Preparation and Study the Optical Properties of
Ps - Cd(NO$_3$)$_2$ .4H$_2$O Composites

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Abstract

The optical properties of polystyrene – Cd(NO$_3$)$_2$. 4H$_2$O composites has been described by the measurement of changes in the UV_visible light absorption spectrum. Polymer composites exhibits a new UV- visible absorption band at a wavelength range (226-235) nm, which is attributed to the interchange interaction. The optical transmission method is successfully used to determine the absorption coefficient (α), dielectric constant and energy gap of four samples. The studies show strongly dependent on the nature of the material and the radiation type.
Key words: optical properties, polystyrene, composites, cadmium nitrate

الخلاصة

يمكن وصف الخصائص البصرية لمتراكب بوليستايرين – نترات الكادميوم المائية المقاسة من خلال قياس التغيير في طيف امتصاص الضوء المرئي – فوق البنفسجي. ان متراكب البويمر يصف مدى من حزمة امتصاص ذات طول موجي (226–235) نانومتر. حيث ينسب الى التفاعل المتبادل. ان طريقة الأنتقال البصري تعتبر ناجحة لحساب معامل الامتصاص، ثابت العزل، فجوة الطاقة، معامل الأنكسار، وثابتي العزل الحقيقي والخيالي لأربعة نماذج مختارة

كلمات مفتاحية: خصائص بصرية، متراكبات، بوليستايرين، نترات الكادميوم

1- Introduction

Composites developed to meet several industrial requirements, such as the need for easier processing and broadening the range of properties, either by varying the type, relative content or the morphology of each component [Hanhua, 2010]. When Cd(NO$_3$)$_2$. 4H$_2$O is used as a filler in polymer composite, the composite properties can change from insulator to conductive ones [Bjoklund, 2007]. Polystyrene and copolymers are susceptible to degradation by the action of sunlight.

The action of the UV radiation is accompanying by the oxidation so that the overall degradation reaction is one of photo oxidation. The extant of degradation varies from location to location owing to differences in the intensity of radiation. This is of considerable importance in many applications, in the case of transparent compositions, in a yellowing effect and generally in a loss of mechanical properties such as a lower elongation at break and reduced impact strength [Golub, 1**957**].

Cd(NO$_3$)$_2$. 4H$_2$O materials are sometimes adding to polymer in order to obtain composites with improved electrical and mechanical properties. The most important of these substances is Cd(NO$_3$)$_2$. 4H$_2$O, which is the most effective stabilizer for most polymers. The effectiveness is dependent on first, the type, second, the size of particles, and third, the degree of dispersion of the particles within the polymer. Cd(NO$_3$)$_2$. 4H$_2$O is considerably more efficient as a weathering stabilizer than would be predicted on the basis of just its ability to screen the polymer from UV_ light. The increased efficiency is usually as Cd(NO$_3$)$_2$. 4H$_2$O cribbed to its ability to trap radicals produced during the photo oxidative processes which lead to chain degradation. Cd(NO$_3$)$_2$. 4H$_2$O stabilize polymers by its ability to quench the exited state induced in the polymer by the absorption of UV. radiation [Hesking , 1970].

The effect of UV light on polymers has attracted considerable interest for many years. polymers with pendant aromatic ring groups , such as polystyrenes are known to show a new fluorescence band at longer wavelength under irradiation due to the interaction between excited and ground state aromatic groups , i.e. the formation of intermolecular exciters. This phenomenon has been widely used as a powerful tool in polymer structure studies [Tong and Chunlin, 1991].

The irradiation of polymers with ionizing radiations leads to a wide variety of changes in their physicochemical properties that can generally be traced back to the rearrangement-taking place in the chemical structure of the polymer because of energy deposition [Srivastava, 2010].

This study deals with results of the effect cadmium nitrate on the optical properties of Ps -$Cd(NO_3)_2$.$4H_2O$ Composites

2- Experimental Details

The samples with deferent polystyrene – $Cd(NO_3)_2$. $4H_2O$ percentages composites content were prepared from (3, 6, 9, 12) wt%. The samples were prepared using casting technique thicknesses of 0.15 mm were cut into 2.6×2.8 cm^2 sized samples. All these samples were subjected to UV– Visible transmission and reflection studies by using Shimadzu double – beam UV - Visible Spectrophotometer (UV- 210 A^0) in the wavelength range (190-800) nm, the method of measurement has been described elsewhere. Samples have been drying in air at 30°C temperature.

