Preparation and Study of Optical Properties of (Polymer-Nickel Nitrate) Composite

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ABSTRACT
Polymer composite of polyvinyl alcohol (PVA), nickel nitrate have been prepared by solution cast method for different doping concentrations of nickel nitrate. The optical characterization has been done by analyzing the absorption spectra in the spectral region 200–800 nm. It was found that the optical energy gap decreases with increasing $NiNO_3$ content. The refractive index (n), extinction coefficient (k), static dielectric constant have been calculated for the investigated films. The optical constants are changing with increase the weight percentages of nickel nitrate.
Key words: composite, polymer, optical constants, nickel nitrate

1. INTRODUCTION

The doped polymers may present useful applications in integrated optics or in real time holography. In order to tailor materials with improved properties within the doped polymer class, it is necessary to understand and control the electronic mechanisms involved in the optical behavior[1]. 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[2]. Polyvinyl Alcohol offers a combination of excellent film forming and binder characteristics, along with insolubility in cold water and organic solvents. This combination of characteristics is useful in a variety of applications . Moreover, it contains a carbon backbone with hydroxyl groups attached to methane carbons. These hydroxyl groups can be a source of hydrogen bonding, hence the assistance in the formation of polymer blends [3]. Recently, we focused our research on studying the optical properties of PVA filled with ($NiNO_3$) fillers.

2. MATERIALS AND METHODS

PVA and $NiNO_3$ used as received. The experiment was carried out at room temperature (25^oC). Different weight percentages of PVA and $NiNO_3$ are dissolved completely in 30ml (weight of each sample 1 gm and the concentrations of nickel nitrate are 0, 0.5, 1, 1.5 wt.%) distilled under constant stirring for 1hour while the mixture was heated up till 90^oC then the mixture was let to cool down to room temperature (25^oC) while the stirring of the mixture was carried out to ensure a homogenous composition. To cast the film, the mixture for each $NiNo_3$ concentrations was poured in a casting glass plate and let it dry at room temperature for 120 hours. 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.

3. RESULTS AND DISCUSSION

The absorption spectra of the composite with different concentrations of nickel nitrite is shown in Fig. 1.

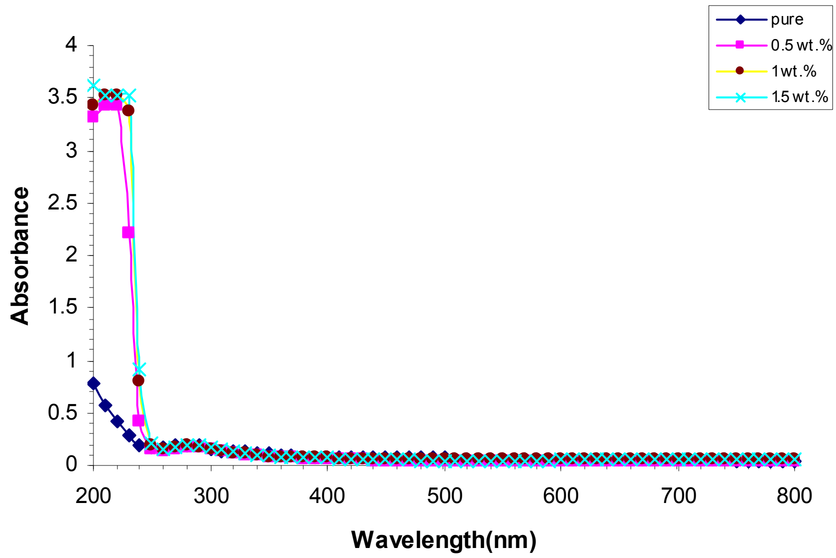

Fig. 1: Absorbance of $NiNO_3$ /PVA composite with different concentrations of nickel nitrite.

It is clear from Fig 1 that as the concentration of the $NiNO_3$ component in the polymer composition increases the absorption

