Study Of Effect Of Titanium Oxide On Some Optical Properties Of Polystyrene

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Abstract

The effect of addition titanium oxide on some optical properties of polystyrene has been studied . The samples has been prepared with different weight percentages of TiO_2 are(0,40,60)wt.% and different thickness .The absorption and transmission spectra has been recorded in the wavelength range (300-1100)nm . The absorption coefficient and energy gap of the indirect allowed and forbidden transition have been determined .

الخلاصة

درس تأثير إضافة اوكسيد التيتانيوم على بعض الخواص البصرية للبولي ستايرين. ولهذا الغرض تم تحضير نماذج بإضافة اوكسيد التيتانيوم إلى البولي ستايرين وبنسب وزنية مختلفة%wt.(0,40,60) من اوكسيد التيتانيوم مع البوليمر وبسماك مختلفة.تم تسجيل طيفي الامتصاص و النفاذية و لمدى الاطوال الموجية nm(٣٠٠-١١٠٠). وقد حسب معامل الامتصاص و فجوة الطاقة للانتقالات غير المباشرة المسموحة و الممنوعة.

Introduction

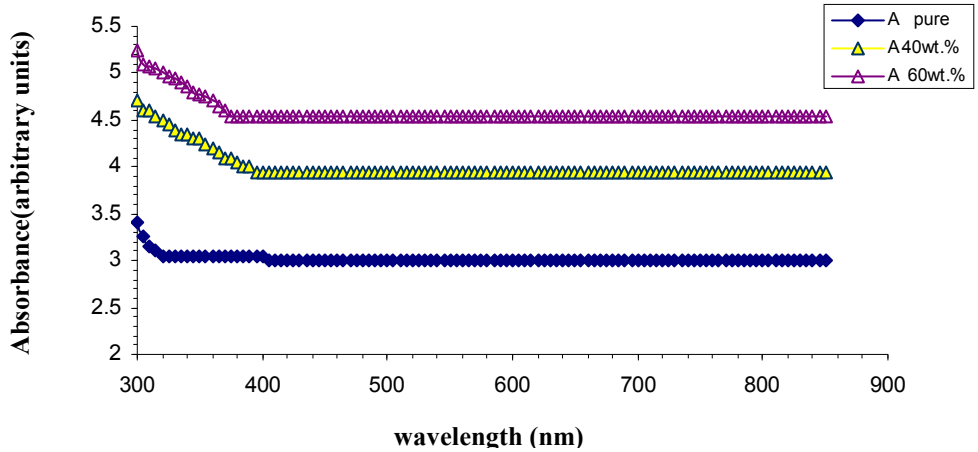
The main two types of optical transitions are direct and indirect transitions, both involve the interaction of an electromagnetic wave with the electron in valence band which may cross the forbidden gap to the conduction band [Mott N., 1971]. Indirect transitions are possible only by phonon assisted transition. The value and shape of the mobility gap in the amorphous semiconductors depend on the preparation condition such as substrate temperature, annealing temperature, degree of impurity and defect of the material. Any variation in such parameters leads to a shift in the absorption edge towards higher or lower energy [Tauc J. ,1974]. In general the interaction of electromagnetic radiation (light) with matter is controlled by three properties, the specific conductivity, the electric conductive capacity and the magnetic inductive capacity. These properties are related to the refractive index and the absorption index of the medium. All material bodies possess a number of critical frequencies at which radiation is in resonance with some internal variation of the body. At these critical frequencies such bodies are strong absorbs of radiation, even if they are transparent to radiation on either side of the critical frequency. Among the optical properties reaction, reflection and scattering of light are the most important [Majdi K. *et.al*.,1997]. Polymeric substances make up the most important class of organic materials, technically and economically. The familiar plastics, fibers, clastomers and biological materials that surround us attest to this importance. Such substances, which are composed of great many identical groups or repeating units, are known as (high polymers). Polymers composed of more than one kind of repeating units are termed copolymers [A.H.Ahmed ,2007]. In order to fulfill the requirements of polymer industry many developers usually blend polymers together in order to reach anoptimun balance of properties. this approach allows high flexibility in proerty adjustment and avoids development of new macromolecules which is generally long and expensive compared to polymer alloying [A. Mohammed, 2007]. This paper deals with results of the effect of TiO_2 on the some optical properties of Polystyrene.

