The Effect of Iron Chromate on the Optical Properties of PMMA Films

BY

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Abstract

Films of pure PMMA and PMMA doped by iron chromate have been prepared using casting method. Transmission and absorption spectra have been recorded in the wavelength range (300-900) nm. the study of the optical properties of the deposited films have done in order to identify the possible change that happen to the PMMA films due to doping. The Absorptance data reveals that the doping affected the absorption edge as a red shift in its values. The study of the optical parameters gives an indication that the doping affected all the studied parameters like, transmission, absorbance, extinction coefficient, and refractive index, real and imaginary parts of dielectric constant.

الخلاصة

حضرت أغشية البولي مثيل ميثاكريلات النقية والمشوبة بكرومات الحديد بطريقة الصب. سجلت قيم النفاذية والامتصاصية في مدى الطول الموجي nm (300 – 900). تم دراسة الخصائص البصرية للأغشية المحضرة وذلك لغرض تحديد التغير الممكن حدوثه لغشاء البولي مثيل ميثاكريلات بسبب التشويب. ان نتائج الامتصاصية تدل على ان التشويب أدى الى الانحراف الاحمر (red shift) في قيمة حافة الامتصاص. ان دراسة المعلمات البصرية أعطت تصور عن تأثير التشويب والذي اثر في كل المعلمات التي درست كالنفاذية، الامتصاصية، معامل الخمود، معامل الانكسار، الجزء الحقيقي والخيالي من ثابت العزل الكهربائي.

Introduction

Poly methyl methacylatc (PMMA) have been widely used due to attractive physical and optical properties decisive about its broad applications. This is the thermoplastic material with a good tensile strength and hardness, high rigidity, transparency, good insulation properties and thermal stability dependent on toxicity [1-3].

It can be as on composite material act as optical diffuser in a liquid crystal display backlighting unit [4], as a photonic material due to its low optical absorption, simple synthesis and low cost [5], as a gel polymer electrolytes due to its reasonable conductivity, high mechanical strength, stability over a wide range of temperature and elector chemical window [6].

As a composite material in multi walled carbon nanotube for gas sensor [7], it can be use to develop capacitors, transistors filed effect transistor sensors, which are usually obtained by intercalating a dielectric layer between a gate electrode and sensor polymer layer [8], as an inorganic-organic film [9], it can be used as a substrate material for precision optics components due to it high transparency in the visible region low refractive index, and hence reduced optical loss [10], for different applications, such as ophthalmic, displays, medical instruments and other, PMMA is coated with antireflective films or interference filters [11], and in optical communication and optical information processing due to quick response, wide transparence simple manufacture, low cost and ease for integration, especially with the development of wavelength division multiplexing, all optical communication network, polymer composite thin film have become a major focus of scientific research [12-14].

In this paper an attempt was introduced to obtain the effect of iron chromate additive on the optical constants of PMMA.

Experimental details

Commercial poly (methyl methacrylate) and iron chromate used in this study were obtained from sigma-aldrich (Germany), chloroform has purity of 99.8% (HPLC_ was used as a common solvent for both PMMA and iron chromate pure PMMA and iron chromate were dissolved separately in chloroform for 4 hour at room temperature. The solution were then muted with 4% and 8% concentration of iron chromate and subsequently cast on to glass dishes and left in an oven at 40 ^{o}C for 24 hour, Several experiments were done on film casting in order to ensure dried sample without bubbles and thermal damage and good transparent films, after curing, all the samples pure PMMA and iron chromate doped PAMMA were removed and then cut as desired.The thickness of the films were measured with the help of thickness gauge (indicating micrometer 0.25 μm) and was found in the range of 20 ± 2 μ m.

The absorbance and transmittance spectra were recorded using double bean schimadzu UV/VIS-160A in the wavelength optical a range (300-900) nm, the measurements were carried out at room temperature.

