Study the Optical Properties of (PVA-PEG-CoO) Nanocomposites

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ABSTRACT

Polymer composites of poly-vinyl alcohol and poly-ethylene glycol with different concentrations of nanoparticles of cobalt oxide (CoO) have been prepared by solution cast method. The optical characterization has been done by analyzing the absorption (A) spectra in the spectral region 200–800 nm. It was found that the optical energy gap decreases with increasing CoO content. The refractive index (n), extinction coefficient (k), static dielectric constant have been calculated for the investigated films.

INTRODUCTION

Optical polymers have attracted considerable attention in recent years because of their important industrial applications. Polymer nanocomposites have received intense attention and research in the past five years, driven by the unique properties of the nanoparticles and potential to create new material systems with superior properties (Ramanathan, T., 2005). This is due to their unique properties such as light weight, high flexibility, and ability to be fabricated at low temperature and low cost (Asogwa, P.U., 2011).

The physical properties of polymers may be affected by doping, the certain structural, optical, mechanical, electrical and magnetic properties of the selected polymer can be controllably modified owing to the type of the doping, concentration, and the way in which it penetrates and interacts with the chains of the polymer (Omed Ghareb Abdullah and Sarkawt Abubakr Hussen, 2010). 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 (Bhattacharya, A., P. Ray, 2003). Hence the assistance in the formation of polymer blends. The optical constants are very important because they describe the optical behavior of the materials. The absorption coefficient of the material is very strong function of photon energy and band gap energy (Reiter, G., 1994). Recently, we focused our research on studying the optical properties of (PVA-PEG-CoO) nanocomposites.

MATERIALS AND METHODS

The experiment was carried out at room temperature. 1 gm (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 °C 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 cobalt oxide (CoO) (0,2,4,6) weight percentage.

Were dissolved as stated above and in this way various samples were obtained. To cast the film, the mixture for each CoO 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 for characterization by measuring optical properties using double-beam spectrophotometer.

RESULTS AND DISCUSSION

The absorption spectra of the composite films with different concentrations are presented in Fig. 1. The composites films are absorption in the ultraviolet range.

It is clear from Fig 1 that as the concentration of the (CoO) component in the polymer composition decreases the absorption edge gets shifted towards the short wavelength side. The importance of this feature is
related to the possibility to move the spectral range of photosensitivity of amorphous composites from ultraviolet to visible.

3.1 Absorption Coefficient and Optical Band GAP:

The absorption coefficient ($\alpha$) of these materials strongly depends on optical Absorption ($A$) and thickness of film ($t$) which is evaluated using the relation (Mwolfe, C., 1989).

$$\alpha = \frac{2.303A}{t}$$

The optical energy gap ($E_g$) of the thin films has been determined from absorption coefficient data as a function of photon energy. According to the generally accepted “non-direct transition model” for amorphous semiconductors proposed by Tauc (Abd El-Raheem, M.M., 2007).

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

Where B is a constant related to the properties of the valance band and conduction band, $h\nu$ is the photon energy, $E_g$ is the optical energy band gap, $m=2,or3$ for indirect allowed and indirect forbidden transition.

From the linear plots of $(\alpha h\nu)^{1/m}$ against $(h\nu)$ for these samples as shown in figure 2, the optical energy gap has been determined from the intercepts of extrapolations to zero with the photon energy axis $(\alpha h\nu)^{1/m} \rightarrow 0$

From the results obtained it is seen that a decrease of concentration of CoO in the system leads to an increase in the optical band gap. The increase in band gap with decrease in concentration can be due to the optical scattering by the grain boundaries. It is found that as the concentration of the CoO decreases there is a red shift in band edge and a change in the slope of absorption spectra (Tintu, R., 2010).

![Fig. 1: The variation of optical absorbance for (PVA-PEG-CoO) composites with wavelength.](image)

![Fig. 2: The relationship between $(ah\nu)^{1/2}$ (cm$^{-1}$ .eV)$^{1/2}$ and photon energy (PVA-PEG-CoO) composites.](image)

3.2 Refractive Index and Extinction Coefficient:

The most important optical properties are the refractive Index (n) and the extinction coefficient (k) which are generally called optical constants The extinction coefficient K, is related to the absorption coefficient $\alpha$ can be calculated by using the relation (Pankov, J., 1971):

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

The refractive index as a function of wavelength can be determined from the reflection coefficient data R and the extinction coefficient k using equation:
\[ n = \left( \frac{4R - \sqrt{R^2 - 1}}{(1-R)^2 - (R+1)(R-1)} \right)^{1/2} \] (4)

The decrease in the extinction coefficient with an increase in wavelength shows that the fraction of light lost due to scattering.

Fig. 3: The extinction coefficient for (PVA-PEG-CoO) composites with various photon energy.

The high refractive index values of these composites are advantageous for strong optical confinement and enhance the optical intensities for nonlinear interactions.

3.3 Dielectric Properties:

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

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 (Tintu, R., 2010):
\[ \varepsilon_r = n^2 - k^2 \] (5)

The imaginary part shows how a dielectric absorbs energy from an electric field due to dipole motion. The dielectric loss (\(\varepsilon_i\)) has been determined from the relation
\[ \varepsilon_i = 2nk \] (6)

Fig. 4: The relationship between refractive index for (PVA-PEG-CoO) composites with photon energy.

Fig. 5: The variation of real part of dielectric constant for (PVA-PEG-CoO) composites with photon energy.
**Fig. 6:** The variation of imaginary part of dielectric constant for (PVA-PEG-CoO) composites with photon energy.

**Conclusions:**

The composites (PVA-PEG-CoO) have high absorbance in the UV region and decrease in the VIS region. The addition nanoparticles of (CoO) to the (PVA-PEG) causes shift the optical energy gap from (4 ev) for pure to (2ev) for 6% wt of (CoO).

The values of the refractive index(n) of the composites increase exponentially with increasing photon energy.

The real and imaginary dielectric constant show the exponential increase with increasing the incident photon energy.

**REFERENCES**


