Characterization of (PMMA-CoCl$_2$) Composites

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Abstract

In this paper, study the of effect cobalt chloride on optical properties of poly (methyl methacrylate). The samples of composites were prepared using casting method with different concentrations of cobalt chloride (0,1,2,3) wt.%. The optical properties have been studied in the wavelength range (200-800)nm. The results show that the optical properties (absorption coefficient, energy gap) and optical constants (refractive index, extinction coefficient and dielectric constants) change with increase of the cobalt chloride concentration.

Key words; composites**,** PMMA**,** cobalt chloride, optical properties.

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الخلاصة

في هذا البحث تم دراسة تاثير كلوريد الكوبلت على الخواص البصرية لبولي مثيل ميثاكريلايت. نماذج المتراكبات حضرت باستعمال طريقة الصب وبتراكيز مختلفة من كلوريد الكوبلت.wt.% (0,1,2,3). الخواص البصرية درست ضمن مدى طول موجي (200− 800)nm. بينت النتائج ان الخواص البصرية (معامل الامتصاص، فجوة الطاقة) والثوابت البصرية(معامل الخمود، معامل الانكسار وثوابت العزل الكهربائي) تتغير مع زيادة تركيز كلوريد الكوبلت.

الكلمات المفتاحية: متراكبات، بولي مثيل ميثاكريلايت، الخواص البصرية

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1.Introduction

Nowadays polymers play a very important role in numerous fields of everyday life due to their advantages over conventional materials (e.g. wood, clay, metals) such as lightness, resistance to corrosion, ease of processing, and low cost production. Besides, polymers are easy to handle and have many degrees of freedom for controlling their properties. Further improvement of their performance, including composite fabrication, still remains under intensive investigation. The altering and enhancement of the polymer's properties can occur through doping with various nano-fillers such as metals, semiconductors, organic and inorganic particles and fibres, as well as carbon structures and ceramics [Glushanin *et.al*, 2006, Hine *et. al*, 2005, Cioffi, *et. al* , 2005 and Pelaiz *et al*, 2005]. Such additives are used in polymers for a variety of reasons, for example: improved processing, density control, optical effects, thermal conductivity, control of the thermal expansion, electrical properties that enable charge dissipation or electromagnetic interference shielding, magnetic properties, flame resistance, and improved mechanical properties, such as hardness, elasticity, and tear resistance [Huang *et al*, 2003, Jordan *et al*, 2005 and Gerard, 2001].

The optical constants are very important because they describe the optical behavior of the materials. The absorption coefficient of the material is very strong function of photon energy and band gap energy [Pelaiz *et al*, 2005]. Absorptance (A) is defined as the ratio between absorbed light intensity (I_A) by material and the incident intensity of light (I_o) [Nahida and Marwa, 2011].

$$A = I_A / I_o \qquad \dots\dots (1)$$

Transmittance (T) is given by reference to the intensity of the rays transmitting from the film(I) to the intensity of the incident rays on it (Io)(T=I/ I_o), and can be calculated by[Huang *et al*, 2003]:

$$T = \exp(-2.303A) \ldots\ldots\ldots (2)$$

And Reflectance (R) can be obtained from absorption and transmission spectra in accordance with the law of conservation of energy by the relation[Jordan *et al*, 2005]:

$$R + T + A = 1 \quad \ldots\ldots\ldots\ldots (3)$$

Absorption coefficient (α) is defined as the ability of a material to absorb the light of a given wavelength

$$\alpha = 2.303A/t \quad \ldots\ldots\ldots (4)$$

t: the sample thickness in cm. The relation between the absorption coefficient, α, and the incident photon energy, hν, can be written as[Pelaiz *et al*, 2005] :

$$(\alpha h\nu)^n = B(h\nu - E_g) \quad \ldots\ldots(5)$$

The Refractive index (n), the index of refraction of a material is the ratio of the velocity of the light in vacuum to that of the specimen [Gerard, 2001].

