Study of Some Physical Properties For(poly methyl methacrylate - TiO_2) composites

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Abstract

The effect of addition of TiO_2 on some optical properties of poly-methyl methacrylate has been studied . For this purpose , many samples have been prepared by adding TiO_2 to the poly-methyl methacrylate with different weight percentages and different thickness .The absorption and transmission spectra have been recorded at the wavelength ranges (300-850)nm . The absorption coefficient, extinction coefficient and energy gap of the indirect allowed and forbidden transition have been determined. Results show that the absorption coefficient and extinction coefficient increase and the energy gap of the indirect allowed and forbidden transition decreases with the wt.% content of TiO_2. .

الخلاصة

تم في هذا البحث دراسة تأثير إضافة TiO_2 على بعض الخواص البصرية للبولي مثيل ميثاكريلايت . اذ حضرت نماذج منه بإضافة TiO_2 إلى البولي مثيل ميثاكريلايت وبنسب وزنية مختلفة من البوليمر وباسماك مختلفة.تم تسجيل طيفي الامتصاص و النفاذية و لمدى الاطوال الموجيةnm(300-850). ثم حسب معامل الامتصاص و معامل الخمود و فجوة الطاقة للانتقال غير المباشر المسموح و الممنوع. بينت النتائج ان معامل الامتصاص ومعامل الخمود يزدادان وفجوة الطاقة للانتقال المباشر المسموح والممنوع تقل مع النسبة الوزنية ل TiO_2 .

Introduction

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) [1]. Polymers composed of more than one kind of repeating units are termed copolymers [1]. In order to fulfill the requirements of polymer industry many developers usually blend polymers together in order to reach an optimum balance of properties. this approach allows to adjust high flexibility in property and avoids development of new macromolecules which is generally long and expensive compared to polymer alloying [2].

In the recent years conjugated, the conducting polymers have been the main focus of research throughout the world . Since the discovery led by 2000 chemistry Nobel winners, Shirakawa, MacDiarmid and Heeger , the perception that plastic could not conduct electricity has changed Nowadays, conducting polymers also known as conductive plastics are being developed for many uses such as corrosion inhibitors, compact capacitors, antistatic coating, electromagnetic shielding and smart windows; which capable to vary the amount of light to pass[3,4].Poly (methyl methacrylate) is one of the best organic optical materials, and has been widely used to make a variety of optical devices, such as optical lenses. It is known that its refractive index changes upon UV irradiation, either in the pure or doped state, which provides a means to fabricate structures, such as gratings or waveguides [5]. This paper deals the effect of TiO_2 on the some optical properties of poly-methyl methacrylate.

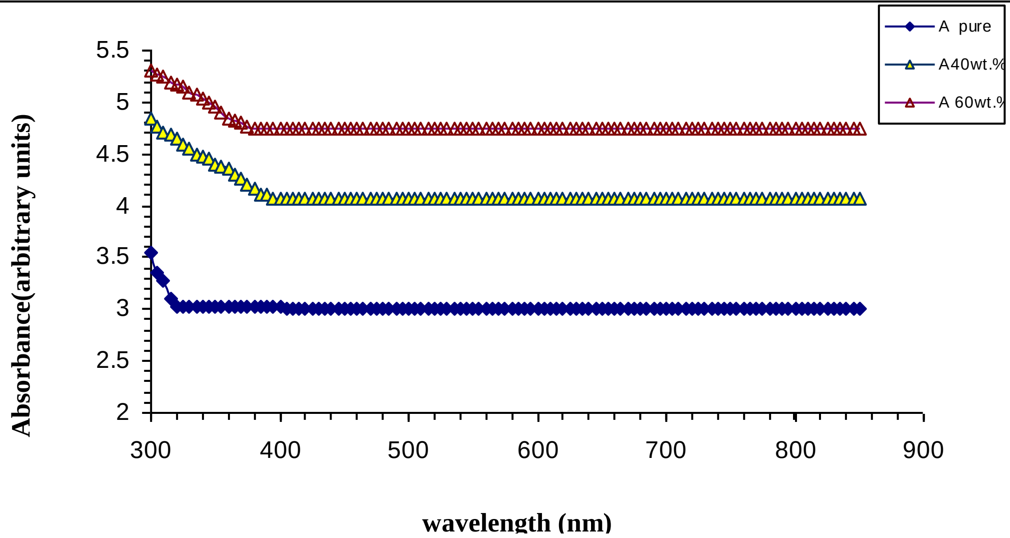
Experiment

The materials used is poly-methyl methacrylate as matrix and TiO_2 as a filler.

