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Effect of Potassium Chloride on Physical and Optical Properties of Polystyrene

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Abstract
Composite materials are used in many industries such: solar cells, optoelectronic device elements, light emitting diodes, aircraft, military and car industry. In this paper, effect of potassium chloride on physical and optical properties of polystyrene has been studied to use the new material in many applications. The physical properties showed that the absorption of composite to water increases with increase time of the submerging in the water. Also, diffusion coefficient increases with increase the potassium chloride concentrations. The optical properties was measured in wavelength range from 200nm to 800nm. The experimental results showed that absorbance of polystyrene increases with increase the potassium chloride concentrations. The optical constants (absorption coefficient, energy band gap, extinction coefficient, refractive index and real and imaginary parts of dielectric constants) are increasing with increase the potassium chloride concentrations.
Keywords: optical properties, composites, physical properties, potassium chloride.

تاثير كلوريد البوتاسيوم على الخواص الفيزيائية والبصرية للبولي ستايرين
مجيد علي حبيب ، بهاء حسين صالح، احمد هاشم
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الخلاصة:
المواد المتراكبة تستخدم في كثير من الصناعات مثل الخلايا الشمسية، عناصر الاجهزة الاكترونية، والدايودات الباعثة للضوء وفي صناعة الطائرات والسيارات. في هذا البحث، درس تاثير كلوريد البوتاسيوم على الخواص الفيزيائية والبصرية للبولي ستايرين الاستخدام المادة الجديدة في كثير من التطبيقات. الخواص الفيزيائية بينت ان امتصاص المتراكبات للماء يزداد مع زيادة زمن الغطس. كذلك معامل الانتشار يزداد مع زيادة تراكيز كلوريد البوتاسيوم. الخواص البصرية قيست ضمن طول موجي من 200nm الى 800nm . النتائج العملية بينت ان الامتصاصية للبولي ستايرين تزداد مع زيادة تراكيز كلوريد البوتاسيوم. الثوابت البصرية (معامل الامتصاص، فجوة الطاقة، معامل الخمود، معامل الانكسار وثابت العزل الحقيقي والخيالي) تزداد مع زيادة تراكيز كلوريد البوتاسيوم.
المفاتيح: الخواص البصرية،المتراكبات، الخواص الفيزيائية، كلوريد البوتاسيوم

Introduction

In recent years, polymers with different optical properties have been attracted much attentions due to their applications in the sensors, light-emitting diodes, and others. The optical properties of these materials can be easily tuned by controlling contents of the different concentrations [1]. Polystyrene is one of the most widely used kinds of plastics. Polystyrene is a thermoplastic made from the aromatic monomer styrene as its basic unit. It is a transparent glass-like substance which does not dissolve in acids, bases, or alcohol, but dissolve in aromatic hydrocarbons, benzene, and esters. Its melting point is 239^{o}C, glass transition temperature is 100^{o}C, density is 1.05g/cm^3 and its random crystallization [2,3] . The studies on optical properties of polymers have attracted much attention in view of their application in electronic and optical devices. The optical properties are studied to achieve better reflection, antireflection, interference and polarization properties[4].

Materials and Method

Polystyrene and potassium chloride used as received, the experiment was carried out at room temperature. Different weight percentages of polystyrene and potassium chloride (the weight percentages of potassium chloride are 0, 2, 4 and 6 wt.%) are dissolved completely in 30ml of chloroform distilled under constant stirring for 1hour. To cast the film, the mixture 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.

Results and Discussion

The absorption spectra of the pure polystyrene and polystyrene with different concentrations of potassium chloride are shown in figure(1).