$$n = (1+R^{1/2})/(1-R^{1/2}) \quad \ldots\ldots\ldots (6)$$

The extinction coefficient (k) was calculated using the following equation [Nahida and Marwa, 2011]:

$$k = \alpha\lambda/4\pi \quad \ldots\ldots\ldots\ldots (7)$$

Dielectric constant is defined as the response of the material toward the incident electromagnetic field. The dielectric constant of compound (ε) is divided into two parts real (ε_1) and imaginary (ε_2).The real and imaginary parts of dielectric constant can be calculated by using equations [Nahida and Marwa, 2011]

$$\varepsilon_1 = n^2 - k^2 \text{ (real part)} \quad \ldots\ldots (8)$$

$$\varepsilon_2 = 2nk \text{ (imaginary part)} \ldots\ldots (9)$$

2.Experimental Part

poly (methyl methacrylate) solution was prepared by dissolving it in chloroform by using magnetic stirrer in mixing process to get homogeneous. The weight percentages of $CoCl_2$ are (0,2,4 and 6) wt.% were added and mixed for 10 minutes to get more homogenous solution. Casting Method was applied by using Petri dish that leaved to dry at room temperature for three days. The dried film was then removed easily by using tweezers clamp. Absorption spectrum was recorded in the range (200-800) nm.

3.Results and Discussion

3.1 The absorbance of (PMMA-CoCl$_2$) composites

Fig. (1) shows the spectrum of group of composite with different concentrations of cobalt chloride, it is found that the absorbance tends to decrease with the wavelength increasing , quantity of impurities and the lowest absorbance is the visible, IR region while the highest is shifted to a lower wavelength at higher impurities quantity, such a change of the light absorbance may be cause by the structure change in the composite. The increase of absorbance of composite with increasing the cobalt chloride attributed to high absorbance of cobalt chloride compared with the absorbance of polymer [Ahmad *et al*, 2007].

Fig.1 The optical absorbance of PMMA-CoCl$_2$ composite with wavelength
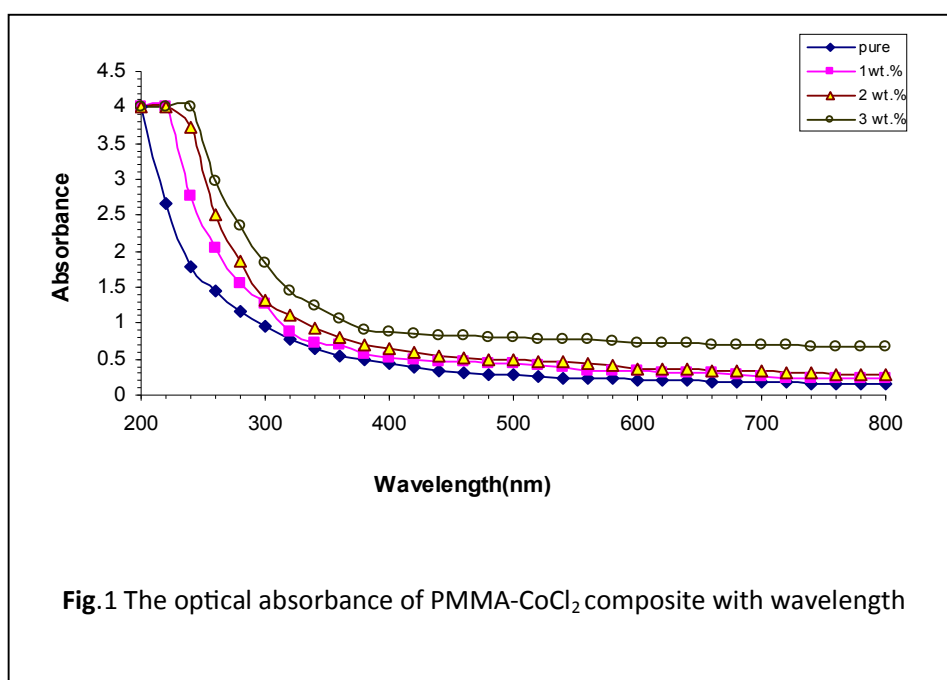
3.2 The Absorption coefficient and energy gap of (PMMA-CoCl$_2$) composites

Fig. (2) shows the absorption coefficient for the (PMMA-CoCl$_2$) composites with different concentrations of cobalt chloride. The values of the absorption coefficient of (PMMA-CoCl$_2$) composites are less than $10^4 cm^{-1}$ in the investigation spectral range. The fundamental absorption, which corresponds to electron excitation from the valence band to conduction band, can be used to determine the nature and value of the optical band gap, *Eg* which calculated by using Eq. 5. as shown in figures (3) and (4).