3- Optical Calculation

Absorbance quantities were converting to absorption coefficients follows [John and Aron, 2008]:

$$\alpha = 2.303 A / l \tag{1}$$

Where (α) (m^{-1}) is absorption coefficient for the samples. Where both of A and l are the absorbance and the thickness of the samples respectively.

The extinction coefficient (K) was calculating by using the following equation [Tauce, 1972]

$$K = \alpha \lambda / 4 \pi \tag{2}$$

Where λ (m) is the wavelength, Ultraviolet-visible (UV/vis) spectroscopy has become an important tool to estimate the value of optical gap energy (E_g) in polymer. The optical absorption edge can be correlated to optical gap energy (E_g) using Tauc's equation. The intersection of extrapolated spectrum with the abscissa yields the optical gap energy (E_g). The Tauc's equation is as follows [Tauce, 1972]:

$$\alpha h \upsilon = A \left(h \upsilon - E_g \right)^n \tag{3}$$

Where, λ (m) is the wavelength, h is a Plank's constant 6.62617×10^{-34} $J.s$ and c the speed of light 3×10^8 m/s , υ (Hz) is the frequency.

The real (ε_1) and imaginary (ε_2) parts of dielectric constants are calculating by following equations (Nahida. J. H. 2011):

$$\varepsilon_1 = n^2 - k^2 \tag{4}$$

$$\varepsilon_2 = 2nk \tag{5}$$

The photon absorbance probability increased proportionally with absorbed molecules concentration and sample thickness [Srivastava A. 2010]:

$$ln (I/I_0) = - K C_m L \tag{6}$$

Where (I_0) is the incident light intensity, (I) is the reflected light intensity, (L) is the length of the photo path, C_m is the molar concentration. The refractive index can be determined from following equation [Xin *et al.,* 1999]:

$$n = \frac{c}{v} \tag{7}$$

Where (c) is the light velocity in vacuum, (v) is the light velocity in medium

4- Results and Discussion

Figure 1. Shows the typical normalized UV- Visible spectra of polystyrene with $Cd(NO_3)_2$. $4H_2O$ content (3, 6, 9, 12) wt. percentage. It is shown that the adding of the filler to the polymer lead to increase the intensity of peak. Critical analysis of UV- Visible spectra of polystyrene – $Cd(NO_3)_2$. $4H_2O$ Composites shows that the highest shift in absorption wavelength is in the range 226-235 nm. This indicated the carbonization of the polymeric materials. The shift in the absorption edge from UV to visible region could be attribute to an increase in conjugation length. In the present case the optical band gap energy can be correlated with the number of carbon atoms for a linear structure polymer [Srivastava ,2010].

The absorption of light energy by polymeric materials in UV and visible regions involves transition of electrons in n to π^* orbital from ground state to higher energy states. This is because the absorption peaks for these transitions fall in an experimentally convenient region of the spectrum (200 – 700). These transitions need an unsaturated group in the molecule to provide the π electron [John and Aron, 2008].

Figure 2. Shows the absorbance value as a function of concentration of the composites. This result may be interpreting with interchange interaction in the outside of polymer coils. While polymer coils approach each other, interchange interaction in the outside of different polymer coils may induce the slight increase of absorbance. The local concentration of $Cd(NO_3)_2$. $4H_2O$ groups may increase linearly with polymer concentration. It is assumed that the micro viscosity increase slowly. [Xin *et al.,* 1999].

The absorption coefficient α was determined for each sample by using the equation (1). It is clear that α must be a strong function of the energy $h\nu$ of the photons.

Figure3. Shows that for $h\nu < E_g$, no electron hole pairs can be created, the material is transparent and α is small. For $h\nu \geq E_g$, absorption should be strong [Dahshan, 2002].

The optical energy gap will be estimate from the optical measurements by analyzing the optical data with the expression for the optical absorbance, and the photon energy, $h\nu$ using equation 3. The optical band gap can be obtained by extrapolating the linear portion of the plot of $(\alpha h\nu)^{1/n}$ versus $h\nu$ to $\alpha = 0$. Using the value n=2, the relation was found to be straight line as shown in figure 4, 5. Representing direct transition [Mostafa and Mohmoud, 2012].