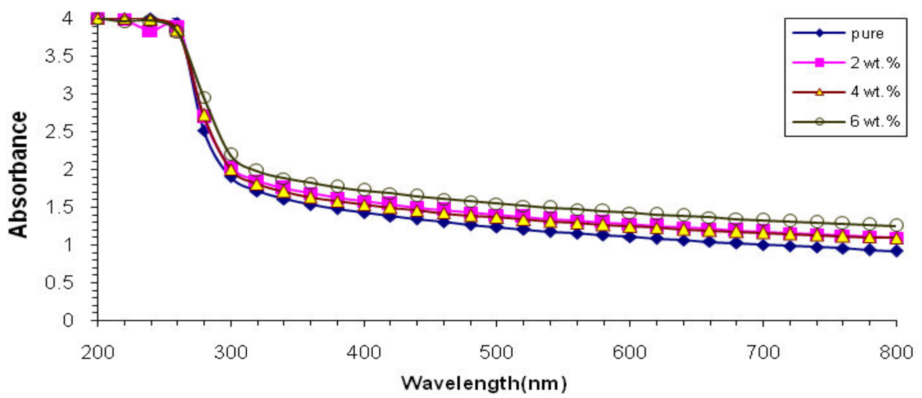

FIG.1
The variation of optical absorbance for (PS-KCl) composite with wavelength

It is clear from Fig. 1 that the absorption is increase, this related to high absorbance of potassium chloride compared with the absorbance of polystyrene.

Fig.2 The variation of absorption coefficient of (PS-KCl) composite with photon energy of different concentrations of potassium chloride is shown in figure (2). The absorption coefficient (α) depends on optical absorbance (A) and thickness of film (d) which is evaluated using the relation [1]:

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

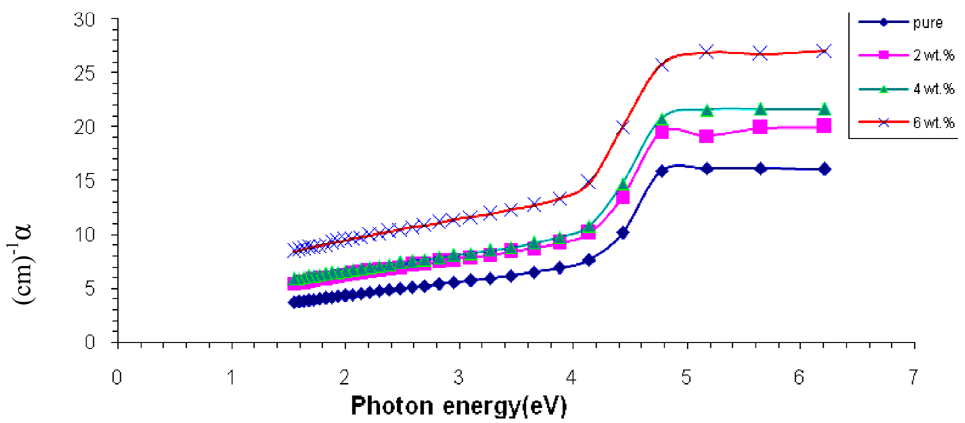

FIG. 2
The variation of absorption coefficient of (PS-KCl) composite with photon energy

The optical energy gap (E_g) of the films has been calculated by following Eq:

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

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 results, we can see the energy band gap is decrease with increasing the potassium chloride concentration. The decrease in band gap with increase in concentration of potassium chloride can be due to the decrease in cluster size of the parent solution. [5] as shown in figures (3a.and 3b.).

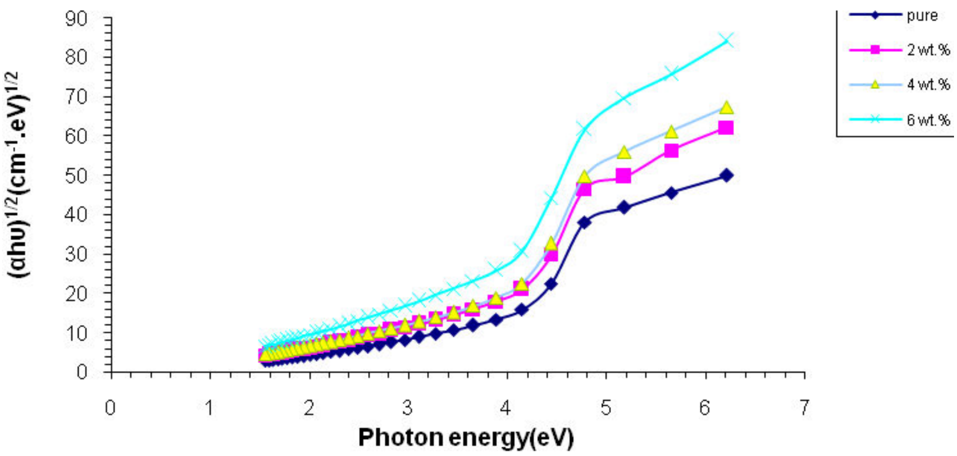

FIG.3
The relationship between $(\alpha h\upsilon)^{1/2}(cm\text{-}1.eV)^{1/2}$ and photon energy of PS-KCl composites.