Results and discussions

The study of the optical absorption spectrum is one of the most productive methods in developing and under standing the structure and energy gap of polymers. Fig. (1) Shows the absorptance versus wavelength for pure and different concentration of iron chromate, it is seen that as the percentage of doping increase, the absorptance increase all the graphs shoes a constant value of absorptance above 350 nm. Also the data show that optical absorption each shifted toward higher wavelength to a red shift.

Fig. (2) Show transmittance of the prepared films versus wavelength, the average the transmittance of PMMA is above 85% (the average value of the transmittance is calculated by taking the average transmittance over 360 nm to 900 nm range of the film), and all the films showing the same behavioun but the transmittance was decrease as the doping percentage increase.

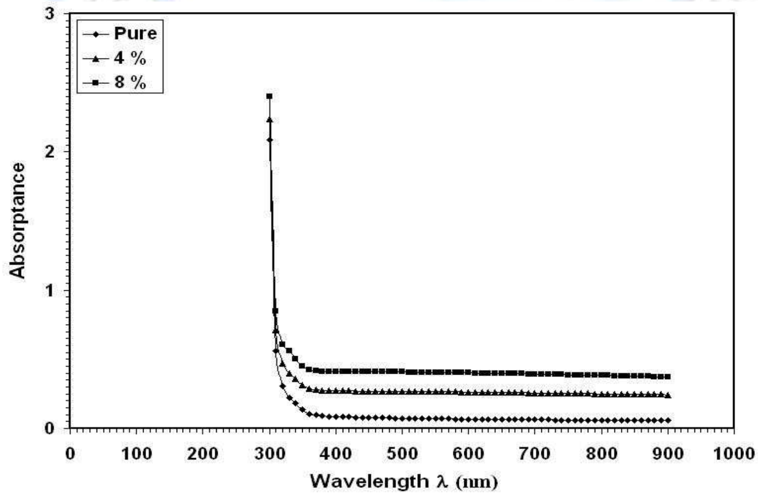

Fig. (1) Absorptance as a function of wavelength for pure and different concentration of iron chromate.

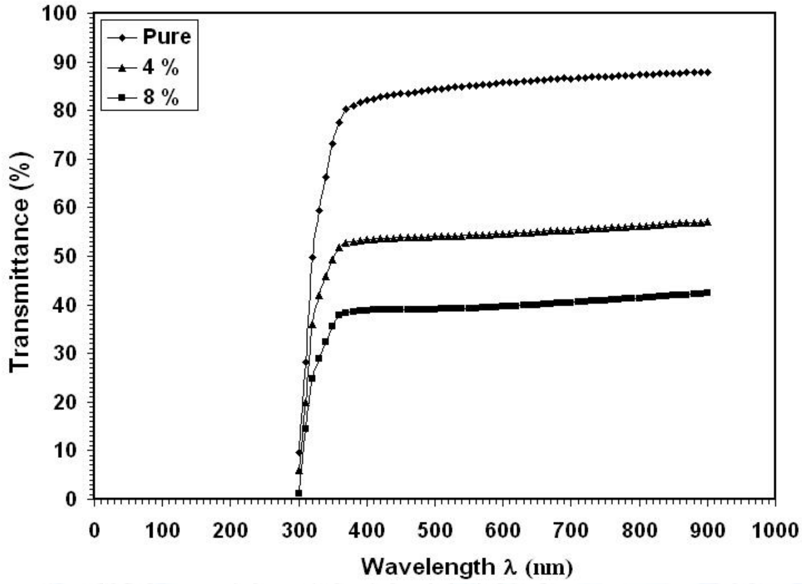

Figure (2) Transmittance as a function of wavelength for pure and different concentration of iron chromate

The refractive index (n) of pure and doped PMMA with iron chromate were determined using the relation [15]:

$$R = \sqrt{\frac{4R}{(R^2-1)^2 - k^2} - \frac{(R+1)}{(R-1)}} \qquad \text{------------- (1)}$$

Where(R) is the reflectance and (k) is the extinction coefficient, Fig. (3) Shows the variation of n as a function of wavelength, the value of the refractive index increase as the doping percentage increased. In order to compare our results of (n) for pure PMMA with the published data, which were calculated at 600 nm. The value of (n) was found (1.85) for thickness (20 μm), while Ahmed et al. [16], obtained (n) value = 2.13 with the thickness 100 μm, Papanu et al. [17], obtained (n) value = 1.48 of PMMA with thickness 1 μm deposited on silicon wafer. The difference in (n) value is attributed to the difference in thickness.