The electronic balance of accuracy 10^{-4} has been used to obtain a weight amount 1gm of TiO_2 powder and polymer powder . These were mixed by Hand Lay up and the Microscopic Examination used to obtain homogenized mixture . The weight percentages are (0 ,40, 60) wt%. The Hot Press method is used to press the powder mixture. The mixture of different TiO_2 percentages has been compacted at 165^oC under a pressure 100 bar for 10 minutes . It was cooled to room temperature , the samples were disc of shape of a diameter about 15mm and thickness ranged between (2.3-4.1)mm. The transmission and absorption spectra of PMMA-TiO_2 composites have been recorded in the length range (300-850) 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 PMMA-TiO_2 composites of various filler contents is shown in figure (1) . The figure shows that the absorptance increases as a result of filler addition but no shift in the peak position, i.e. adding different amounts of filler to pure polymer does not change the chemical structure of the material but new physical mixture is formed. The value of absorptance is constant after 320,360,400nm respectively.



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

The absorption coefficient (α) was calculated in the fundamental absorption region from the following equation[6]:

$$\alpha = 2.303\frac{A}{d} \qquad (1)$$

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

Figure (2) shows the relationship between the absorption coefficient and photon energy of the PMMA-TiO_2 composites, we note that the change in the absorption coefficient is small at low energies this indicates the possibility of electronic transitions is a few. At high energy , the change of absorption coefficient is large, this

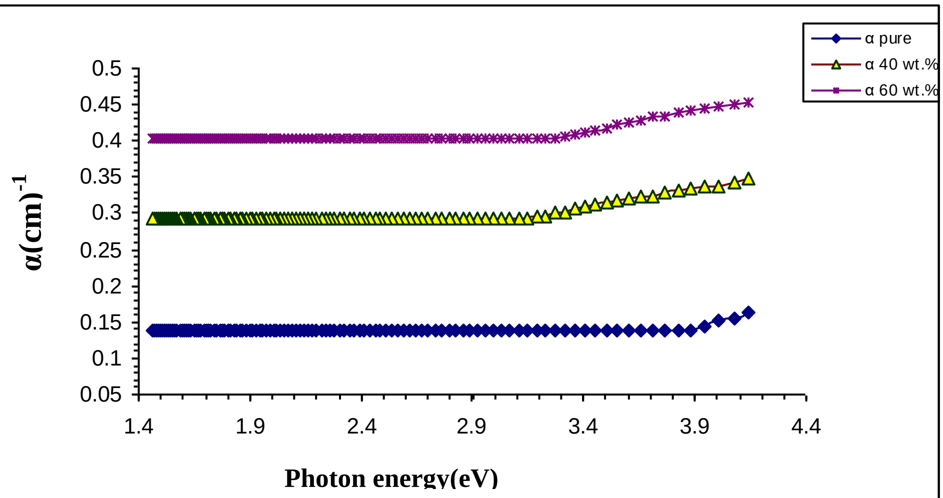


Figure (2) the relation ship between the absorption coefficient and photon energy of the PMMA- TiO_2 composites

indicates the large, probability of electronic transitions are the absorption edge of the region [7]. The absorption coefficient helps to know 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 in this case an indirect electronic transitions, the momentum of the electron and photon preserves by phonon helps[8]. The results showed that the values of absorption coefficient of the PMMA-TiO_2 composites less than $10^4 cm^{-1}$ which indicates the indirect electronic transition. The forbidden energy gap of indirect transition both allowed, and forbidden is calculated according to the relationship[9] :

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

Where : hυ is the energy of photon , A is proportionality constant, Eg is forbidden energy gap of the indirect transition.
If the value of (m=2) this indicates an allowed indirect transition . When the value of (m=3), this indicates forbidden indirect transition. Figure (3) shows the relationship between $(\alpha h\nu)^{1/2}$ and the photon energy of pure polymer(PMMA), which take the

