVA-PVP-TiO$_2$) nanocomposites is increased with the increase of titanium oxide concentrations. The energy gap of (PVA-PVP-TiO$_2$) nanocomposites is decreased with the increase of titanium oxide concentrations. The absorption coefficient, extinction coefficient, refractive index, real and imaginary dielectric constants of (PVA-PVP-TiO$_2$) nanocomposites are increasing with the increase of titanium oxide concentrations.

INTRODUCTION

Nanotechnology literally means any technology performed on a nanoscale that has applications in the real world. Nanotechnology encompasses the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the integration of the resulting nanostructures into larger systems. Nanotechnology is likely to have a profound impact on our economy and society in the early twenty-first century, science and technology research in nanotechnology promises breakthroughs in such areas as materials and manufacturing, nanoelectronics, medicine and healthcare, energy, biotechnology, information technology, and national security. It is widely felt that nanotechnology will be the next industrial revolution (Ali, Z.I., 2014). Polymeric nanocomposites consisting of organic polymers and inorganic nanoparticles in a nanoscale regime represent a novel class of materials that have motivated considerable interest in recent years. This composite material differs from the pure polymer in respect to some of the physical and chemical properties and hence it is useful for many applications in different fields (Bhaiswar, J.B., 2014). One advantage of nanoparticles, as polymer additives appear to have is that compared to traditional additives, loading requirements are quite low. Micromized particles used as reinforcing agents scatter light, thus reducing light transmittance and optical clarity. Efficient nanoparticle dispersion combined with good polymer–particle interfacial adhesion eliminates scattering and allows the exciting possibility of developing strong yet transparent films, coatings and membranes (Bhaiswar, J.B., 2014). Optical properties of polymers constitute an important aspects in study of electronic transition and the possibility of their application as optical filters, a cover in solar collection, selection surfaces and green house. The information about the electronic structure of crystalline and amorphous semiconductors has been mostly accumulated from the studies of optical properties in wide frequency range (Shaymaa Hadi, 2011). Poly(vinyl pyrrolidone) (PVP) and poly(vinyl alcohol) (PVA) are included in the list of synthetic polymers which are used in medicine. PVP has a good reputation due to its outstanding absorption and complexes abilities, whereas PVA presents important features such as high hydrophilicity, recognized biodegradability, biocompatibility and good processability on film formation. Moreover, these synthetic polymers are water soluble which is a remarkable characteristic for film formation. Nevertheless, this characteristic could be a disadvantage because the material would dissolve in contact with fluids into the human body (Andres Bernal, 2014). In this paper preparation of (PVA-PVP-TiO$_2$) nanocomposites and study their structural and optical properties.
MATERIALS AND METHODS

The matrix polymer has been prepared by using (polyvinyl alcohol (90 wt.%), and polyvinyl pyrrolidinone (10 wt. %)) as a matrix. The polymers are dissolved in distill water by using magnetic stirrer in mixing process to get homogeneous solution. The additive (titanium oxide nanoparticles) is added to solution with different weight percentages are (0, 2, 4 and 6) wt.%. The casting technique is used to preparation the (PVA- PVP- TiO$_2$) nanocomposites. FTIR spectra is recorded by FTIR (Bruker company, German origin, type vertex -70 ) Fourier transformation infrared radiation in the wave number range (400 – 4000)cm$^{-1}$. The optical properties are measured by using UV/1800/ Shimadzu spectrophotometer in range of wavelength (200-800) nm.

Absorption coefficient ($\alpha$) is calculated by following equation (Jaleha, B., 2011):

$$\alpha = 2.303 A/t$$

(1)

Where $A$: is the absorbance and $t$: is the thickness.

The indirect transition model of nanocomposites gives (Jaleha, B., 2011):

$$\alpha h\nu = B(h\nu - E_g)^r$$

(2)

Where $B$ is a constant, $h\nu$ 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 bee determined by following equation (Wasan Al-Taa’y, 2014):

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

(3)

Where $R$ is the reflectance of nanocomposites.