Experiment

The materials used in the paper is polystyrene as matrix and *titanium oxide* as a filler. The electronic balanced of accuracy 10^{-4} have been used to obtain a weight of TiO_2 powder and polymer powder . These mixed by Hand Lay up and the microscopic examination used to obtain homogenized mixture . The weight percentages of TiO_2 are (0 , 40 and 60) wt.%. The Hot Press method is used to press the powder mixture. The mixture of different TiO_2 percentages have been compacted at temperature 185^{o}C under a pressure 100 bar for 10 minutes . Its cooled to room temperature , the samples were disc shape of a diameter about 30mm and thickness ranged between (1.05-1.24) mm. The transmission & absorption spectra of PS- TiO_2 composites have been recording in the length range (300-1100) nm using double-beam spectrophotometer (UV-210^{o}A shimedza).

Results and Discussion

The optical absorbance as a function of the wavelength of the incident light for PS-TiO_2 composites of various filler contents is shown in figure (1) . The figure shows that the intensity of the peak increased as a result of filler addition but no shift in the peak position, i.e. adding different amounts of filler to pure polymer do not change the chemical structure of the material but new physical mixture is formed.



Figure(1): Optical Absorbance for PS composite with various TiO_2 concentration.

The absorption coefficient (α) was calculated in the fundamental absorption region from the equation[S. D. Hutagalwng and B. Y. Lee ,2007]:

$$\alpha = 2.303\frac{A}{d} \quad \text{.....(1)}$$

Where : A is absorbance and d is the thickness of sample.

Figure (1) shows the relationship between the absorption coefficient and photon energy of the PS- TiO_2 composites we note the change in the absorption coefficient is small at low energies this is indicates the possibility of electronic transitions is a few. At high energy , the change of absorption coefficient is large this is indicates the large Probability of electronic transitions are the absorption edge of the region [S. M Scholz *et al*,2008].

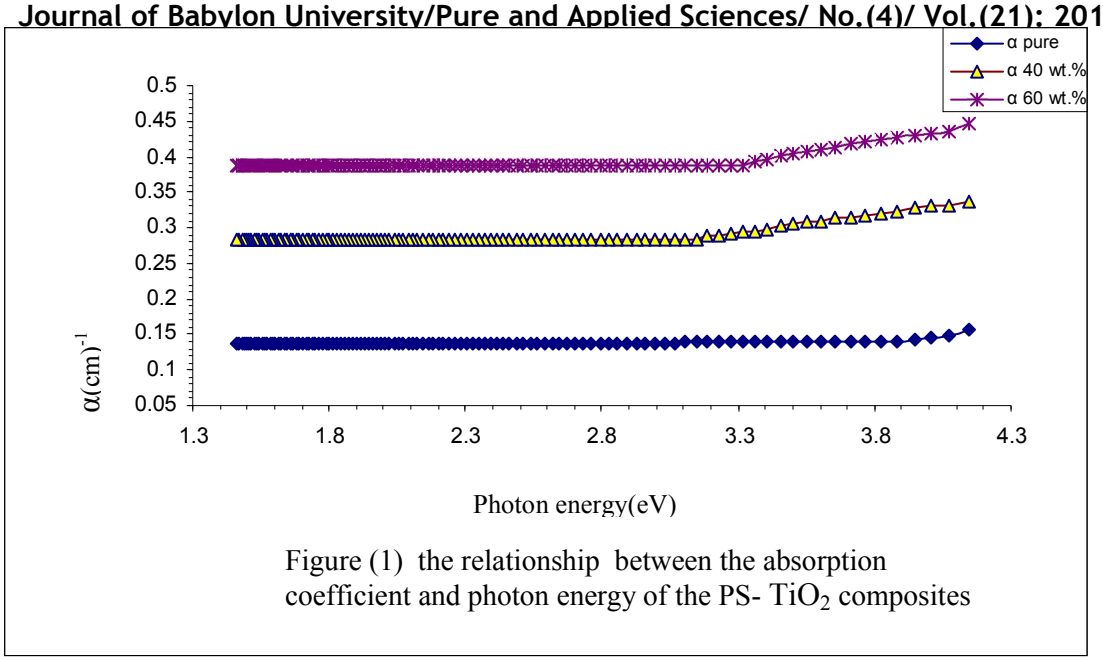


Figure (1) the relationship between the absorption coefficient and photon energy of the PS- TiO_2 composites

