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Preparation and Study Optical Properties of (PVA-PVP-$CrCl_2$) Composites

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Abstract

In present research, the effect of addition chromium chloride ($CrCl_2$) on the optical properties of (PVA-PVP) composite has been studied, samples have been prepared by adding ($CrCl_2$) to poly vinyl alcohol and poly vinyl pyrrolidone with different weight percentages, the absorbance spectra was recorded in the wavelength range (200-1100) nm. The absorption coefficient, optical energy gap of the indirect transition, extinction coefficient, refractive index and (real, imaginary) dielectric constant have been determined.
Keywords: Optical properties, (PVA-PVP) composites, chromium chloride.

Introduction

The new composites materials have become the foundation to change and develop engineering designs for many commodities and industrial products, the most important of these automotive industry, aircraft, ships, and construction materials [1]. Polyvinyl alcohol has excellent film forming, emulsifying, and adhesive properties. It is also resistant to oil, grease and solvent. PVA is odorless and nontoxic, as well as has high oxygen and aroma barrier properties [2], its molecular formula is $(C_2H_4O)x$, and its density is between 1.19 and 1.31 g/cm^3 [3]. PVP is a white, hygroscopic powder with a weak characteristic order. In contrast to most polymers, it is readily soluble in water and a large number of organic solvents, such as alcohols, amines, acids, chlorinated hydrocarbons, amides, and lactams [4]. Many polymers in everyday use contain fillers and coloring agents that render them opaque. The optical properties of the base polymer are thus obscured. On the other hand the clarity of optical transmission of many polymers and the fact that they are almost colorless, coupled with their low density and excellent mechanical properties, are the reasons for their use to replace glass in many applications [5].

Experimental work

Three films from (PVA-PVP-$CrCl_2$) composites have been prepared by adding chromium chloride to (PVA-PVP) with different weight percentages of salt concentration (3,6,9)wt.%. Preparation of films have been done by using casting method. The absorbance spectra recorded in the wave length (200-1100) nm by using UV spectrophotometer (UV-1800), the absorption coefficient(α) was calculated from the following equation: [6]

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

Where A is absorption and d is the sample thickness

The optical energy gap has been calculated by using this equation: [7]

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

Where hf is the energy of photon, B is proportionality constant and Eg is optical energy gap.

The extinction coefficient (k) is directly proportional to the absorption coefficient (α): [8]

$$k = \alpha\lambda/4\pi \quad (3)$$

Where λ is the wavelength of light.

The refractive index has been calculated by using this equation: [9]

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

The real and imaginary part of dielectric constants have been determined from this equation:[10]

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

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

Results and Discussion

The absorbance of (PVA-PVP-$CrCl_2$) composite with varies concentration over wavelength (200-1100) nm was recorded at room temperature. Figure (1) display the variation of optical absorbance with wave length for (PVA-PVP-$CrCl_2$) composite. The intensity of the peak increasing and no shift in the peak position. The absorbance increases with increasing of weight percentages of the chloride, this is due to absorb the incident light by free electrons [11].