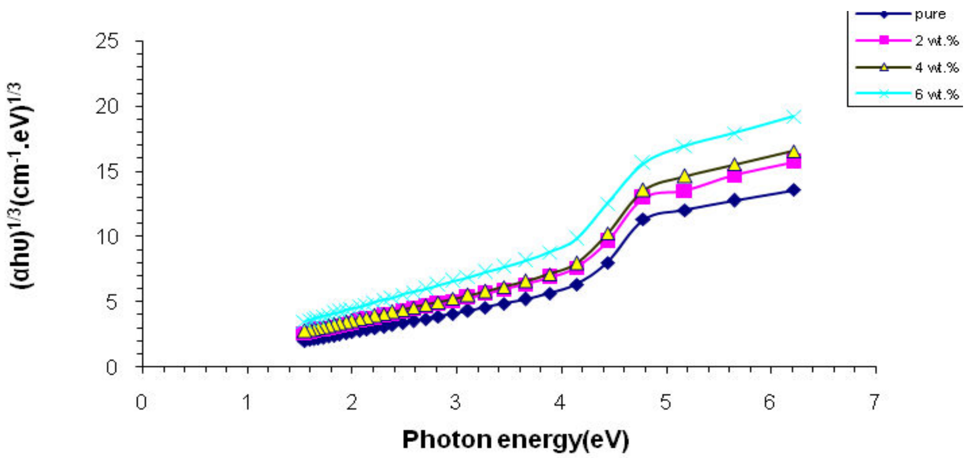

FIG.4
the relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of PS-KCl composites.

Fig.4 The variation of extinction coefficient(k) of (PS-KCl) composite with wavelength is shown in figure(4). The extinction coefficient is related to the absorption coefficient α can be calculated by using the relation[6]:

$$K = \alpha\lambda / 4\pi \qquad (3)$$

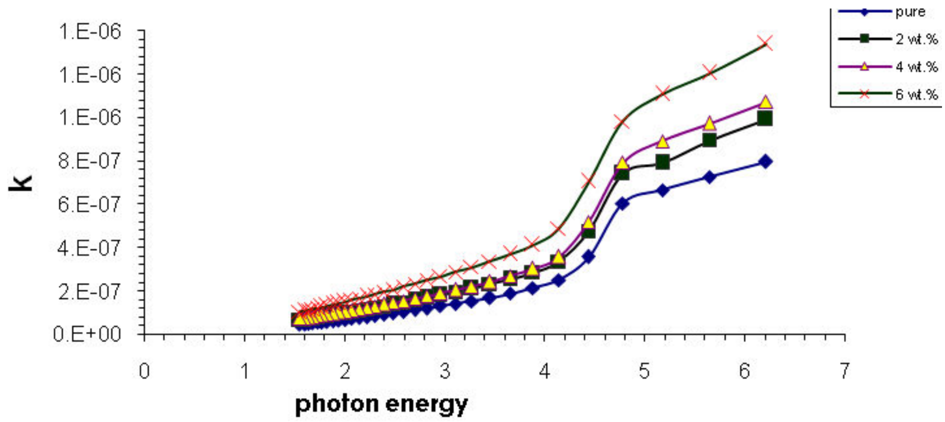

FIG.5
The extinction coefficient for (PS-KCl) composite with various photon energy

Fig. 5 shows the variation of refractive index as a function of wavelength. The reflection can be determined from the reflection coefficient data R and the extinction coefficient k using equation [7]:

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

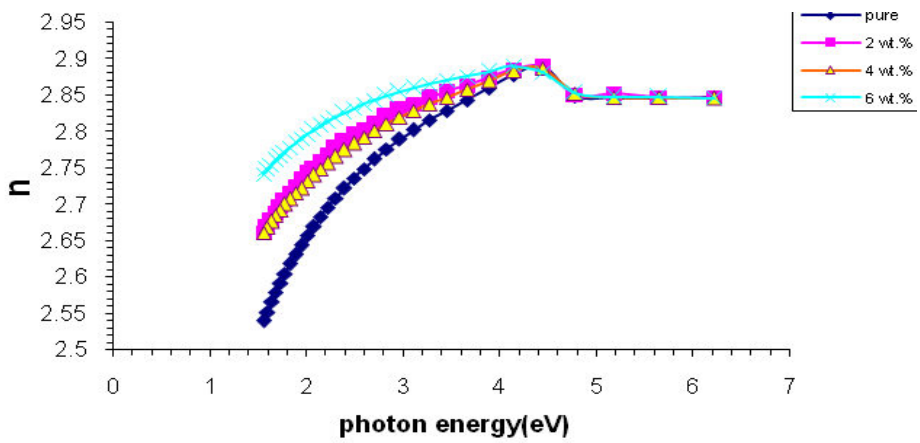

FIG.6
The relationship between refractive index for (PS-KCl) composite with photon energy