The absorption coefficient helps to conclude the nature of electronic transitions, when the high absorption coefficient values ($\alpha>10^4 cm^{-1}$) at high energies we expected direct electronic transitions ,and the energy and momentum preserve of the electron and photon , when the values of absorption coefficient is low($\alpha<10^4 cm^{-1}$) at low energies we expected indirect electronic transitions, the momentum of the electron and photon preserves by phonon helps[B.Thangaraju and P. Kalianna,2000]. The results showed that the values of absorption coefficient of the PS- TiO_2 composites less than $10^4 cm^{-1}$ which indicates to the indirect electronic transition. The forbidden energy gap of indirect transition both allowed, forbidden calculated according to the relationship[A. Kathalingam et.al. , 2007] :

$$\alpha h\nu = B(h\nu - E_g)^m \quad \text{.....(2)}$$

Where : hv is the energy of photon , B is proportionality constant, E_g is forbidden energy gap of the indirect transition. If the value of (m=2) indicates to allowed indirect transition . when the value (m=3) indicates to forbidden indirect transition. Figure (2) shows the relationship between $(\alpha h\nu)^{1/2}$ $(cm^{-1}.eV)^{1/2}$ and the photon energy of pure polymer (PS) , with take over part

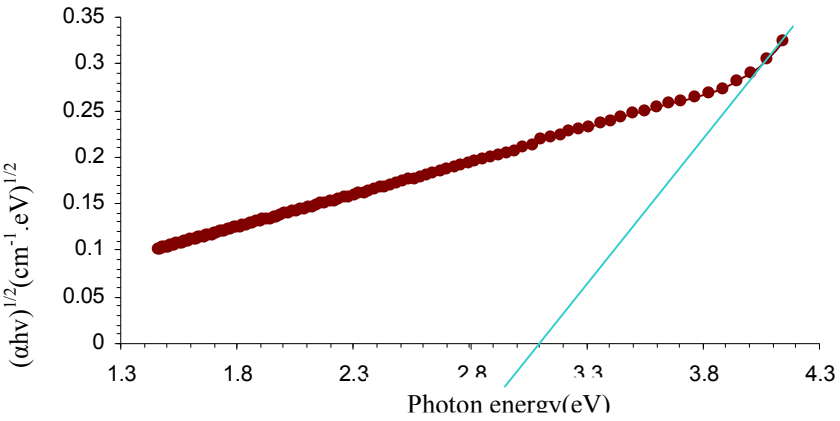


Figure (2) the relationship between $(\alpha h\nu)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of pure polymer (PS).

of the straight cut oriented axis at the point $(\alpha hv)^{1/2}=0$ will get the value of forbidden energy gap of the allowed indirect transition , which equal (3.1eV). Figure (3) and figure (4) represents the same relationship but to the polymer filled with (TiO_2) with volume percentages of TiO_2 are (40 , 60) wt.% , the same way we can be

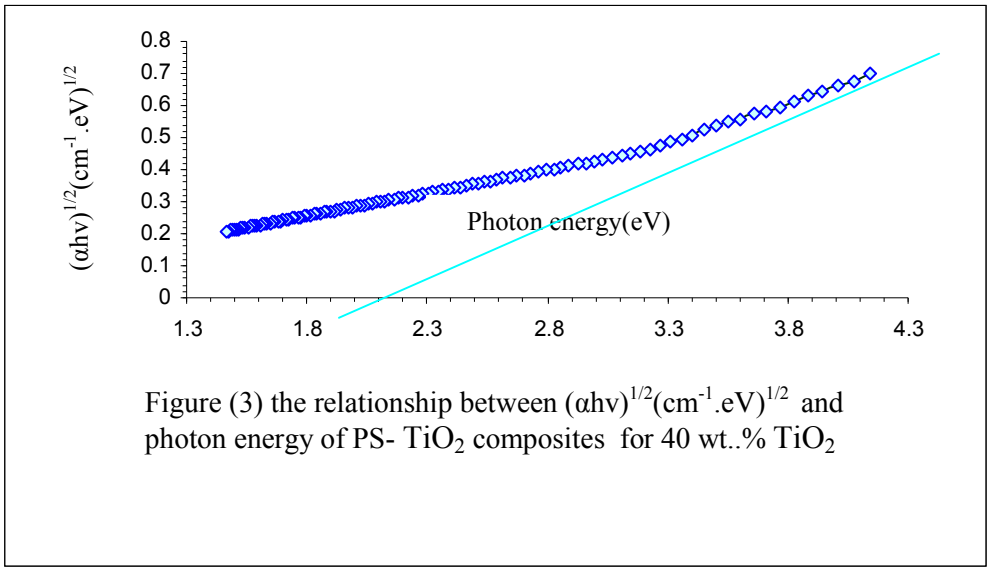


Figure (3) the relationship between $(\alpha hv)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of PS- TiO_2 composites for 40 wt..% TiO_2