From these figures we can see the energy band gap of (PMMA-CoCl$_2$) composites is decrease with increasing the cobalt chloride concentrations which attributed to decrease the distance between the valance band and conduction band[10].
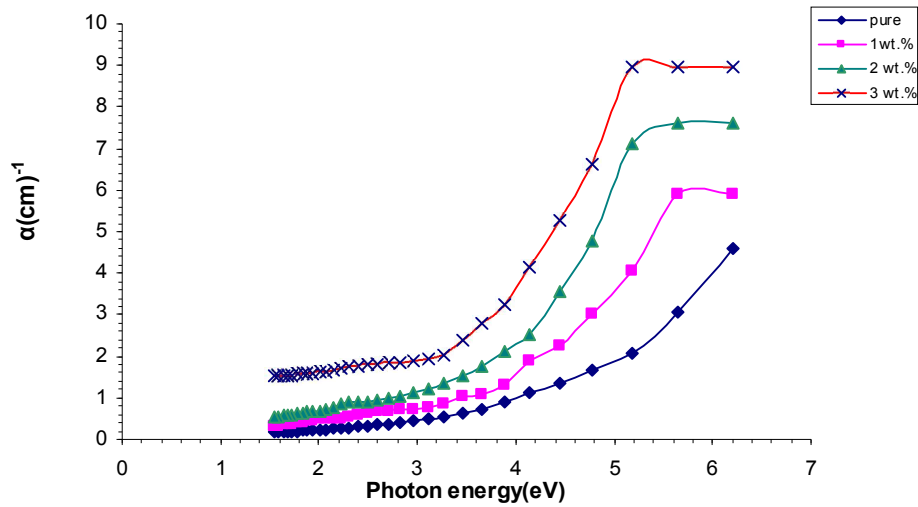
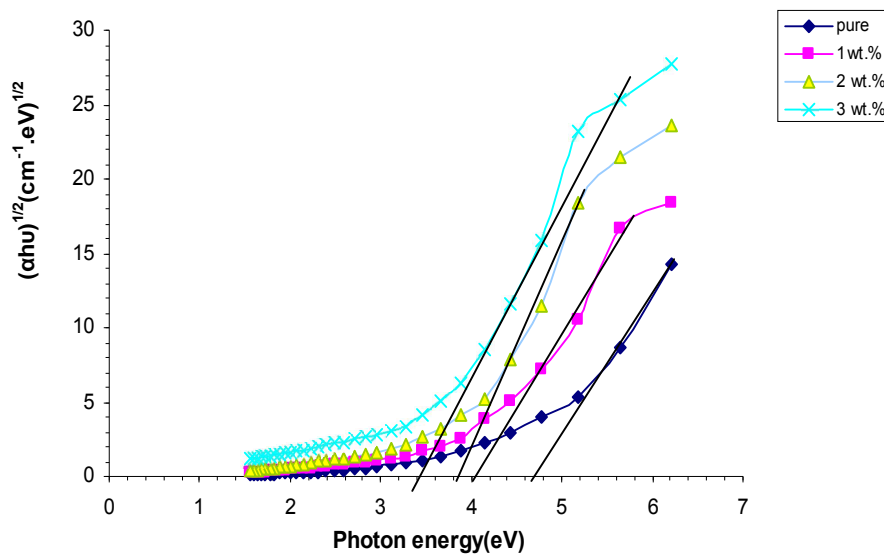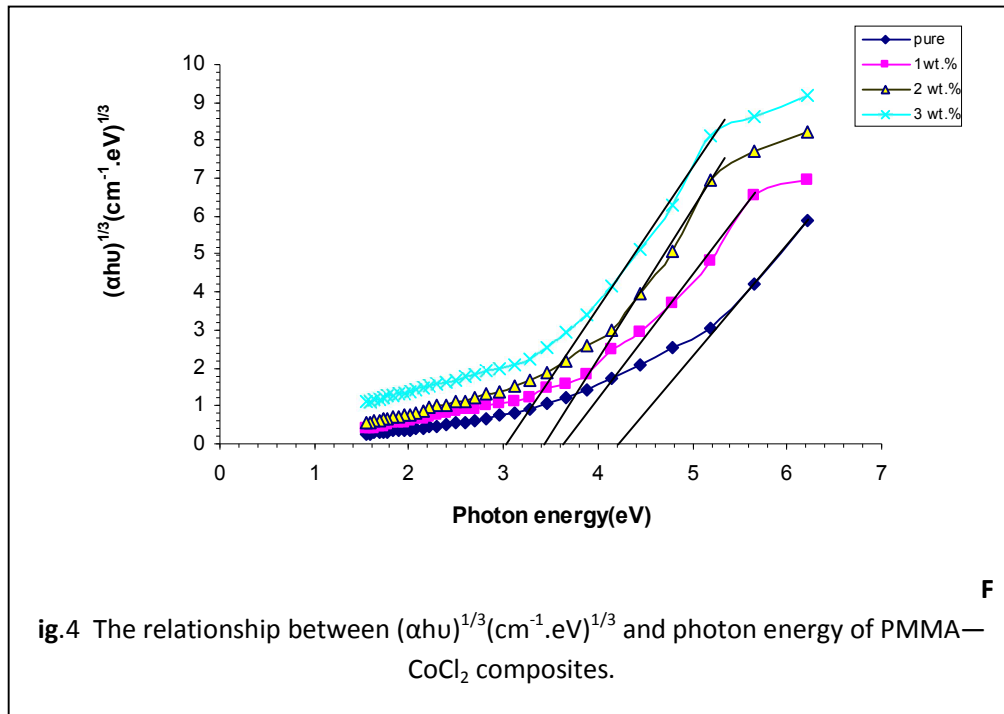**Fig**.2 The absorption coefficient of PMMA-CoCl$_2$ with photon energy

