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Optical Properties of (PVA-$CoCl_2$) Composites

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Abstract
Polymers are used in a wide range of manufacture applications for their low cost, light weight, mechanical and optical properties. In this paper, study effect of addition cobalt chloride on optical properties of poly-vinyl alcohol(PVA). The cobalt chloride was add to poly-vinyl alcohol with weight percentages are (0,1,2,4) wt.%. The absorption and transmission spectra has been recorded in the wavelength range (200-800) nm. The experimental results showed that the absorption coefficient, optical energy gap, extinction coefficient, refractive index and real and imaginary dielectric constant effected by addition different weight percentages from cobalt chloride.
Keyword: polymer, optical constants, absorption, cobalt chloride.

Introduction

Per last years composite materials attract the rapt attention both in industry applications and in science. In these materials there is the possibility to combine mechanical, electric and optical properties of constituent components in one sample. From optical point of view, several fascinating properties of these composites can be obtained [1]. Polymers are generally used in a wide range of applications often for their low cost, light weight and a mechanical properties, or for the three characteristics combined [2]. 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[3]. Rtintu *et al*,[4] studied the optical properties of PVA/ Ge28Se60 Sb12 composite. They found that the optical energy gap decreases with increase of Ge28Se60 Sb12 concentration. Also, the refractive index decreases with the decrease in concentration The present study deals with the effect of cobalt chloride on the optical properties of polyvinyl alcohol composite.

Experimental part

The materials used in this paper are polyvinyl alcohol and cobalt chloride. The weight percentages of cobalt chloride are (1,2, and 3) wt.%. The samples were prepared casting technique thickness ranged between (442-796)μm.

The transmission and absorption spectra of composites have been recording in the wavelength range (200-800) nm using double-beam spectrophotometer (UV-210^{o}A shimedza).

The absorption coefficient(α) is calculated by using the following equation [5]:

$$\alpha = 2.303A/t \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where A is absorption and t is the thickness of film .

The optical energy gab and electronic transition obtained from this equation :

$$\alpha h\upsilon = B(hf - E_g)^r \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The refractive index is calculated by using the following formula :

$$n = [4R/(R-1)^2 - (R+1/R-1)]^{1/2} \quad \ldots\ldots\ldots\ldots (3)$$

The extinction coefficient is obtained by the relation :

$$K = \alpha\lambda/4\pi \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Real and imaginary dielectric constant is calculated from the equations :

$$\varepsilon_1 = n^2 - k^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

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

Results and Discussion

The absorption spectra of PVA-$CoCl_2$ composite of different concentration of cobalt chloride is shown in figure (1). This figure shows, the absorbance of polymer increases with increase concentration of cobalt chloride this is due to absorb the incident light by the free charge carriers[6].

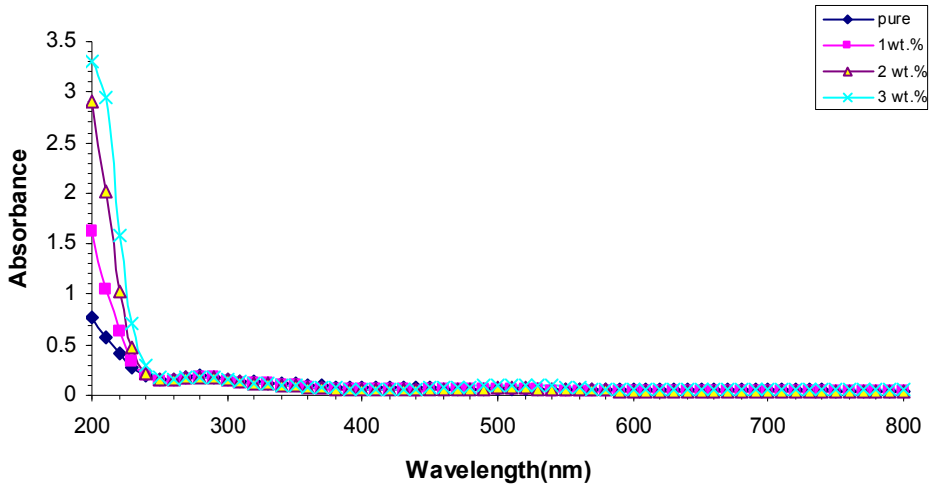

FIG.1
The variation of optical absorbance for (PVA-$CoCl_2$) composite with wavelength

Figure (2) shows the variation of absorption coefficient with photon energy of composite. From this figure, the absorption coefficient is small at low energies, this indicates the possibility of electronic transitions is small. At high energies absorption coefficient is large this indicates the large probability of electronic transitions at the absorption edge of the region.

