The Effect of NiNO$_3$ on Optical Properties for (PVA- PEG) Composites Polymers

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Abstract
The present paper is aimed to modification of the optical properties of poly-vinyl alcohol and poly-ethylene glycol with different concentrations of (NiNO$_3$). The absorption and transmission spectra have been recorded in the wavelength range (200-800)nm. The absorption coefficient and energy gap of the indirect allowed and forbidden transition have been determined, Also, extinction coefficient, index coefficient, real and imaginary part of dielectric constant have been calculated.

Keywords: optical properties, polymer composites, optical constants, polyethylene glycol.

Introduction
The study of the optical absorption spectra in solids provides essential information about the band structure and the energy gap in the crystalline and non-crystalline materials. Analysis of the absorption spectra in the lower energy part gives information about atomic vibrations while the higher energy part of the spectrum gives knowledge about the electronic states in the atoms[Omed Ghareb and Sarkawt Abubakr, 2010]. The important increasing for using polymer blending and polymer composites came from results of industrial and large technology development which it was seeing in world and as substitute from traditional engineering materials which its used in industry[Moayad Abd,2008]. The development of polymer systems with high ionic conductivity is one of the main objectives in polymer research. This is because of their potential applications as electrolytes in solid-state batteries, fuel cells, electrochemical display devicesSMART windows, photo electrochemical cells etc., due to their high conductivity, high energy density, wide electrochemical stability and easy process ability. The main advantages of polymer electrolytes are their mechanical properties, ease of fabrication of thin films of desirable sizes and their ability to form proper electrode/electrolyte contact in electrochemical devices[U. Sasikala et al, 2012].

Experimental Part
The materials used in the paper is poly-vinyl alcohol and poly-ethylene glycol with different additives of (NiNO$_3$) as a filler.

The electronic balanced of accuracy $10^{-4}$ have been used to obtain a weight amount of (NiNO$_3$) powder and polymer powder. These mixed by Hand Lay up and the Microscopic Examination used to obtain homogenized mixture. The weight percentages of (NiNO$_3$) are (0, 5, 10,15) wt%. The casting technique was used to preparation the composites and thickness ranged between (0.015-0.007)mm. The transmission & absorption spectra of (PVA- PEG-NiNO$_3$) composites have been recording in the length range (200-800) nm using double-beam spectrophotometer (UV-1800*A shimidza)
Results and Discussion

Fig. (1): shows absorbance as function of wavelength accident light, we note the intensity of the peak increase as a result of increasing (NiNO$_3$) concentration.

![Absorbance vs Wavelength](image1)

The absorption coefficient ($\alpha$) was calculated in the fundamental absorption region from the following equation [Hutagalwng and Lee, 2007]:

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

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

Fig. (2): shows the relationship between the absorption coefficient and photon energy of the (PVA-PEG-NiNO$_3$) composites. The change in the absorption coefficient is small at low energies this is indicates the possibility of electronic transitions is a few. At high energy, the change of absorption coefficient is large this is indicates the large probability of electronic transitions are the absorption edge of the region [S. M Scholz et al., 2008]. The absorption coefficient helps to conclude the nature of electronic transitions, when ($\alpha<10^4$ cm$^{-1}$) at low energies we expected in this case indirect electronic transitions, the momentum of the electron and photon preserves by phonon helps [B. Thangaraju and P. Kaliana, 2000]. The forbidden energy gap of indirect transition both allowed, forbidden calculated according to the relationship [A. Kathalingam et al.,]
2007] :

\[ \alpha h\nu = A \left( h\nu - E_g \right)^n \]

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

If the value of (m=2) indicates to allowed indirect transition . when the value of (m=3) indicates to forbidden indirect transition. Figures(3 and 4) shows the dependence of the absorption edge \((\alpha h\nu)^{1/m}\) of (PVA-PEG-NiNO\(_3\)) composites of different filler contents (NiNO\(_3\)) as a function of the energy of the incident light \((h\nu)\). The obtained results showed that \(E_{opt}\) decreased with increase of the \((\text{NiNO}_3)\) concentration.

The extinction coefficient \((k)\) was calculated in the fundamental absorption region from the following equation [H.Frohlich,1958]:

\[ K = \alpha \lambda / 4 \pi \]

Where : \(\lambda\) wave length of accident light

Fig. (5) shows the relationship between the extinction coefficient and photon energy of the \((\text{PVA-PEG-NiNO}_3)\) composites we note in low construction of \((\text{NiNO}_3)\) additive the extinction coefficient small but when increase of \((\text{NiNO}_3)\) additive the extinction coefficient increasing because of increasing of absorption.
The extinction coefficient for (PVA-PEG-NiNO$_3$) composite with various photon energy

![Graph of extinction coefficient versus photon energy](image)

We found refractive index ($n$) from relation below (A.Zaky and R.Hawley, 1970):

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

Where $R$: Reflectance, $k$: Extinction Coefficient

Fig. (6) shows the relationship between refractive index and photon energy of the (PVA-PEG-NiNO$_3$) composites, we note the change in the refractive index where it increase as NiNO$_3$ increases special in range (5-7 eV) photon energy because low wave length in this range, the reason of increase in refractive index of (PVA-PEG-NiNO$_3$) composites to high absorbance for (NiNO$_3$) addition.

![Graph of refractive index versus photon energy](image)

The real part of dielectric constant ($\varepsilon_1$) was calculated from the following equation [S.P.Seth and D.V.Gupta, 1981]:

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

Fig. (7) shows the relationship between the variation of real part of dielectric constant and photon energy of the (PVA-PEG-NiNO$_3$) composites, we note the real part of dielectric constant depend on refractive index($n$) greatly since the extinction coefficient ($k$) is small in addition of in low construction of (NiNO$_3$) additive the real part of dielectric constant is a small but when increase of (NiNO$_3$) additive the real part of dielectric constant of the (PVA-PEG-NiNO$_3$) increasing because of increasing of absorption coefficient ($\alpha$).
The imaginary part of dielectric constant ($\varepsilon_2$) was calculated from the following equation [H.A. Sarvetnick, 1969]:

$$\varepsilon_2 = 2nk$$

Fig. (7) shows the relationship between the variation of imaginary part of dielectric constant and photon energy of the (PVA-PEG-NiNO$_3$) composites, we note the imaginary part of dielectric constant depend on refractive index ($n$) and extinction coefficient ($k$) in addition of in low construction of (NiNO$_3$) additive the imaginary part of dielectric constant is a small but when increase of (NiNO$_3$) additive the imaginary part of dielectric constant of the (PVA-PEG-NiNO$_3$) increasing.

Conclusion

1. The absorption coefficient is increasing with increasing of the filler wt.% content of NiNO$_3$ additive.
2. The experimental results showed that the absorption coefficient less than $10^4$ cm$^{-1}$ this indicates to forbidden and allowed indirect electronic transitions.
3. The forbidden energy gap is decreasing with increasing of the concentration of NiNO$_3$.
4. The extinction coefficient is increasing with increasing of the concentration of NiNO$_3$ additive.
5. The refractive index is increasing with increasing of the concentration of NiNO$_3$ additive.
6. The Real and Imaginary parts of dielectric constant increasing with increasing of the concentration.
of NiNO3 additive.

References


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