obtained on the value of forbidden energy gap of allowed indirect transition which equal (2.1eV) for 20 wt.% TiO_2, and (1.82eV)for 50 wt.% TiO_2 . we note that the

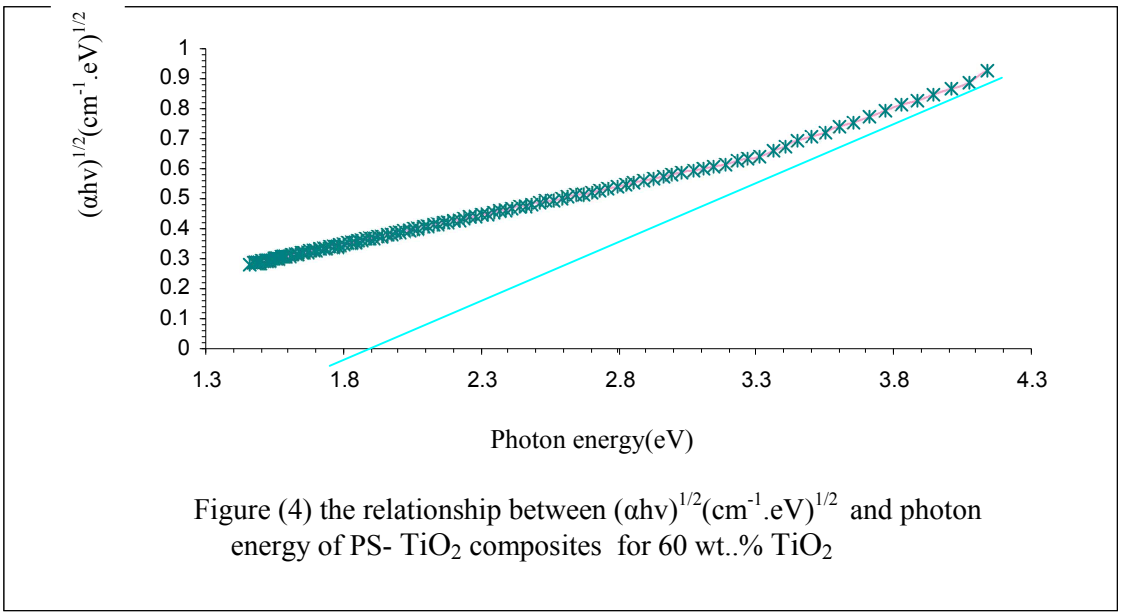


Figure (4) the relationship between $(\alpha hv)^{1/2}(cm^{-1}.eV)^{1/2}$ and photon energy of PS- TiO_2 composites for 60 wt..% TiO_2

value of the forbidden energy gap decreases with increasing TiO_2 concentration.. Figure(5) shows the relationship between the $(\alpha hv)^{1/3}$ $(cm^{-1}.eV)^{1/3}$ and photon energy of pure polymer (PS),the same way we obtain to the forbidden energy gap of

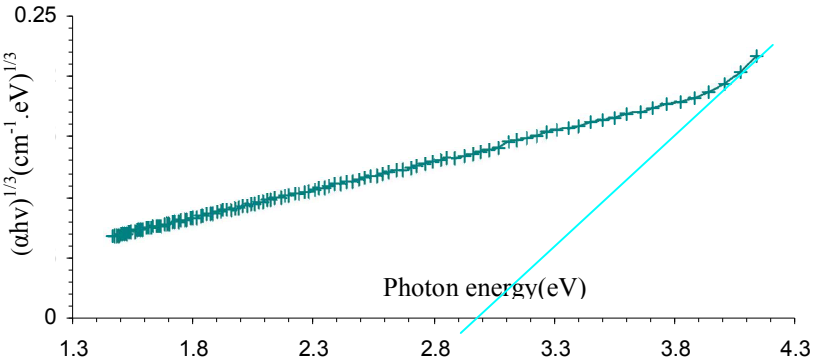


Figure (5) the relationship between $(\alpha hv)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of pure polymer (PS).