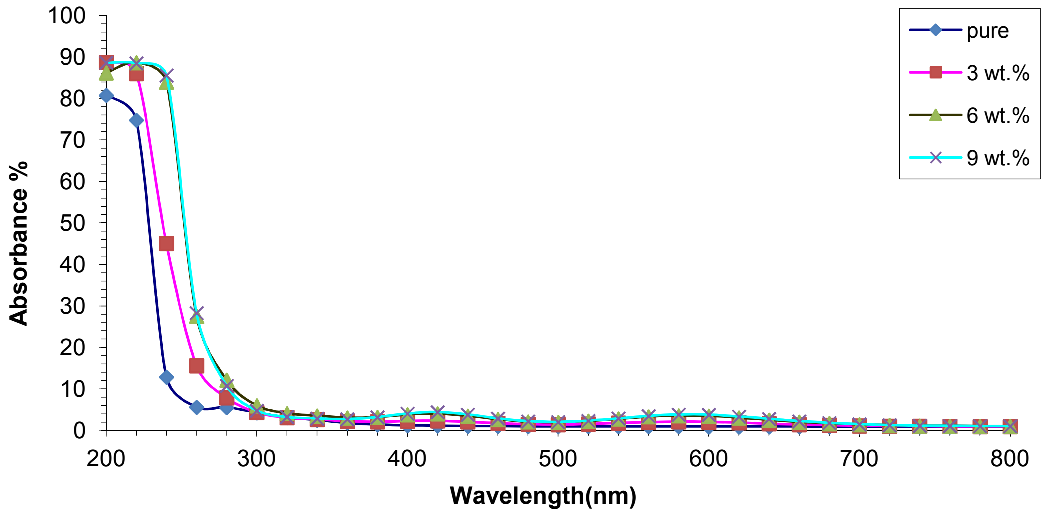
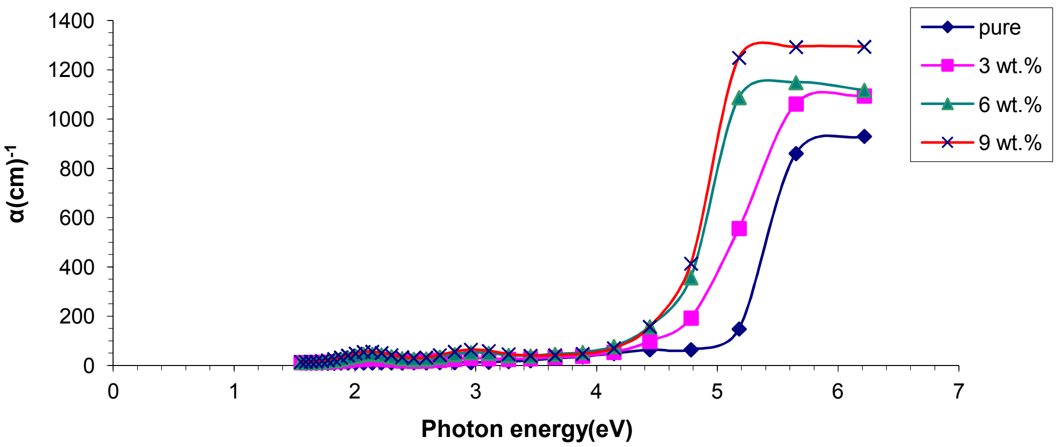


Figure (1): Variation between absorbance with wavelength for (PVA-PVP-$CrCl_2$) composite.

Figure (2) shows the relation between the absorption coefficient and photon energy of the (PVA-PVP-$CrCl_2$) composite. From this figure notice that the absorption coefficient dependent on the photon energy, where the absorption is little at low energy this is means that the possibility of electron transition is little because the energy of the incident photon is notice sufficient to move the electron from the valance band to the conduction band. At high energies the absorption coefficient assists in figuring out the nature of electron transition when the values of the absorption coefficient is high ($\alpha > 10^4$) cm^{-1} it is expected that direct transition of electron occur on the other band when the values of absorption coefficient is low ($\alpha < 10^4$) cm^{-1} it is expected that indirect transition of electron occur [12].



Figure(2): Relationship between absorption coefficient and photon energy for (PVA-PVP-$CrCl_2$) composite.

The variation between $((\alpha hf)^{1/2}$ $(cm^{-1}.eV)^{1/2}$) and photon energy of (PVA-PVP-$CrCl_2$) composite shown in figures (3). It is appear from this figure the values of optical energy gap decrease by increasing weight percentages from ($CrCl_2$) this is attributed to the increase of disorder in the material, that means allowing excitation secondary levels inside the energy gap and increase the width of these levels with the increasing of ($CrCl_2$) concentration which leads to decrease the width gap. Figure (4) show the relationship between $((\alpha hf)^{1/3}$ $(cm^{-1}.eV)^{1/3}$) and photon energy of composites, we can see from this figure the values of energy gap for forbidden indirect transition decrease by increasing weight percentages of chlorides, as well as these values of forbidden indirect transition are less than the values of allowed indirect transition [13]. The values of optical energy gap for indirect transition (allowed, forbidden) for all samples shown in table (1).