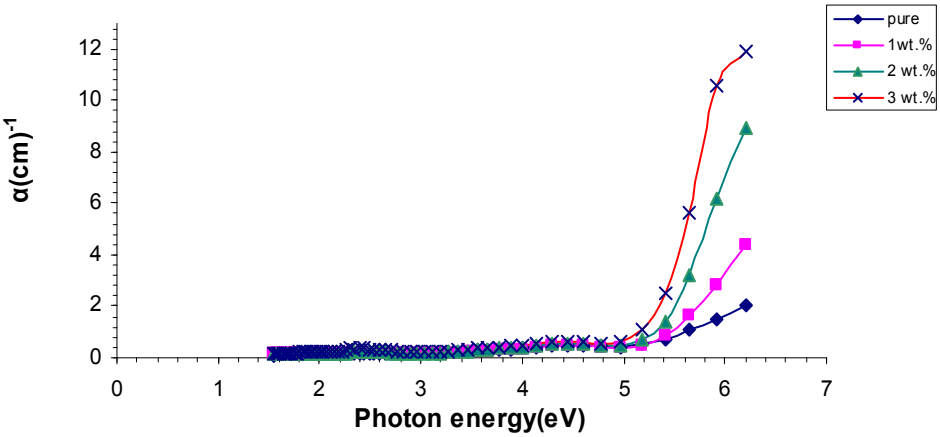

FIG.2
The absorption coefficient for (PVA-$CoCl_2$) composite with various photon energy

The absorption coefficient helps to conclude the nature of electronic transitions, when the absorption coefficient values are high ($\alpha > 10^4 cm^{-1}$) at high energies we expect direct electronic transitions ,and the energy and momentum of the electron and photon are persevered, when the values of absorption coefficient are low($\alpha < 10^4 cm^{-1}$) at low energies we expect are indirect electronic transitions, the momentum of the electron and photon preserved by phonon helps[7]. The results show that the values of absorption coefficient of composites are less than $10^4 cm^{-1}$ which indicates the indirect electronic transition. The forbidden energy gap of indirect transition both allowed, forbidden is calculated according to equation(2) as show in figures 3 and 4.

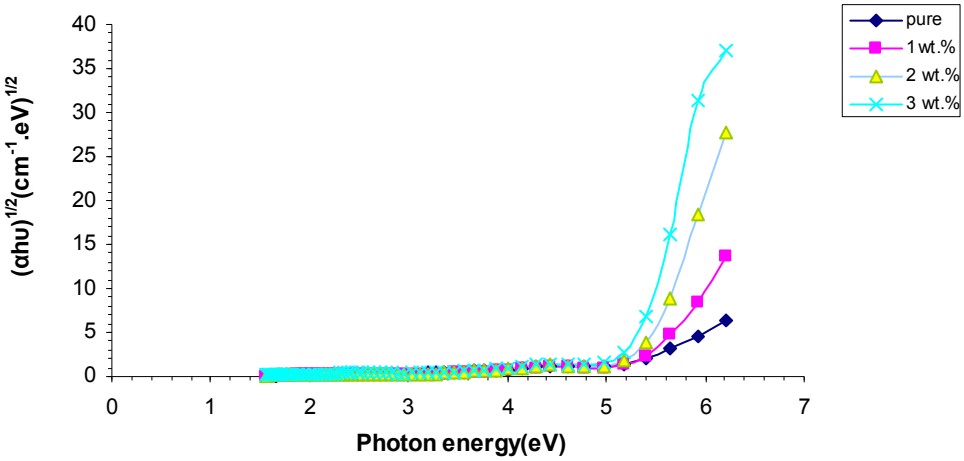

FIG.3

The relationship between $(\alpha hu)^{1/2}(cm\text{-}1.eV)^{1/2}$ and photon energy of PVA-$CoCl_2$ composites.