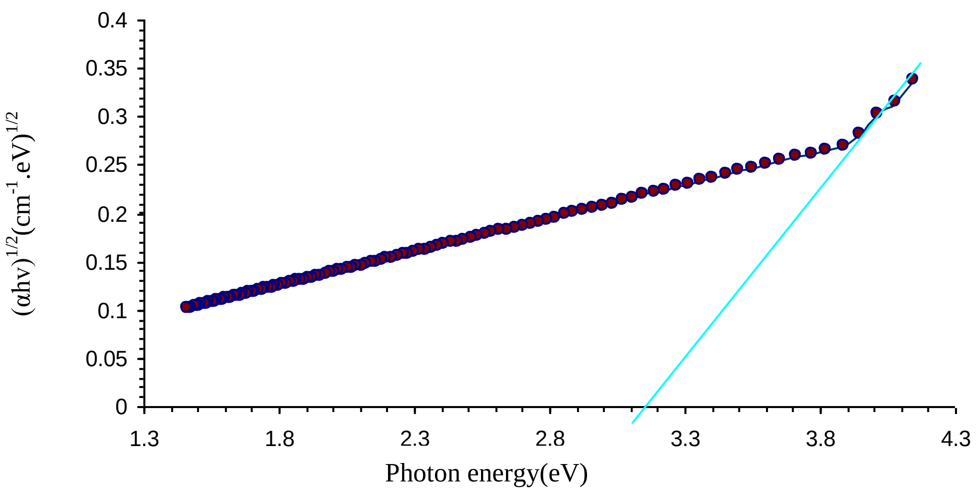


Figure (3) the relation ship between $(\alpha h\nu)^{1/2}$ and photon energy of pure polymer (PMMA).

value the straight line cut oriented axis at the point $(\alpha h\nu)^{1/2}=0$ will get the value of forbidden energy gap of the allowed indirect transition , which equal to (3.15eV). Figure (4) and figure(5) represents the same relationship but to the polymer filled with (TiO_2) at volume percentages (40,60) wt.%. We can be obtained the value of forbidden energy gap of allowed indirect transition in the same way which equals(1.8eV) for 40wt.% TiO_2, and (1.65eV) for 60wt.% TiO_2. We note that the

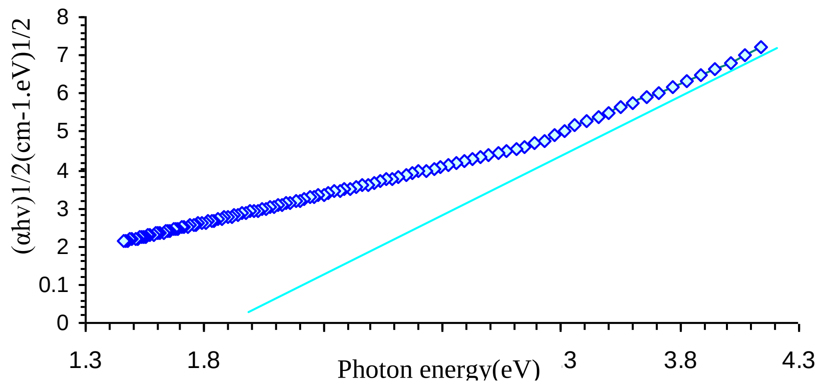


Figure (4) the relation ship between $(\alpha h\nu)^{1/2}$ and photon energy of PMMA- TiO_2 composites for 40wt.% LiF value of the forbidden energy gap decreases with increasing TiO_2 concentration.