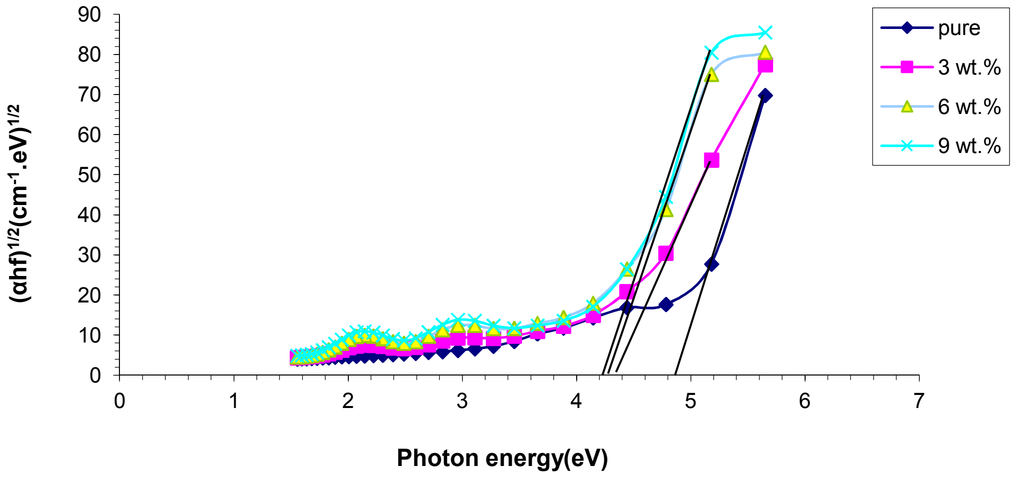


Figure (3): Relationship between $(\alpha hf)^{1/2}$ $(cm^{-1}.eV)^{1/2}$ and photon energy for (PVA-PVP-$CrCl_2$) composite.

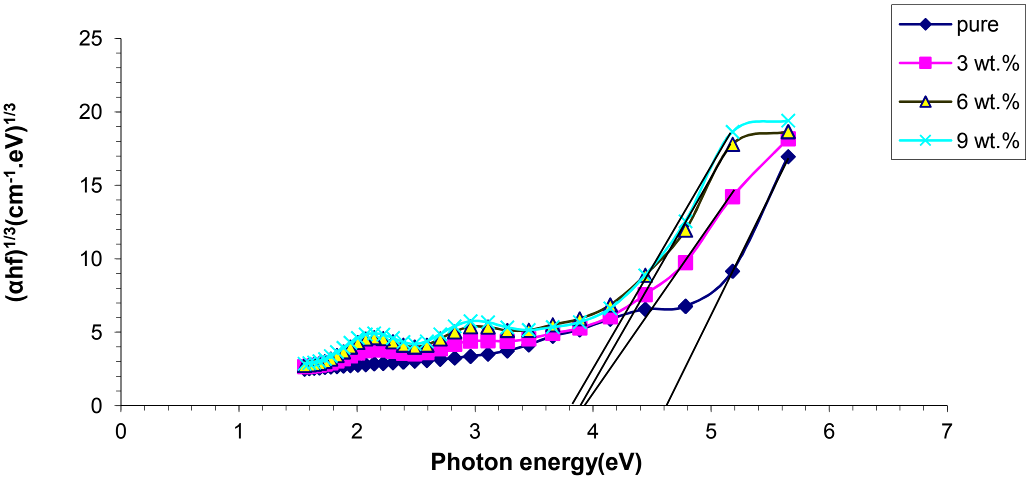


Figure (4): Relationship between $(\alpha hf)^{1/3}$ $(cm^{-1}.eV)^{1/3}$ and photon energy for (PVA-PVP-$CrCl_2$) composite.

Table (1): Values of the optical energy gap of indirect transition for all samples.

Optical energy gap for indirect transition		
Samples	Allowed	Forbidden
	PVA-PVP-$CrCl_2$	PVA-PVP-$CrCl_2$
pure	4.85	4.6
3wt.%	4.39	3.95
6wt.%	4.3	3.9
9wt.%	4.2	3.8

Figure (5) show the relationship between refractive index and photon energy for (PVA-PVP-$CrCl_2$) composites. It is obvious from this figure the refractive index increase with increasing of chloride concentration because of increasing in density composites. In ultraviolet region we note that high values of the refractive index because of the little transmittance in this region, but in the visible region note that low values because of the high transmittance in this region [14].