Fig.3 The relationship between $(\alpha h\upsilon)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of   PMMA—CoCl$_2$ composites

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ig.4 The relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of PMMA—
CoCl$_2$ composites.

3.3 Refractive Index and Extinction Coefficient of (PMMA-CoCl$_2$)composites

Figures (5) and (6) show the variation of refractive index (n) and extinction coefficient (k) of the (PMMA-CoCl$_2$) composite with photon energy. The values of refractive index increased exponentially with increasing photon energy . This increase indicates that the electromagnetic radiation passing through the material is faster in the low photon energy. Also, the values of refractive index (n) and extinction coefficient (k) are increasing with increase the concentration of cobalt chloride in which attributed to increase the density of composite[Ahmad *et al*, 2007].
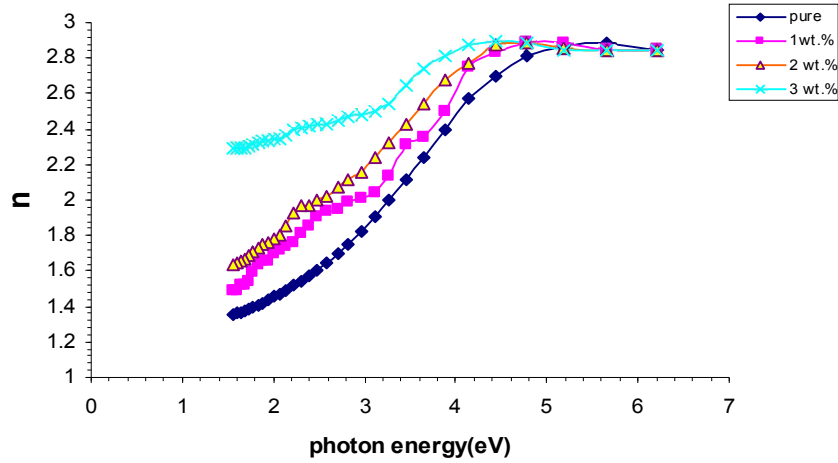
Fig.5 The relationship between refractive index of PMMA-CoCl$_2$ with photon energy
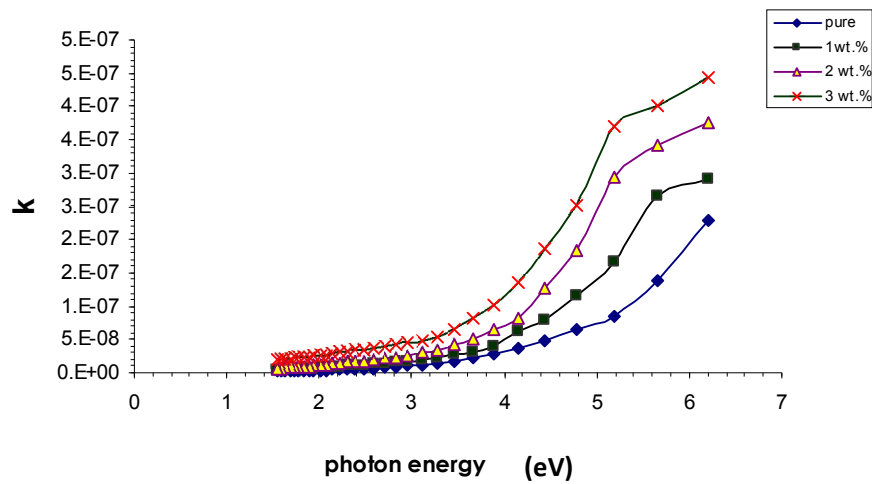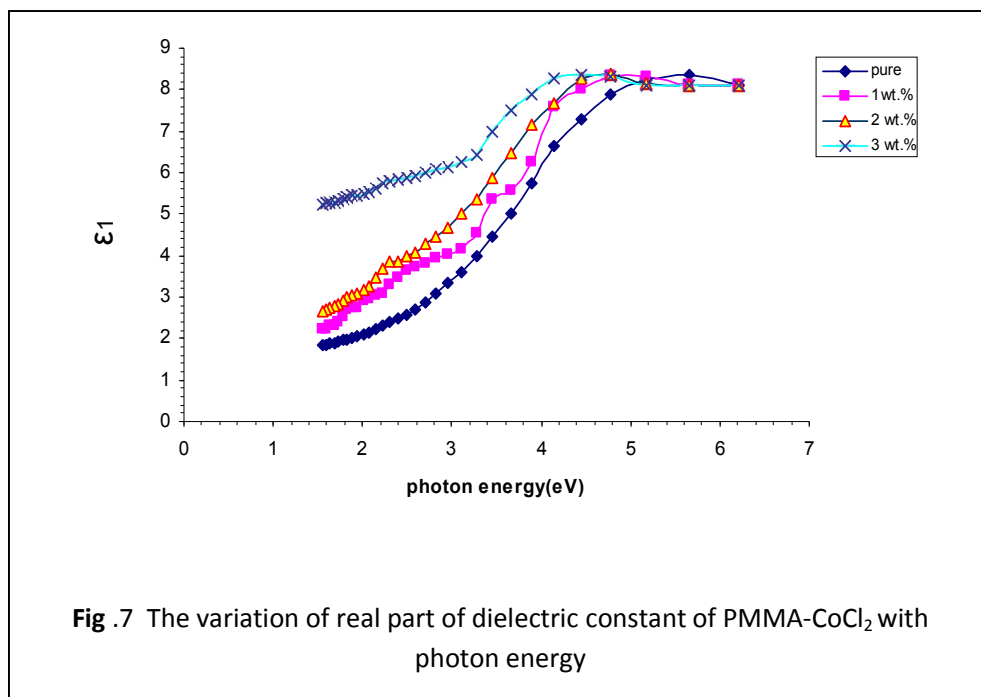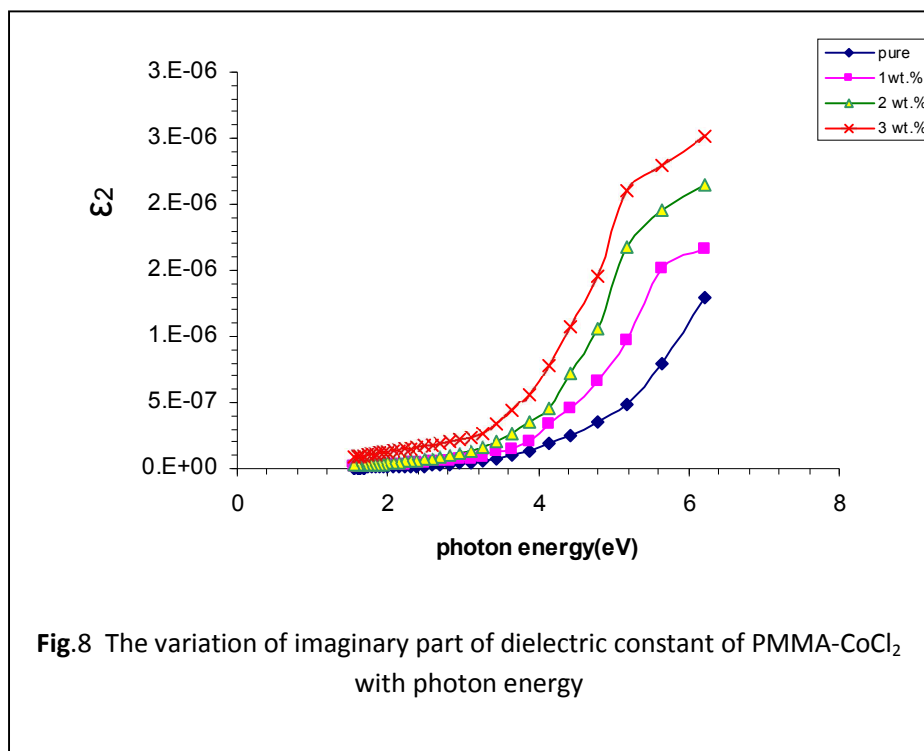