Figure 4,5 reveal the behavior of decreasing the values of optical gap with increasing with polystyrene - $Cd(NO_3)_2.4H_2O$ composites content which may be attributed to the decrease in the packing density with increasing composites content [Naser and Zaliman, 2009].

The variation of extinction coefficient (k) with wavelength for the composites is shown in figure 6, indicating that the extinction coefficient increase with increasing

the weight percentage of the added $Cd(NO_3)_2.4H_2O$ to the polyestyrene and decreases with increasing the incident wavelength. The behavior of extinction coefficient can be describing according to high absorption coefficient.

Figure 7 shows the variation of refractive index of the composites with photon energy. The refractive index increases with the increasing of the photon energy, this behavior attributed to the electromagnetic radiation passing through the material is faster in the low photon energy. The refractive index is increasing with the increase of the concentration of composites which due to the increase of their density (Tariq, 2010).

Figure 8, 9 show the behavior of real and imaginary parts of dielectric constants polystyrene – $Cd(NO_3)_2.4H_2O$ composites respectively. The variation of real (ε_1) part depends on refractive index because of small values of extinction coefficient, while imaginary part depends on the extinction coefficient values which related to the variation of the absorption coefficient (Nahida, 2011).

5-Conclusion

There are many parameters, which affect the composite structure and properties. The results showed the optical properties of composites can changed using the concentration of polystyrene – $Cd(NO_3)_2.4H_2O$ composites. The absorption coefficient, refractive index, real and imaginary part of dielectric, and The extinction coefficient increased with increasing the weight percentage of the added composites and decreases with increasing the incident wave length. The optical energy gap was decreasing with increasing the concentration of the composites.

6- References

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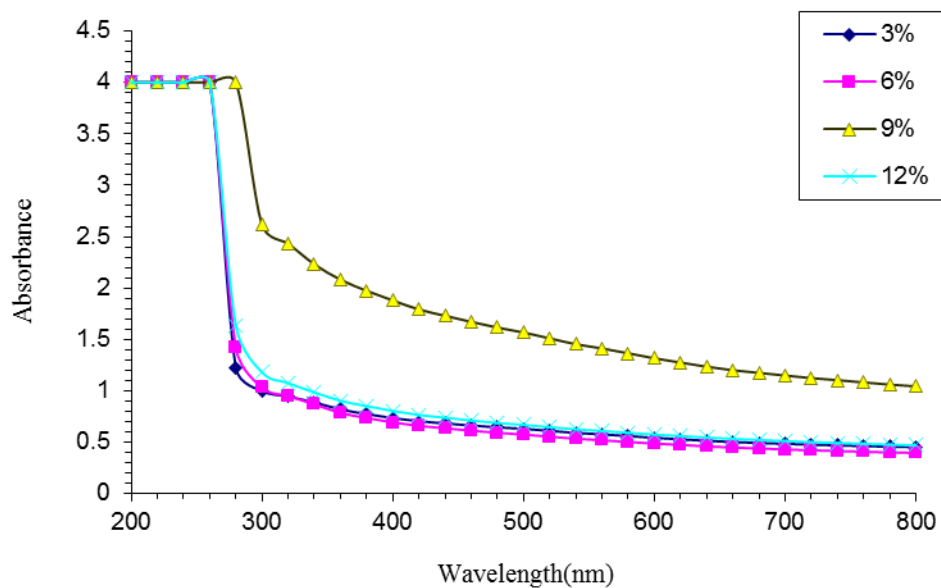Xin S., Guo C., and Bing L. 1999, Chinese Chemical Letters, 11. 961-964 .