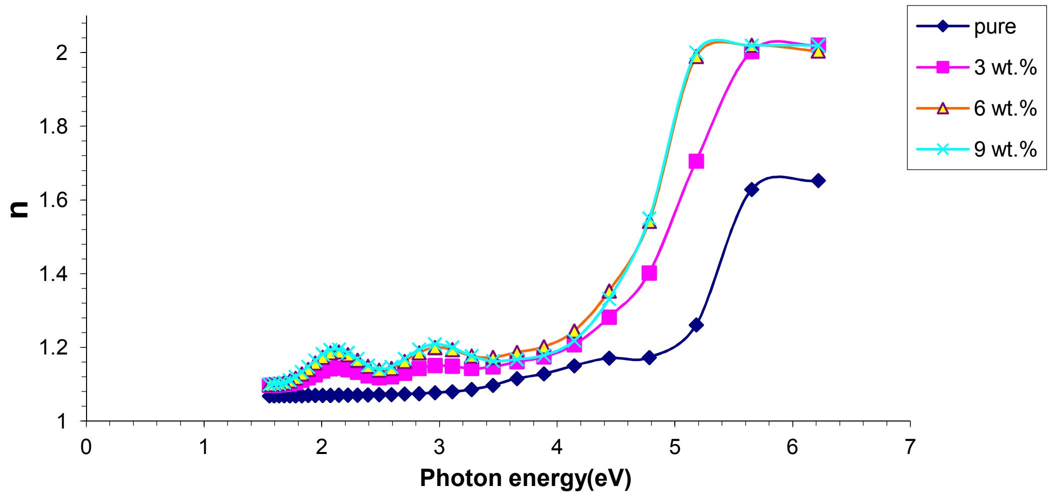


Figure (5): Relationship between refractive index and photon energy for (PVA-PVP-$CrCl_2$) composite.

The variation of the extinction coefficient for (PVA-PVP-$CrCl_2$) composite as a function of wavelength shown in figure (6). This figure show that extinction coefficient (k) has low values at (UV-region) and with the little concentration, as well as it is increased with increasing of additive concentrations of chlorides because of increasing in absorption coefficient, but at visible region we note that the extinction coefficient is very low because of the low absorption at this region[15].

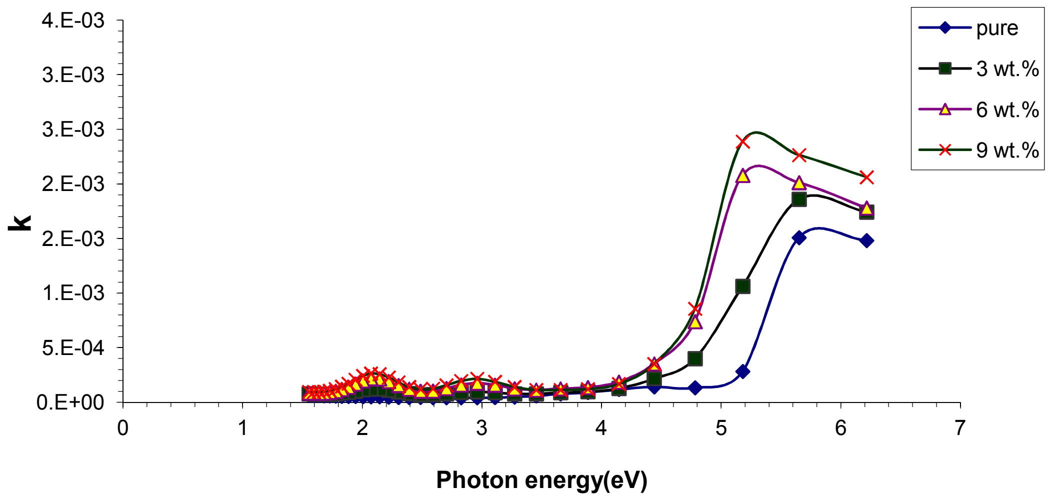


Figure (6): Extinction coefficient for (PVA-PVP-$CrCl_2$) composite with photon energy.

The dielectric constant for two parts (real and imaginary) have been calculated from equations (5) and (6). Figure (7) show the variation between real part of dielectric constant (ε_1) with photon energy. It is concluded that the variation of (ε_1) mainly dependence on (n^2) because of small values of (k^2), while (ε_2) mainly dependence on the (k) values which are related the variation of absorption coefficient, as shown in figure (8).