Fig.6 **The variation extinction coefficient of PMMA-CoCl$_2$ with variation of photon energy**

3.4 Dielectric Constant of (PMMA-CoCl$_2$)composites

The calculation of real part and imaginary part of the dielectric constant provide information about the loss factor. Figures (7) and (8) show the variation of real and imaginary parts of dielectric constants (ε_1 =n^2-k^{2}and ε_2=2nk) of composites .It is concluded that the variation of ε_1 mainly depends on (n^2) because of small values of (k^2), while ε_2 mainly depends on the (k) values which are related to the variation of absorption coefficients[9]. 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 and the imaginary part shows how a dielectric absorbs energy from an electric field due to dipole motion [RTINTU *et al*, 2010].

Fig .7 The variation of real part of dielectric constant of PMMA-CoCl$_2$ with photon energy

Fig.8 The variation of imaginary part of dielectric constant of PMMA-CoCl$_2$ with photon energy

4. Conclusions

• The absorbance of (PMMA-CoCl$_2$) composites is very large in the UV, region. The absorption coefficient is smaller and stable in the low photon energy and its increased with increase the weight percentages of cobalt chloride.

• The absorption coefficient and extinction coefficient are increasing as a result of the scattering centers in the (PMMA-CoCl$_2$) composites. The values of the refractive index(n) of the(PMMA-CoCl$_2$) composites increases with increasing the photon energy. Also, the absorption coefficient and extinction coefficient are increased with increase the weight percentages of cobalt chloride.

• The energy band gap of (PMMA-CoCl$_2$) composites decreased with increase the weight percentages of cobalt chloride.

• The real and imaginary dielectric constants are increasing with increase the weight percentages of cobalt chloride.

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