Fig.2 shows the variation of absorption coefficient for composite with various photon energy. The absorption coefficient (α) of composite depends on optical absorbance (A) and thickness of film (d) which is evaluated using the relation [4]:

$$\alpha = 2.303A/d................(1)$$

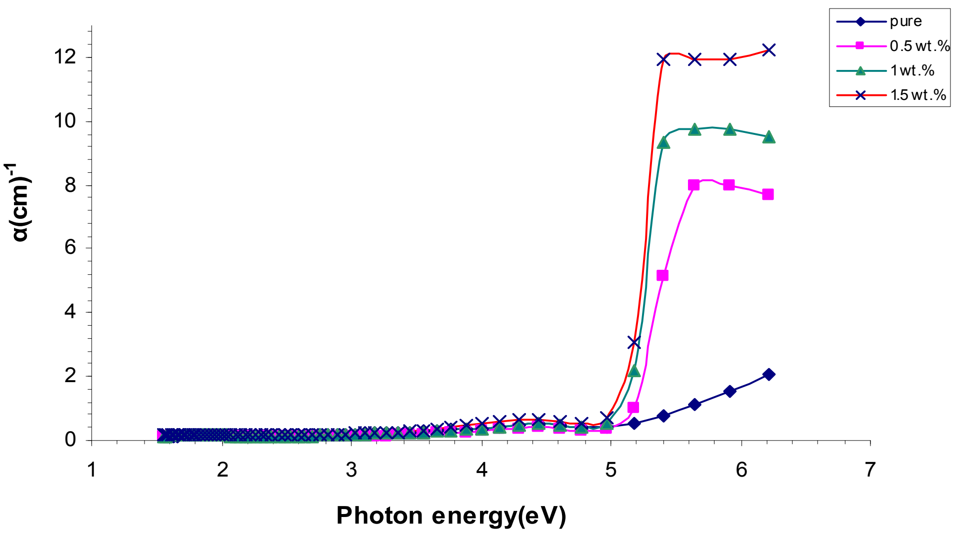

Fig.2 absorption coefficient for composite with various photon energy

The optical energy gap (Eg) 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 [5],

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

Where B is a constant related to the properties of the valance band and conduction band, hυ is the photon energy , E_g is the optical energy band gap, r=2,or3 for indirect allowed and indirect forbidden transition .From the linear plots of $(\alpha\ h\ \nu)^{1/r}$ against (h ν), the optical energy gap has been determined from the intercepts of extrapolations to zero with the photon energy axis $(\alpha h\nu)^{1/r} \rightarrow 0$. From the results obtained it is seen that an decrease of concentration of $NiNO_3$ 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 decrease in cluster size of the parent solution. It is found that as the concentration of the $NiNO_3$ decreases there is a red shift in band edge and a change in the slope of absorption spectra[6] as shown in figures (3a.and 3b.).

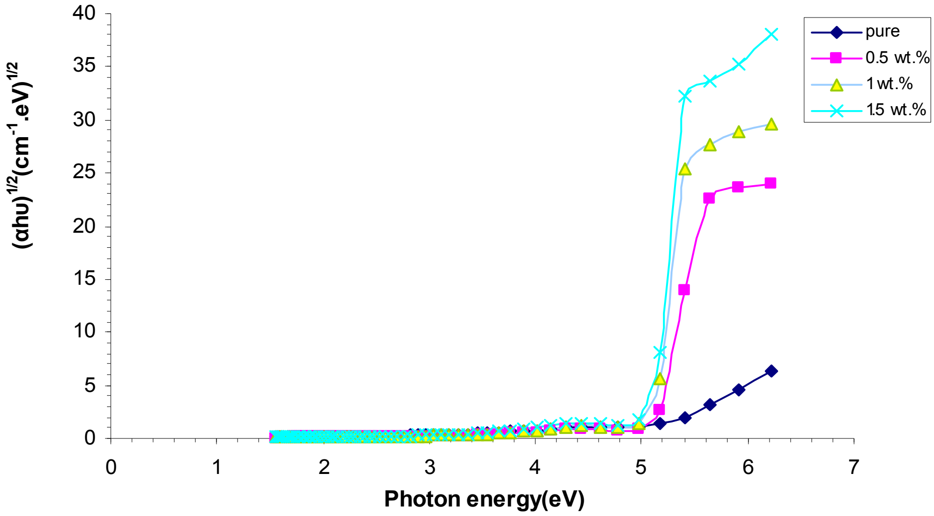

Fig..3a. the relationship between $(\alpha h\upsilon)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of composites.