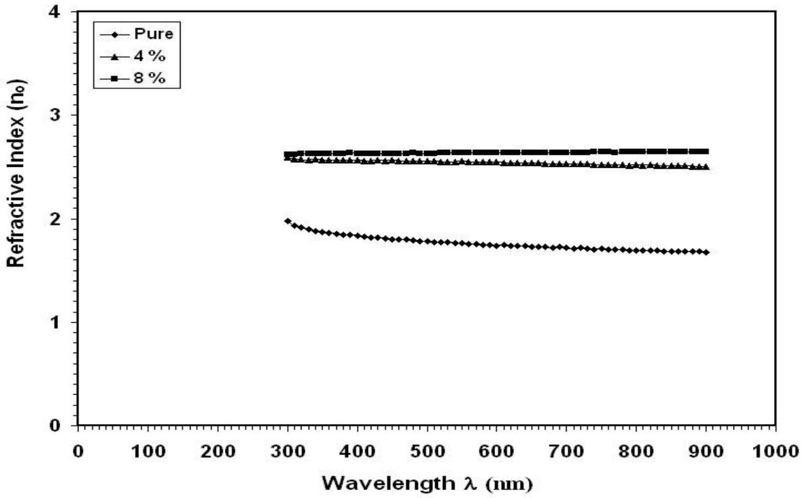

Figure (3) Refractive indices as a function of wavelength for pure and different concentration of iron chromate

The extinction coefficient (k) is directly proportional to the absorption coefficient as see in relation [18]:

$$k = \frac{\alpha \lambda}{4 \pi} \quad \text{------------- (2)}$$

Where (α) is the absorption coefficient and (λ) is the wavelength of the incident photon.

Fig. (4) Shoes the variation in K as a function of the wavelength. The behavior of the pure PMMA is different in comparison with doping films, for PMMA it seems that the extinction coefficient remains nearly constant as the wavelength increased but for doping, the attenuation coefficient increase in comparison with the undoped one, also this factor seems to be increase as the wavelength increase.

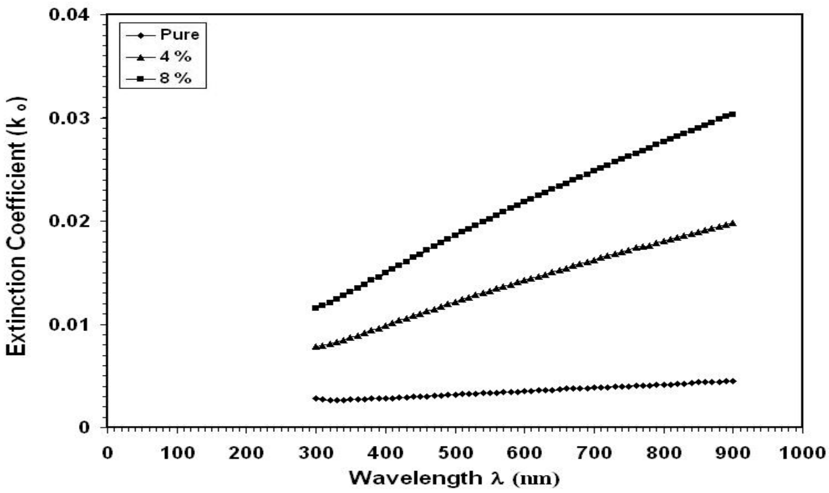

Figure (4) Extinction coefficient as a function of wavelength for pure and different concentration of iron chromate.