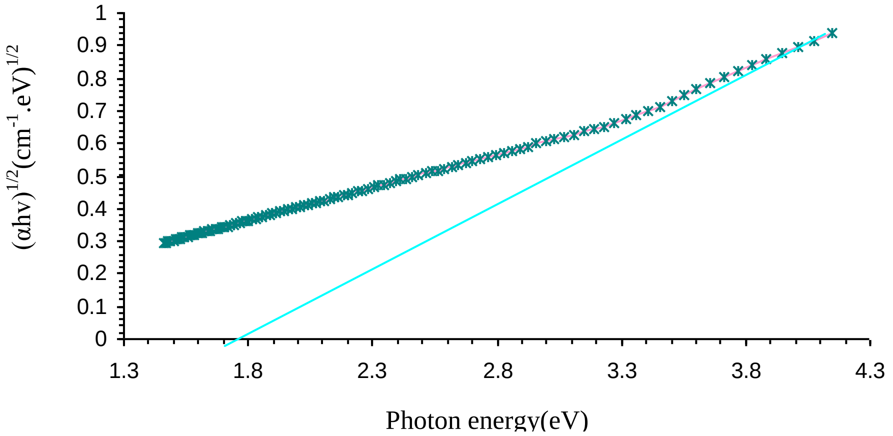


Figure (5) the relation ship between $(\alpha h\nu)^{1/2}$ and photon energy of PMMA- TiO_2composites for 60wt.% TiO_2

Figure(6) shows the relationship between the $(\alpha h\nu)^{1/3}$ and photon energy of pure polymer (PMMA). In the same way, we obtain the forbidden energy gap

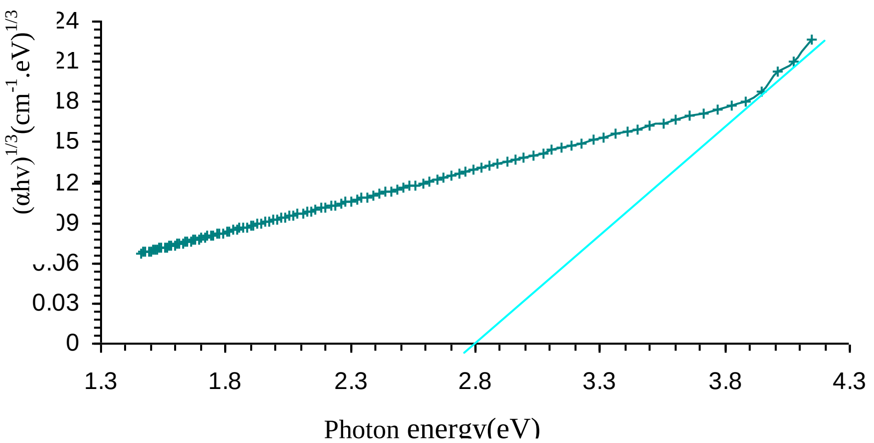


Figure (6) the relation ship between $(\alpha h\nu)^{1/3}$and photon energy of pure polymer (PMMA).

Indirect transition which equals (2.95eV) . Figure (7) and figure (8) represent the same relationship but of the polymer filled with(TiO_2) with volume percentages (40,60) wt.%. In the same way, we can be obtained the value
of the forbidden energy gap of the forbidden indirect transition which equal to (1.75eV) for 40wt.% TiO_2, and (1.55eV) for 60 wt.% TiO_2.

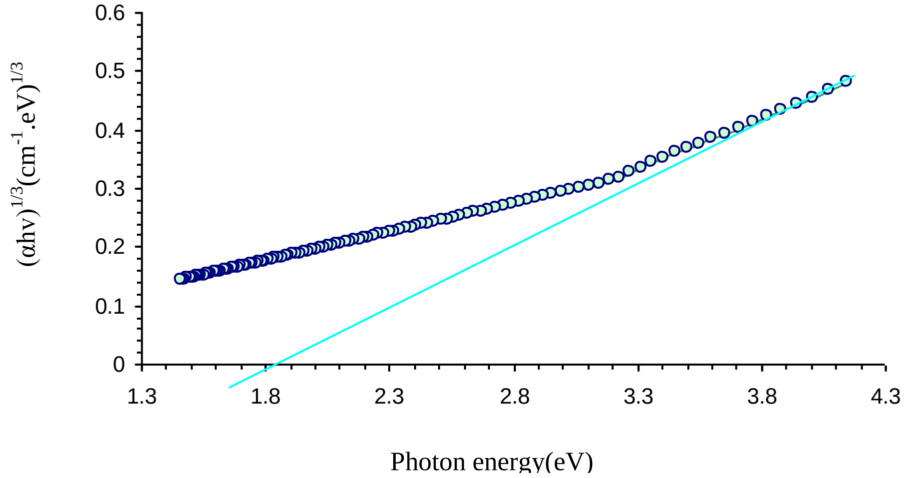


Figure (7) the relation ship between $(\alpha hv)^{1/3}$ and photon energy of . of PMMA- TiO_2 composites for 40wt.% TiO_2

We note that the value of the energy gap decreases with increasing TiO_2 concentration[10].