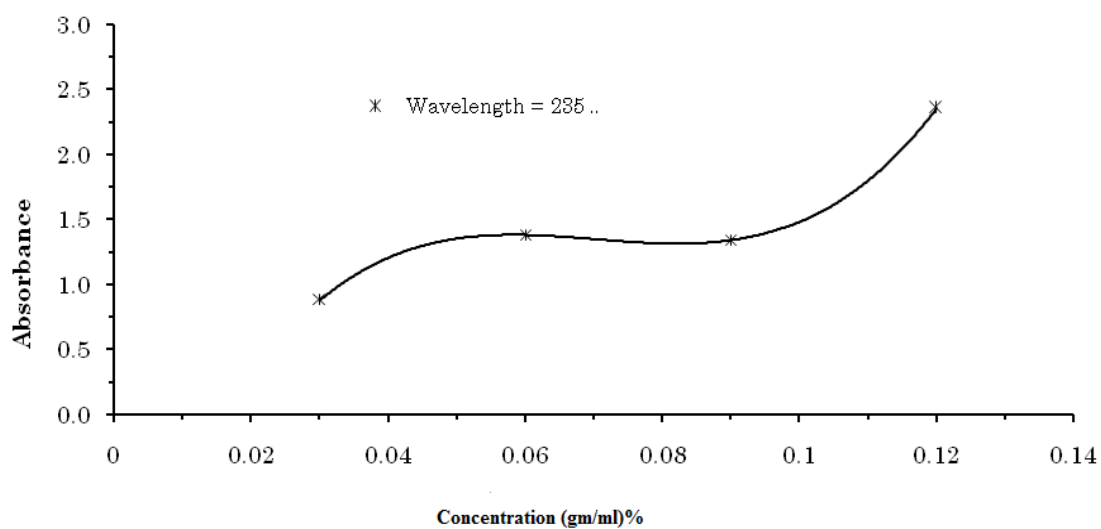**Fig. 1.UV/Vis spectra of polystyrene – Cd(NO$_3$)$_2$.4H$_2$O Composites**

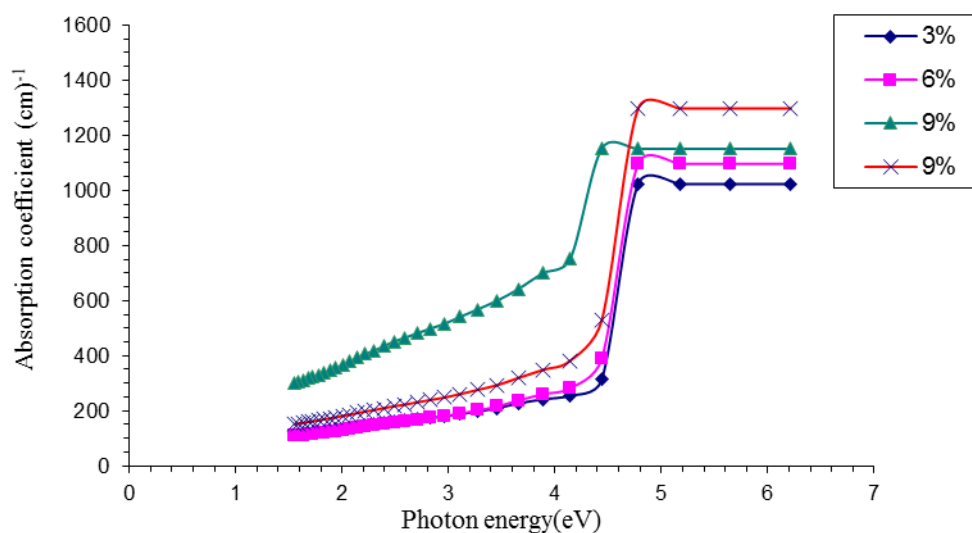**Fig. 2. The absorbance as a function of concentration of Ps – Cd(NO$_3$)$_2$.4H$_2$O**

Fig. 3. The absorption coefficient for Ps – Cd(NO₃)₂.4H₂O composites as a function of photon energy
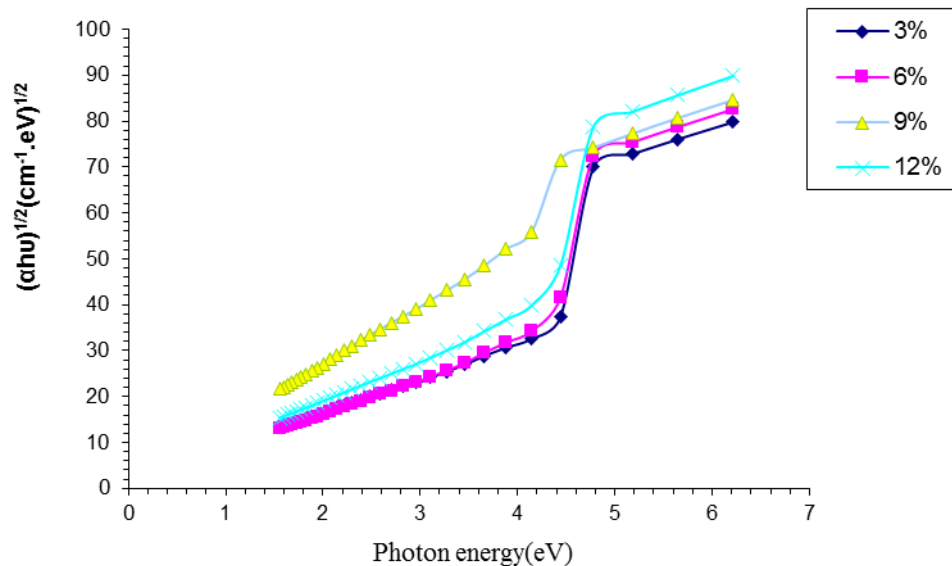