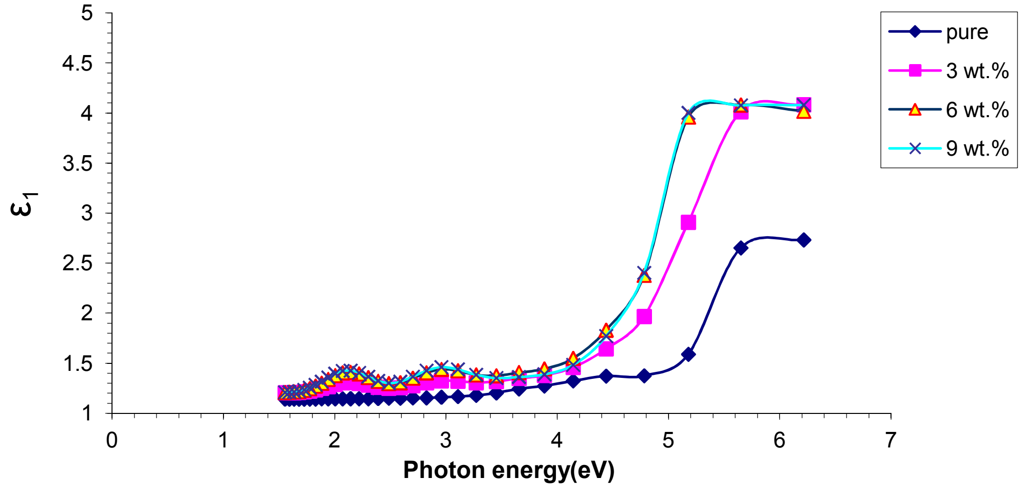


Figure (7): Relation between real part of dielectric constant (ε_1) with photon energy for (PVA-PVP-$CrCl_2$) composite.

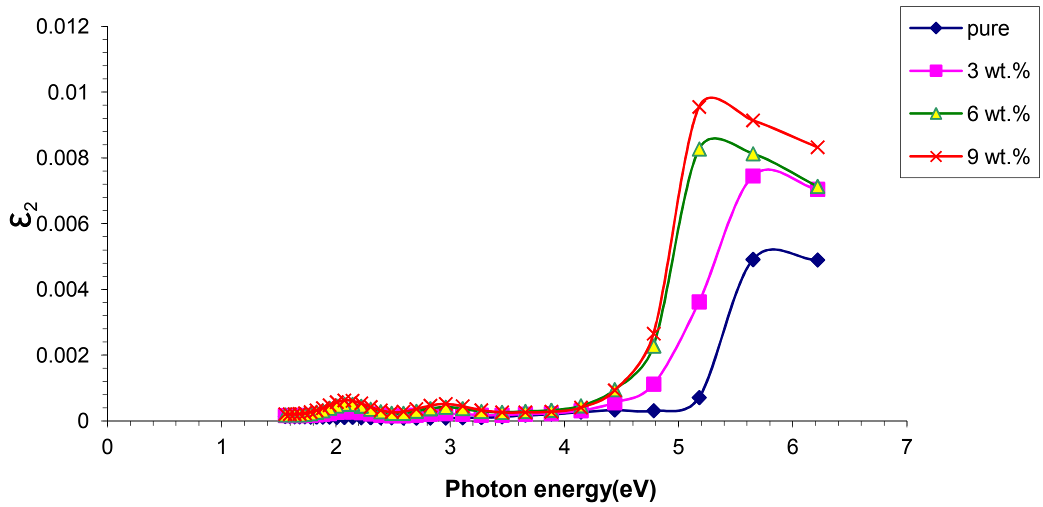


Figure (8): Relation between imaginary part of dielectric constant (ε_2) with photon energy for (PVA-PVP-$CrCl_2$) composite.

Conclusions

1- The absorption coefficient for all composites has more increased in (UV-region) and less increased in a visible region, generally the absorption coefficient increased with increasing of chloride concentration.
2- The energy gap for indirect transition (allowed, forbidden) decreased with increasing of chloride concentration.
3- Extinction coefficient has low values, generally it is increased with increasing of concentration for all samples.
4- Refractive index and dielectric constant (real, imaginary) increased with increasing of concentration for all samples.

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