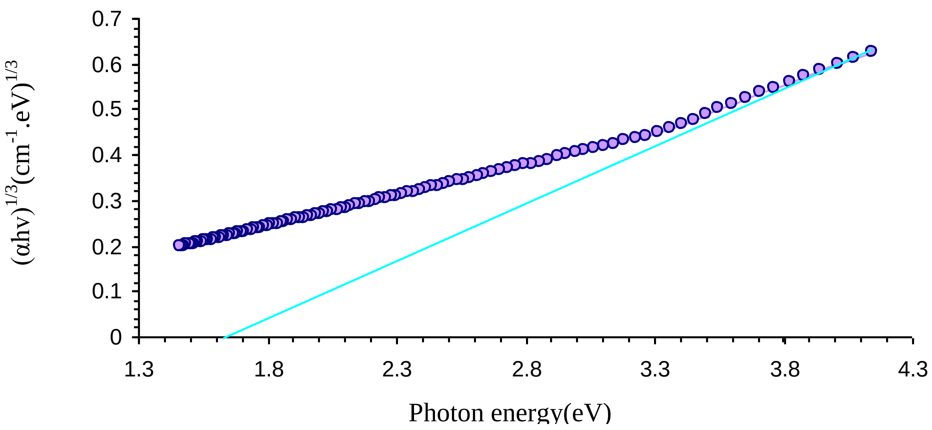


Figure (8) the relation ship between $(\alpha hv)^{1/3}$ and photon energy of of PMMA- TiO_2 composites for 60wt.% TiO_2

Figure(9) shows the variations of extinction coefficient (k) with wavelength of pure and doped PMMA with TiO_2 . k($k=\alpha\lambda/4\pi$) shows an increase with increasing fillers. The behavior of (k) can be ascribed to high absorption coefficient. This result indicates that the filled atoms of TiO_2 will modify the structure of the host polymer. An interesting result is TiO_2 fills an increases the absorbance in the visible region[5].

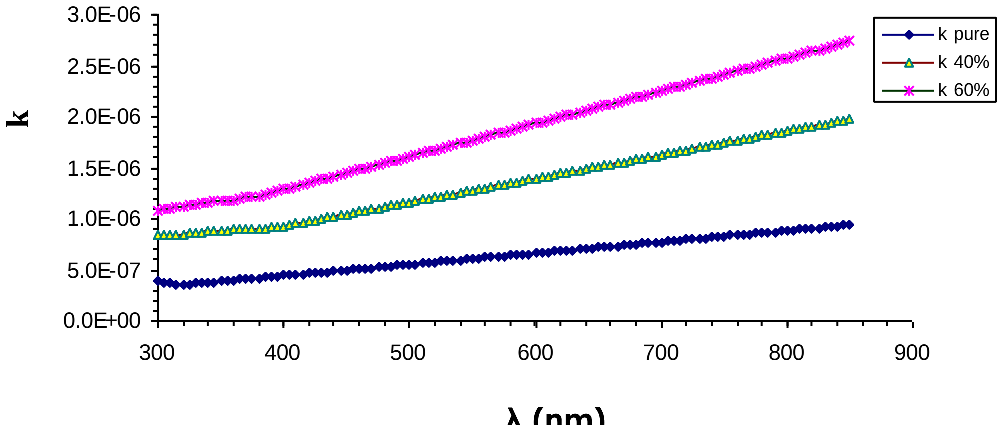


Figure (9) the relation ship between the extinction coefficient (k) and wavelength(λ) of the PMMA- TiO_2 composites

Conclusion

1. The absorption coefficient increases with increasing of the filler wt.% content.
2. The experimental results showed that the absorption coefficient less than $10^4 cm^{-1}$ this indicates to forbidden and allowed indirect electronic transitions.
3. The TiO_2 additive changes not the nature of electronic transitions of PMMA samples.
4. The forbidden energy gap decreases with increasing of the wt.%. filler.
5- The extinction coefficient increases with increasing of the wt.% filler.

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