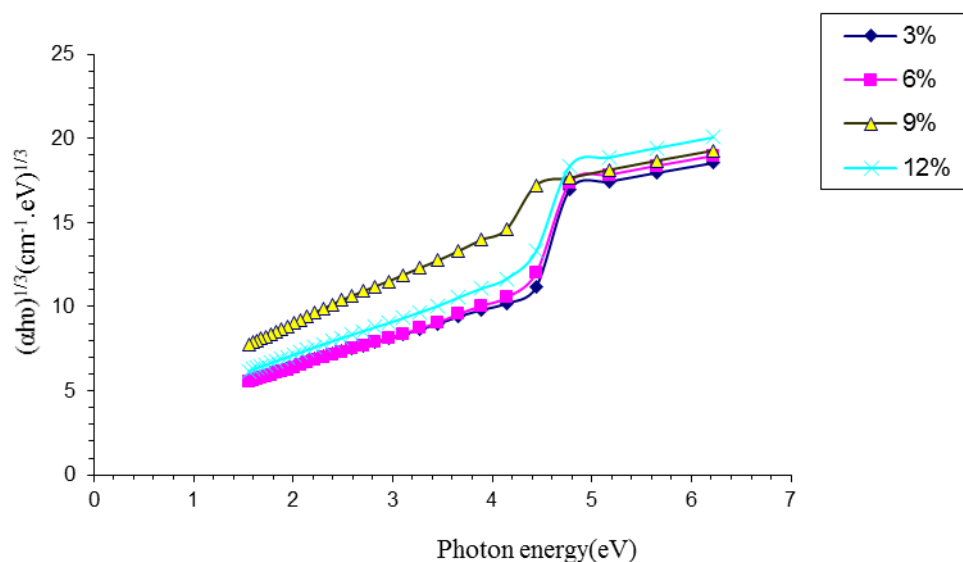**Fig. 4. Plot of (αhυ)^{1/2}. hυ of Ps – Cd(NO₃)₂.4H₂O composites as a function of photon energy**