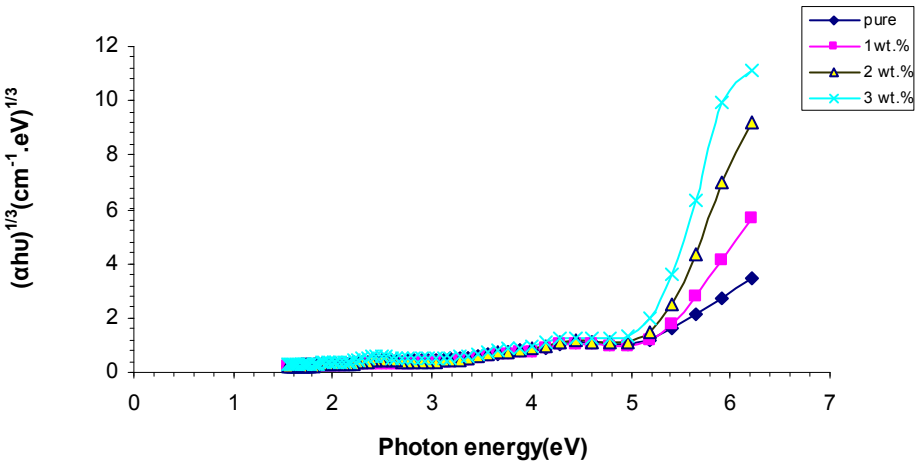

FIG.4

the relationship between $(\alpha hu)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of PVA-$CoCl_2$ composites.

Figure (5) shows the variation of extinction coefficient and photon energy of the composites. From the figure we see that the extinction coefficient increases with increasing of concentration of cobalt chloride, this related to high absorption coefficient of doping atoms of cobalt chloride will modify the structure of the host polyvinyl alcohol [8].

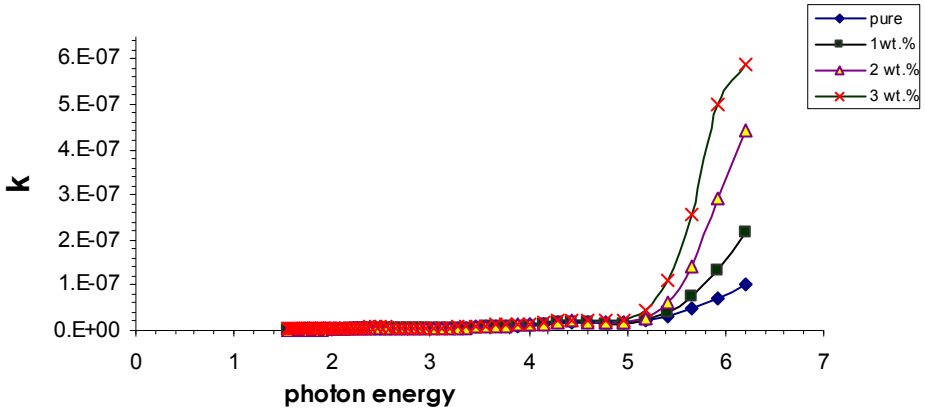

FIG.5

The extinction coefficient for (PVA-$CoCl_2$) composite with various photon energy

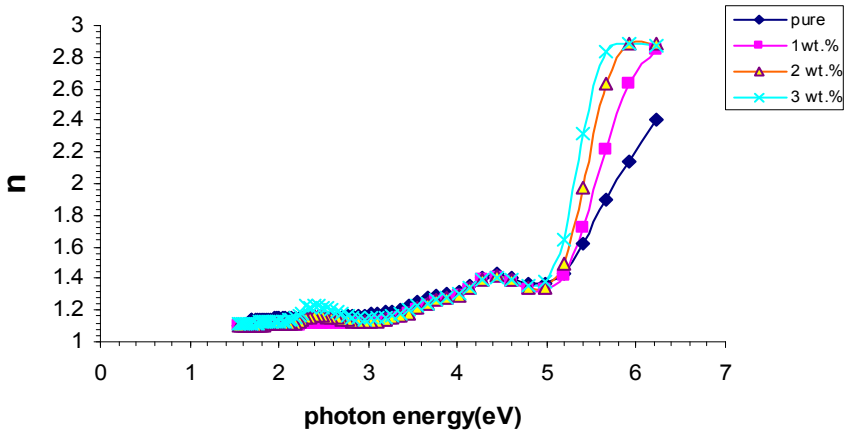

FIG.6

The relationship between refractive index for (PVA-$CoCl_2$) composite with photon energy

Figure (6) shows the effect of addition cobalt chloride on refractive index with different photon energies. The figure shows that the refractive index increases with increase of cobalt chloride concentration this related to the fraction of light lost due to scattering [4].