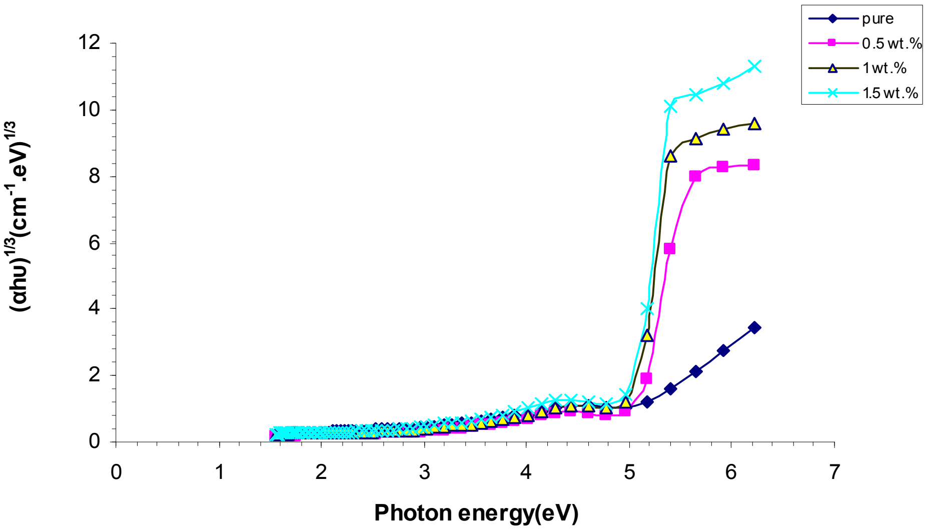

Fig..3b. the relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of composites.

Fig.4 shows the variation of extinction coefficient for composite with various wavelength. The extinction coefficient K, is related to the absorption coefficient α can be calculated by using the relation[6]:

$$K = \alpha\lambda / 4\pi \text{..................................}(3)$$

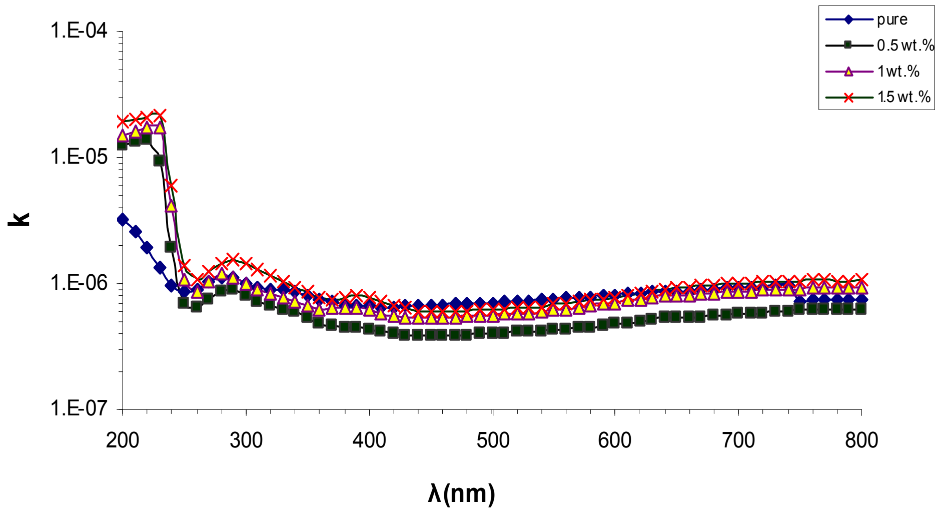

Fig.4 extinction coefficient for composite with various wavelength

The refractive index as a function of wavelength can be determined from the reflection coefficient data R and the extinction coefficient k using equation (as shown in figure 5)[6]:

$$n = \left(\frac{4R}{(1-R)^2} - K^2\right)^{1/2} - \frac{(R+1)}{(R-1)} \;...........(4)$$

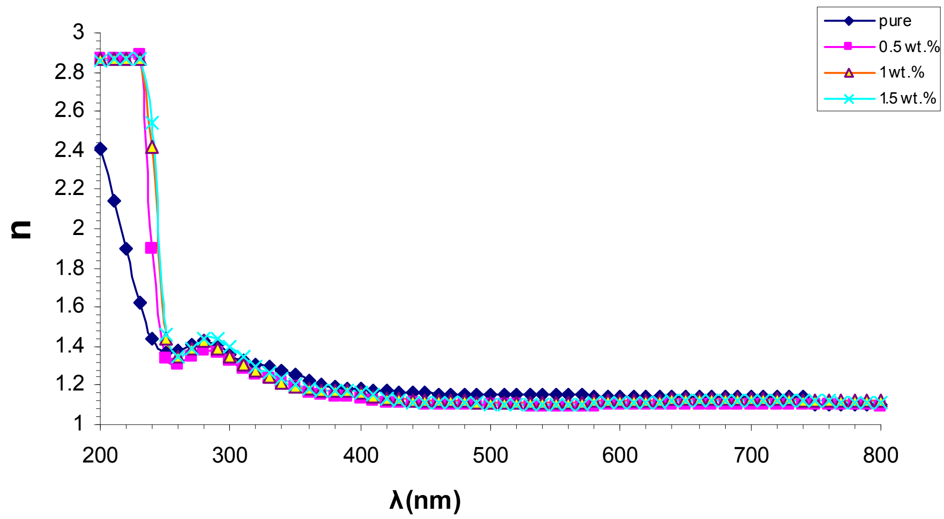

Fig.5 the relationship between refractive index for composite with wavelength

The decrease in the extinction coefficient with an increase in wavelength shows that the fraction of light lost due to scattering[6].