Fig. 5. Plot of $(\alpha h\upsilon)^{1/3}$. $h\upsilon$ of Ps – Cd(NO$_3$)$_2$.4H$_2$O composites as a function of photon energy
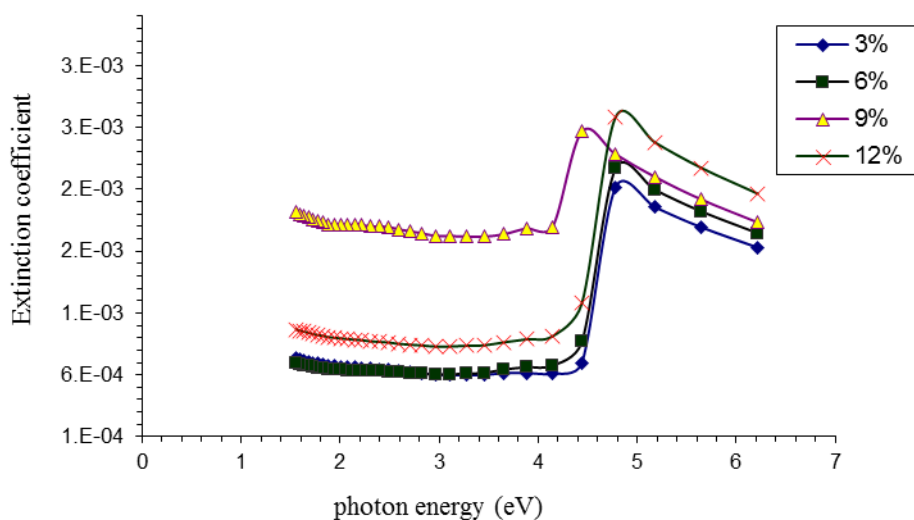
Fig. 6. The extinction coefficient of Ps – Cd(NO$_3$)$_2$.4H$_2$O composites as a function of photon energy
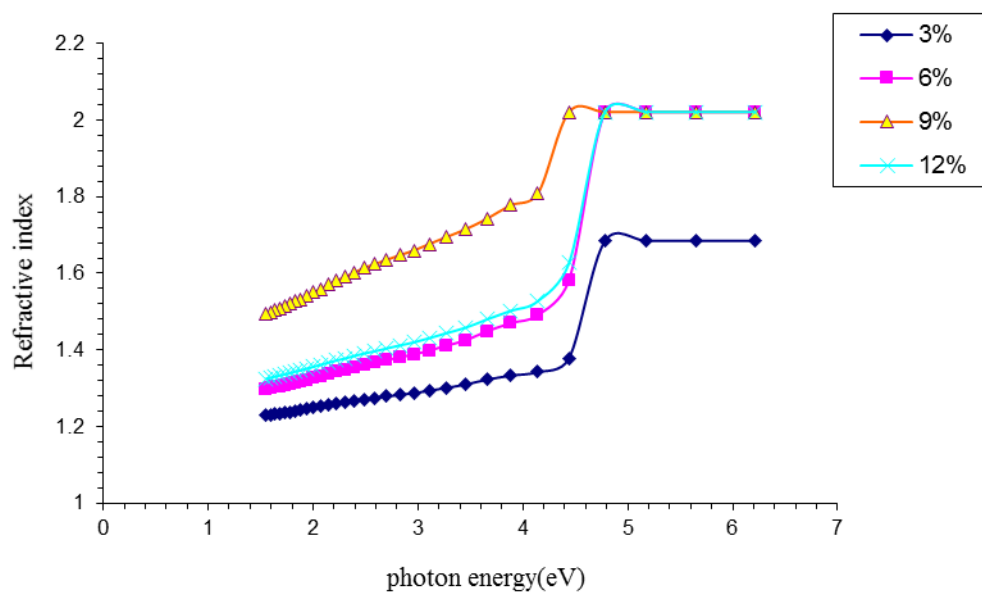
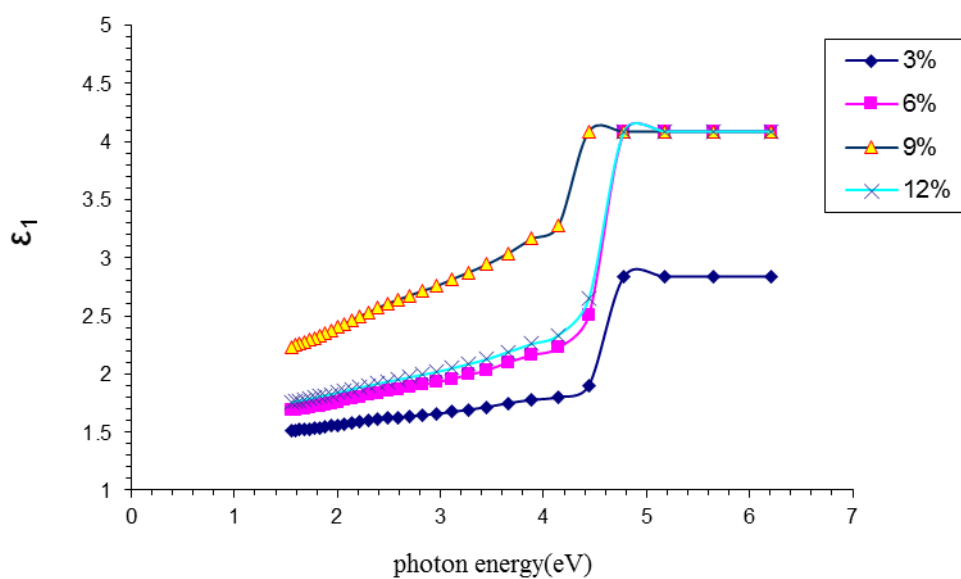**Fig. 7. The refractive index of Ps – Cd(NO$_3$)$_2$.4H$_2$O composites as a function of photon energy**

Fig. 8. The real part of dielectric constant of Ps – Cd(NO$_3$)$_2$.4H$_2$O composites as a function of photon energy