The decrease in the extinction coefficient with an decrease in photon energy shows that the fraction of light lost due to scattering[7].

The real part of the dielectric constant can be calculated by using the relation[8]:

$$\varepsilon_1 = n^2 - k^2 \text{..........}(5)$$

and imaginary part of the dielectric constant can be calculated by using the relation[8]:

$$\varepsilon_2 = 2nk \text{ ....}(6)$$

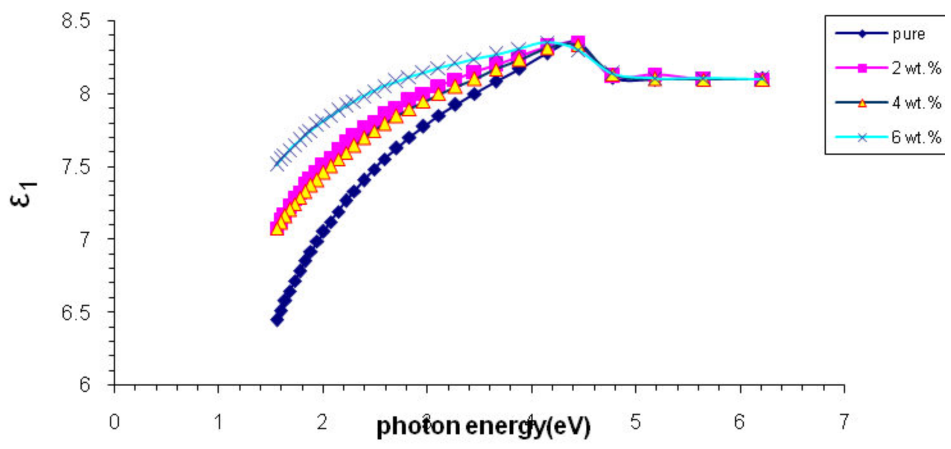

FIG.7
The variation of real part of dielectric constant (PS-KCl) composite with photon energy

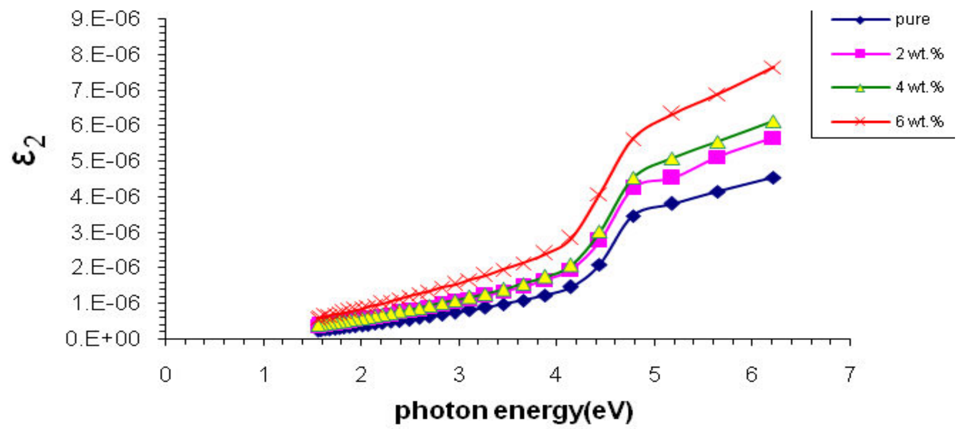

FIG.8
The variation of imaginary part of dielectric constant(PS-KCl) composite with photon energy

The real part is associated with the term that shows how much it will slow down the speed of light in the material. 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 [8].