The high refractive index values of these composites are advantageous for strong optical confinement and enhance the optical intensities for nonlinear interactions. 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[6]:

$$\varepsilon_1 = n^2 - k^2 \;..........(5)$$

and imaginary part of the dielectric constant can be calculated by using the relation[7]:

$$\varepsilon_2 = 2nk \quad ....(6)$$

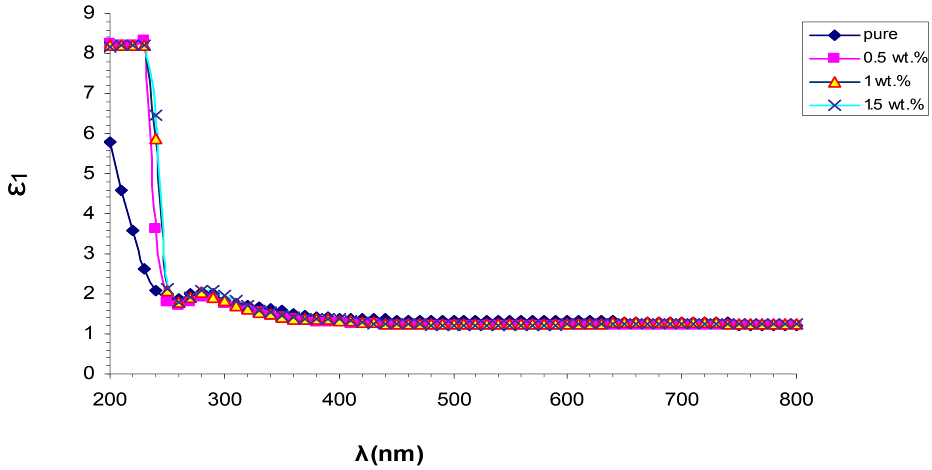

Fig.6 variation of real part of dielectric constant of composite with wavelength

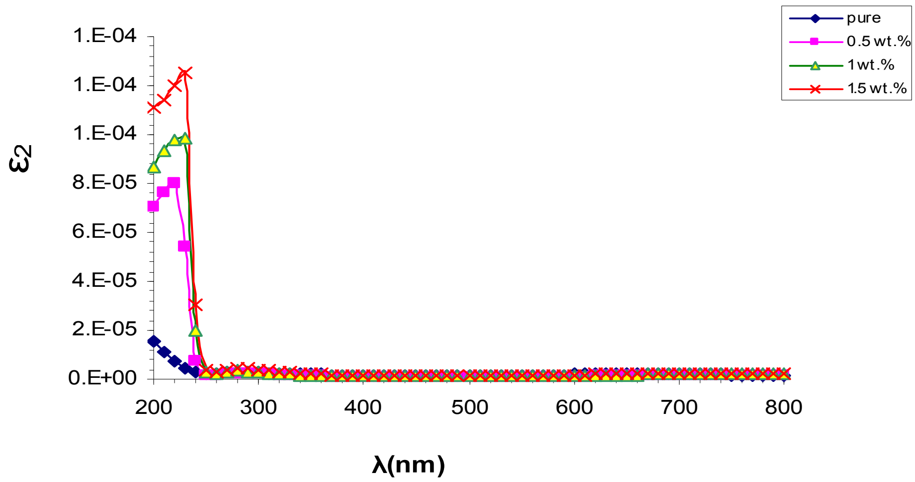

Fig.7 variation of imaginary part of dielectric constant of composite with wavelength

The imaginary part shows how a dielectric absorbs energy from an electric field due to dipole motion. The dielectric constant (ε_1) and dielectric loss (ε_2) have been determined from [7].

4. CONCLUSIONS

1. The absorbance increases with increase the concentration of nickel nitrite.
2. The absorption coefficient, extinction coefficient, refractive index and real and imaginary parts of dielectric constants are increasing with increase the weight percentages of nickel nitrite.

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