Indirect transition which equal (2.95eV) . Figure (6) and figure (7) represents the same relationship but to the polymer filled with (TiO_2) with volume percentages of TiO_2 are(40,60)wt.l%, the same way we can be obtained on the value of the forbidden

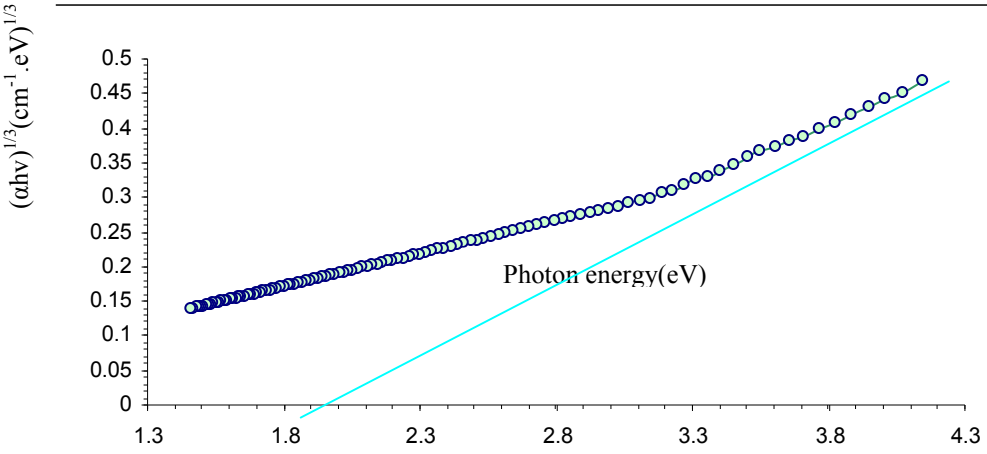


Figure (6) the relationship between $(\alpha hv)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of of PS- TiO_2 composites for 20 wt.% TiO_2

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forbidden energy gap of the forbidden indirect transition which equal (1.85eV) for 40 wt.% TiO_2, and (1.65eV) for 60 wt.% TiO_2 we note that the value of the energy

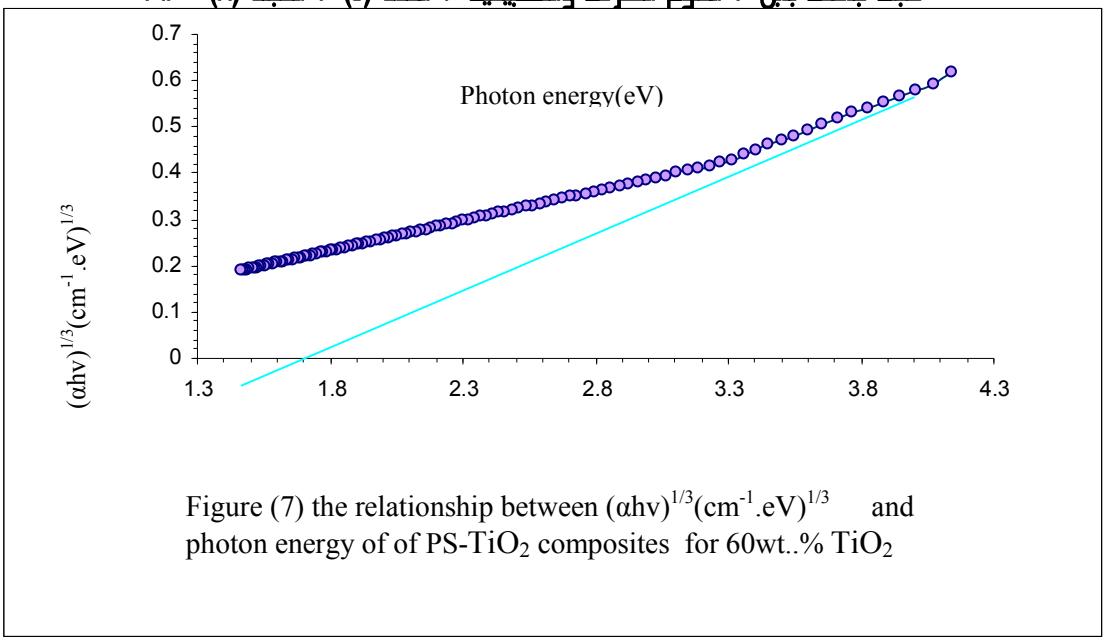

Figure (7) the relationship between $(\alpha hv)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of of PS-TiO_2 composites for 60wt..% TiO_2

gap decreases with increasing TiO_2 concentration[L. I. Soliman and W. Sayed,2002].