The extinction coefficient ($k$) is given by using the following equation (Wasan Al-Taa’y, 2014):

$$K=\alpha \lambda/4\pi$$

(4)

The real and imaginary parts of dielectric constant ($\varepsilon_1$ and $\varepsilon_2$) for (PVA-PVP-TiO$_2$) nanocomposites are calculated by using equations (Nahida, J.H., R.F. Marwa, 2011):

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

(5)

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

(6)

RESULTS AND DISCUSSION

The FTIR spectra of (PVA- PVP- TiO$_2$) nanocomposites is shown in figure 1. The spectra exhibited characteristic bands of stretching and bending vibrations of the functional groups formed in nanocomposites. From the spectra, the broad band at about 3200 cm$^{-1}$ is assigned to the stretching vibration of hydroxyl group (OH) of polymer, which may be due to the intermolecular or intramolecular type of hydrogen bonding of the polymer and the nanoparticles. The peaks at about 1700 cm$^{-1}$ attributed to the C= O, C= C stretching mode. From the figure, we can see change in the IR spectrum of the nanocomposites was observed for the band peaking at about 1050 (cm$^{-1}$). These changes are more pronounced for the nanocomposites with higher content of inorganic phase (Abdelrazek, E.M., 2012).
The optical properties is calculated by recorded the absorbance spectra of (PVA-PVP-TiO$_2$) nanocomposites with wavelength range (200-800) nm. The absorbance of nanocomposites with wavelength is shown in figure 2. We note that the absorbance of nanocomposites increases with the increase of concentrations of titanium oxide nanoparticles this behavior attributed to titanium oxide nanoparticles absorbs the incident light (Baishya, U. and D. Sarkar, 2011).
The variation of optical absorbance for (PVA-PVP-TiO\textsubscript{2}) nanocomposite with wavelength is shown in figure 2. The absorbance coefficient for (PVA-PVP-TiO\textsubscript{2}) nanocomposites is increased with the increase of titanium oxide nanoparticles concentrations which attributed to increase the number of carries charges in nanocomposites. The absorption coefficient values are less than $10^4$ cm\textsuperscript{-1}, this mean the nanocomposites have indirect energy gap which is shown in figures (4 and 5) for allowed indirect and forbidden indirect transition of nanocomposites respectively. The energy gap is decreased with the increase of the titanium oxide nanoparticles concentrations, this due to increase of the localized level in energy band gap (Baishya, U. and D. Sarkar, 2011).
**Fig. 5:** The relationship between \((\alpha h\nu)^{1/3}\) (cm\(^{-1}\).eV\(^{1/3}\)) and photon energy of (PVA-PVP-TiO\(_2\)) nanocomposite.

Figure 6: shows the variation of the extinction coefficient of nanocomposites with photon energy for different concentration of titanium oxide nanoparticles. The extinction coefficient is increased with the increase of titanium oxide nanoparticles concentrations which attributed to the increase of absorb part of the incident light (Adnan Kurt, 2010).

**Fig. 6:** The extinction coefficient for (PVA-PVP-TiO\(_2\)) nanocomposite with various photon energy.

The relationship of refractive index of nanocomposites with photon energy for different concentrations of titanium oxide nanoparticles is shown in figure 7. The refractive index of (PVA-PVP-TiO\(_2\)) nanocomposites is increased with the increase of titanium oxide nanoparticles attributed to increase the density of nanocomposite (Adnan Kurt, 2010).

**Fig. 7:** The relationship between refractive index for (PVA-PVP-TiO\(_2\)) nanocomposite with photon energy.
The real and imaginary parts of dielectric constants nanocomposites with photon energy for different concentrations of titanium oxide nanoparticles are shown in figures (8 and 9). The real and imaginary parts of dielectric constants for (PVA-PVP-TiO$_2$) nanocomposites are increasing with the increase of titanium oxide nanoparticles concentrations, this behavior attributed to increase the absorption of incident light and the density of nanocomposites with the increase of concentrations of titanium oxide nanoparticles (Ahmad, A.H., 2007).

**Fig. 8:** The variation of real part of dielectric constant of (PVA-PVP-TiO$_2$) nanocomposite with photon energy.

**Fig. 9:** The variation of imaginary part of dielectric constant of (PVA-PVP-TiO$_2$) nanocomposite with photon energy.

**Conclusions:**
1. The absorbance of polymer matrix (PVA-PVP) increases with the increase of titanium oxide nanoparticles concentrations.
2. The energy band gap for (PVA-PVP-TiO$_2$) nanocomposites is decreased with the increase of titanium oxide nanoparticles concentrations.
3. The optical constants (absorption coefficient ($\alpha$), extinction coefficient ($k$), refractive index ($n$), real and imaginary dielectric constants are increasing with the increase of titanium oxide nanoparticles concentrations.

**REFERENCES**