The real (ε_1) and imaginary (ε_2) parts of the dielectric constant related to the (n) and (k) values. The (ε_1) and (ε_2) values were calculated using the form [19]:

$$\varepsilon_r = n^2 - k^2 \qquad \text{------------- (4)}$$

$$\varepsilon_i = 2nk \qquad \text{------------- (5)}$$

Fig. (5) and Fig. (6) Shows (ε_1) and (ε_2) values dependence of wavelength. the real and imaginary parts dielectric constant for pure and doped PMMA the real part of it associated with the term that how much it will slow down the speed of light in the material and imaginary part gives that how a dielectric absorb energy from electric field due to dipole motion, it was clearly seen for both (ε_1) and (ε_2) that the value of them increase as the percentage of doping increased.

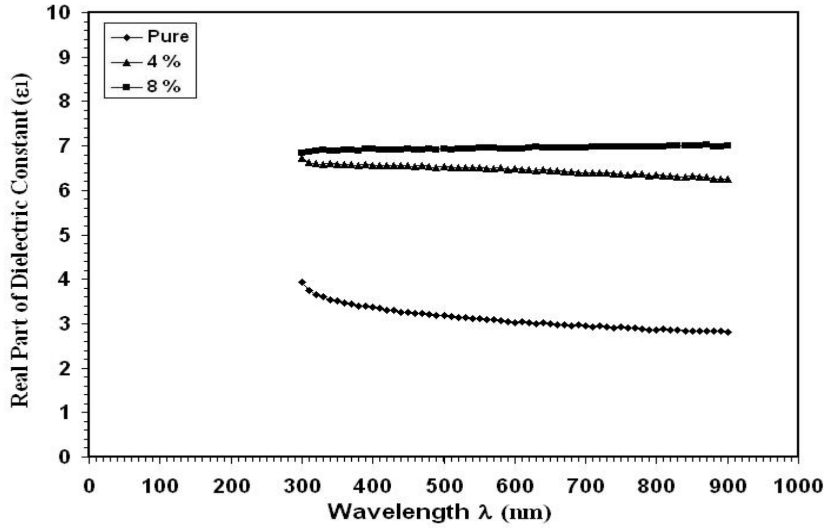

Figure (6) Real part as a function of wavelength for pure and different concentration of iron chromate

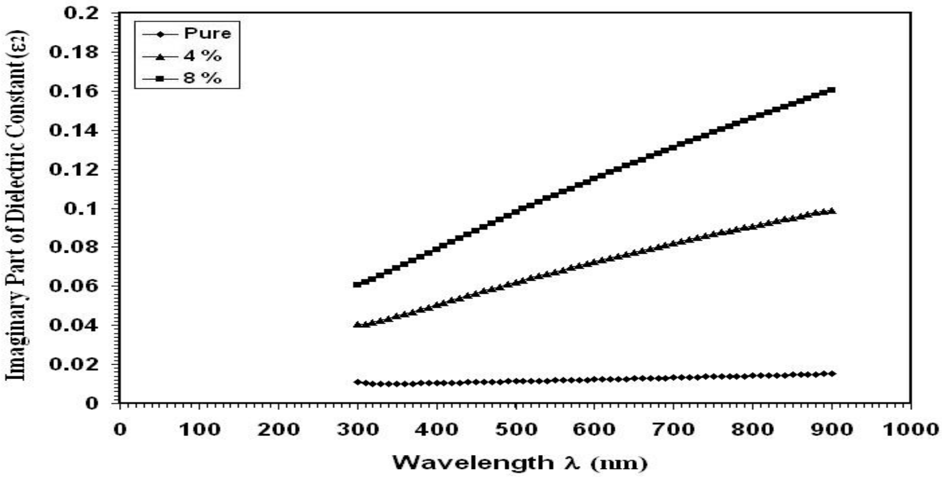

Figure (7) Imaginary part as a function of wavelength for pure and different concentration of iron chromate

Conclusions

Pure PMMA and iron chromate doped PMMA with the different concentration have been prepared successfully by casting method, the calculated values of the optical parameters illustrated that there was a red shift in the optical absorption edge which indicate that there was an increase in the energy gap (Eg) as the doping concentration increased.

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