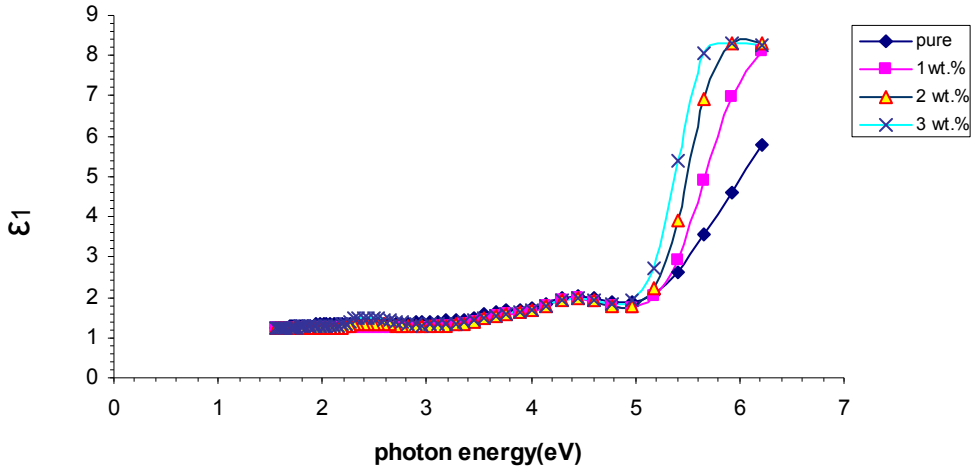

FIG.7
The variation of real part of dielectric constant (PVA-$CoCl_2$) composite with photon energy

Figures (7) and (8) show the effect of addition cobalt chloride on real and imaginary dielectric constants as a function of photon energy composite. From the figure we can see that the real and imaginary dielectric constants are increasing with increase the cobalt chloride concentration. The real and imaginary dielectric constants that shows how much it will slow down the speed of light in the material and the imaginary part shows how a dielectric absorbs energy from an electric field due to dipole motion [4]. The increase of real and imaginary dielectric constants due to increase the density of free charge carriers.

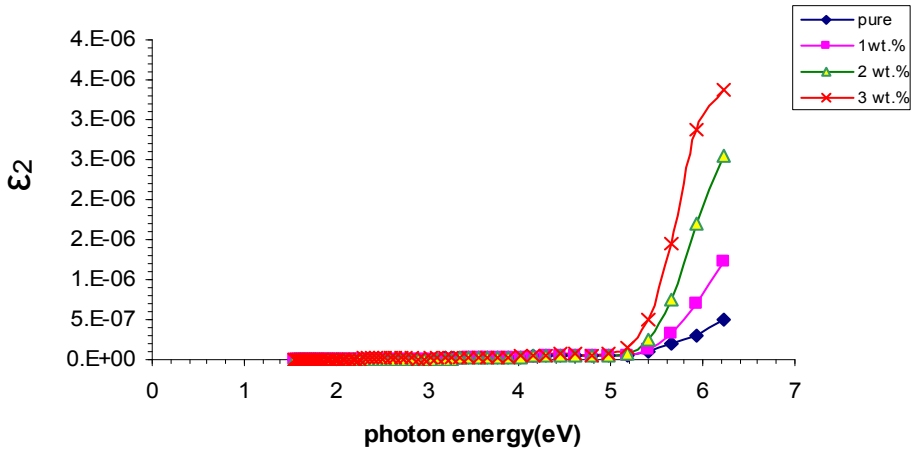

FIG.8
The variation of imaginary part of dielectric constant(PVA-$CoCl_2$) composite with photon energy

Conclusions

The experimental results showed that the absorption coefficient of composite less than 10^4 cm^{-1} this is indicate to forbidden and allowed indirect electronic transition, the forbidden energy gap of (PVA-$CoCl_2$) composite decreases with increase of concentration of cobalt chloride. The extinction coefficient, refractive index, real and imaginary dielectric constants are increasing with increase the cobalt chloride concentration.

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