Figure(9) shows the variation of weight again with time of different concentration of potassium chloride. From the figure, we can see the weight again is increased with increasing the time, this due to amorphous structure and random crystallization of polystyrene with consisting of spaces between the molecules, thus the water pass through these holes. The increase of salt concentration will decrease the weight again which attribute to decrease the holes in amorphous polymers, thus the diffusion coefficient ($D = \pi \left[\frac{Kb}{4 M \infty} \right]^2$ where M∞ is the big value of weight gain, k is weight gain and b is thickness of sample) will be decrease as shown in figure (10) [9].

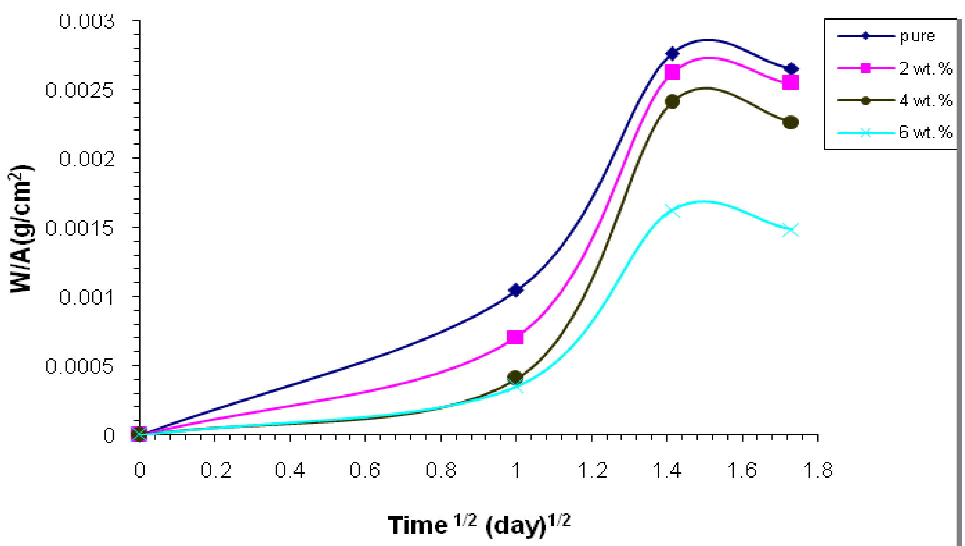

FIG. 9
Variation of wight gain with the time

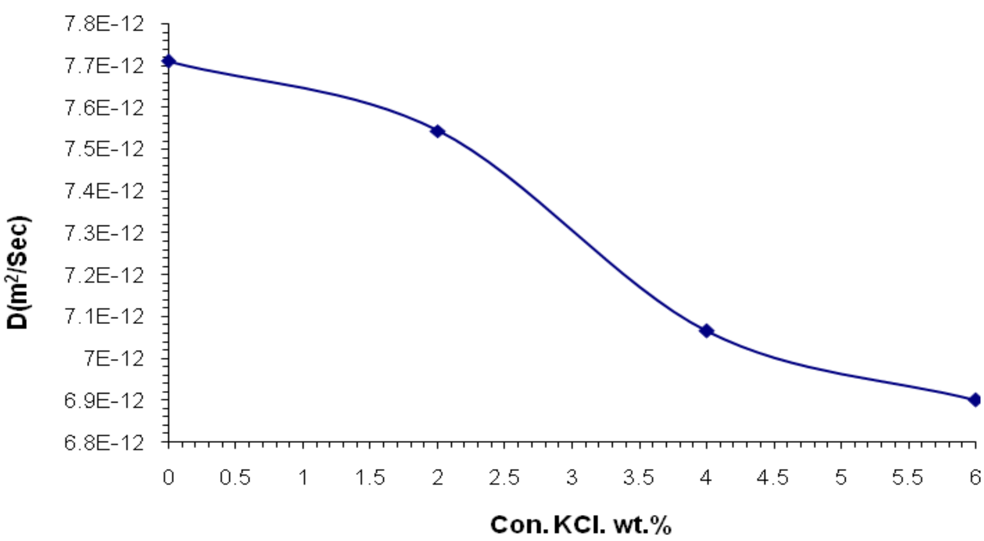

FIG.10
The effect of zinc concentration on the diffusion coefficient of polystyrene

Conclusions

1. The absorbance is increased with increase the concentration of potassium chloride.
2. The absorption coefficient, extinction coefficient, refractive index and real and imaginary parts of dielectric constants are increasing with increase the weight percentages of potassium chloride.
3. The weight gain and diffusion coefficient are decreasing with increase the concentration of potassium chloride.

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