Figure(9) shows the variations of extinction coefficient ($k=\lambda\alpha/4\pi$) with wave length of pure and doped PS with TiO_2 . (k) shows an increase with increasing dopant concentration. The behavior of (k) can be ascribed to high absorption coefficient. This result indicates that the dopant atoms of TiO_2 will modify the structure of the host polymer. An interesting result is TiO_2 dopants increases the absorbance in the visible region[R.Ahmed,2008]

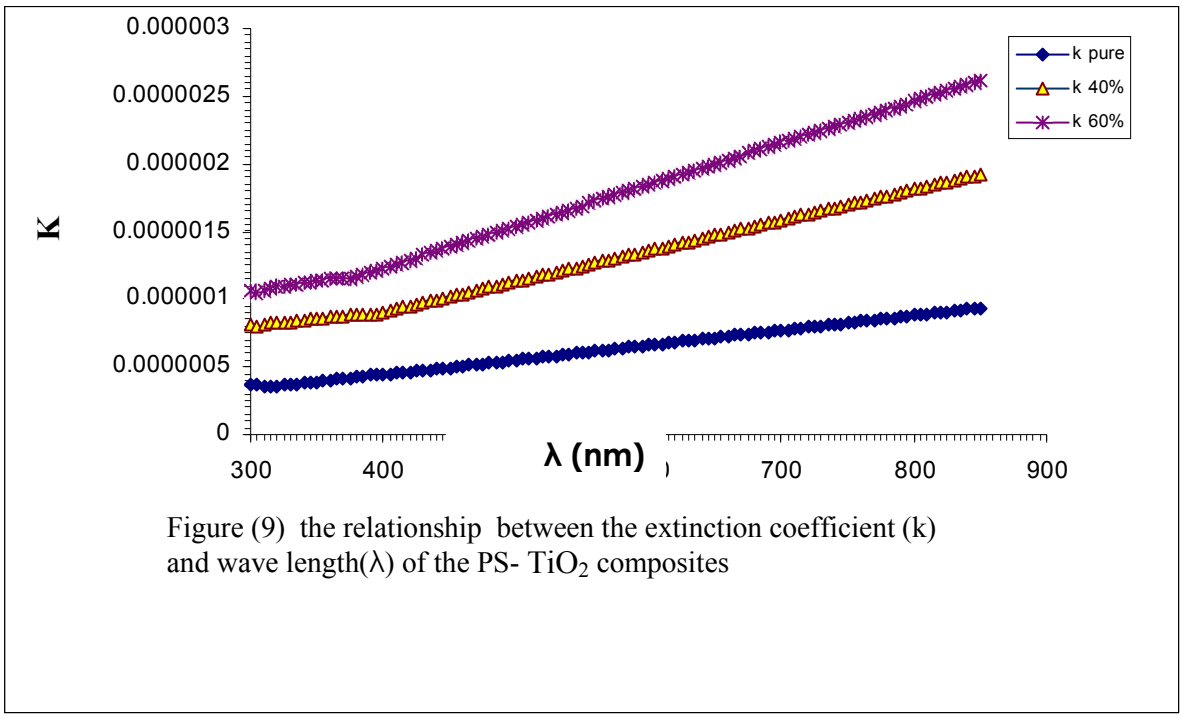

Figure (9) the relationship between the extinction coefficient (k) and wave length(λ) of the PS- TiO_2 composites

Conclusion

1. The absorption coefficient of polystyrene increases with increasing of titanium oxide concentrations.

2. The experimental results showed that the absorption coefficient of (PS-TiO_2) composites less than $10^4 cm^{-1}$ this is indicates to forbidden and allowed indirect electronic transitions.

3. The forbidden energy gap of polystyrene decreases with increasing of titanium oxide concentrations.
4. The extinction coefficient of polystyrene increases with increasing of titanium oxide concentrations.

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