Effect of Polystyrene Film Thickness on Some Optical Parameters

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Abstract

Films of polystyrene of different thicknesses have been prepared by casting method. Transmission and absorption spectra have been recorded in order to study the effect of increasing thickness on some optical parameters such as transmittance absorptance, refractive index, extinction coefficient, and absorption coefficient, real and imaginary parts of dielectric constant. This study reveals that all these parameters affect by increasing the thickness.

الخلاصة:

حضرت أغشية البولي ستايرين بأسماك مختلفة باستعمال طريقة الصب .سجل طيفي النفاذية والامتصاصية وذلك لغرض دراسة بعض المعلمات البصرية مثل :النفاذية، الامتصاصية، معامل الانكسار، معامل الخمود، ثابت العزل بجزيئيه الحقيقي والخيالي .توصلت هذه الدراسة الى أن لسمك الغشاء تأثير على كافة المعلمات البصرية.

Introduction

Polystyrene is one of the most important polymer its popularity stems from the fact that is possesses many good properties, such as good process ability, rigidity, low water absorbability, transparency, and that it can be produced at low cost however polystyrene has some disadvantages, such as sensitivity to chemicals and food materials with high oil content, poor UV-resistance and brittleness [1]. Polystyrene has wide applications mainly used in the packaging industry; optical of polystyrene is used in manufacture of unbreakable glasses for gauges, windows and lenses, as well as in countless specialties and novelties and also for edge lighting of indicators and dials [2]. Furthermore, it can be used as a polystyrene-single-walled carbon annotates composites [3], polystyrene multi-walled carbon annotates composites [4], aqueous suspensions of polystyrene microspheres are widely used as phantoms for the studies of tissue and cell optics and benchmarks for calibration of instruments such as flow cytometers [5], as a core shell spheres including biosensors [6], chemical sensors [7], and recently as three dimensional polystyrene opal photonic crystal [8] The aim of this work is to study the affect polystyrene thickens on some optical constants.

Experimental details

Films of Polystyrene were prepared by casting method using pure polystyrene supplied by (Dentaurun Company) Germany, the PS were dissolved in chloroform then casted on a glass Petri dish to obtain polymer films with different thicknesses (10 ❍m, 20 ❍m, 30 ❍m, 40 ❍m) after dried at room temperature for 24 hours, the film thickness was measured by (indicating micrometer 0.25 ❍m) with an error not exceeding $\pm$ 5%, these films were clear and transparent.

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

Results and discussions

Fig. (1) Shows the absorptance versus wavelength, the absorptance increase as the thickness of the film increase, the absorption edge shift toward shorter wavelengths shows a blue-shift.

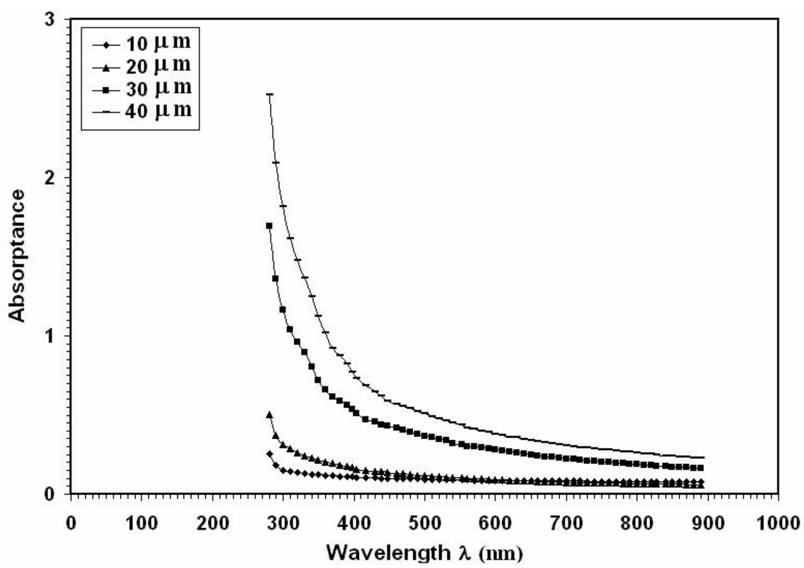

Figure (1): Absorptance versus wavelength for the as deposited films.

Fig. (2) Shows the optical transmittance in the UV-NIR regions of polystyrene films with different thicknesses. The average transmittance in the visible range is above 78% for the polystyrene films with 10 Om and 20 Om thickness while by increasing the thickness the optical transmittance will decreased as the thickness increase. The average value of the transmittance is calculated by taking the average value of the transmittance over 500 nm to 800 nm range of film for each sample.

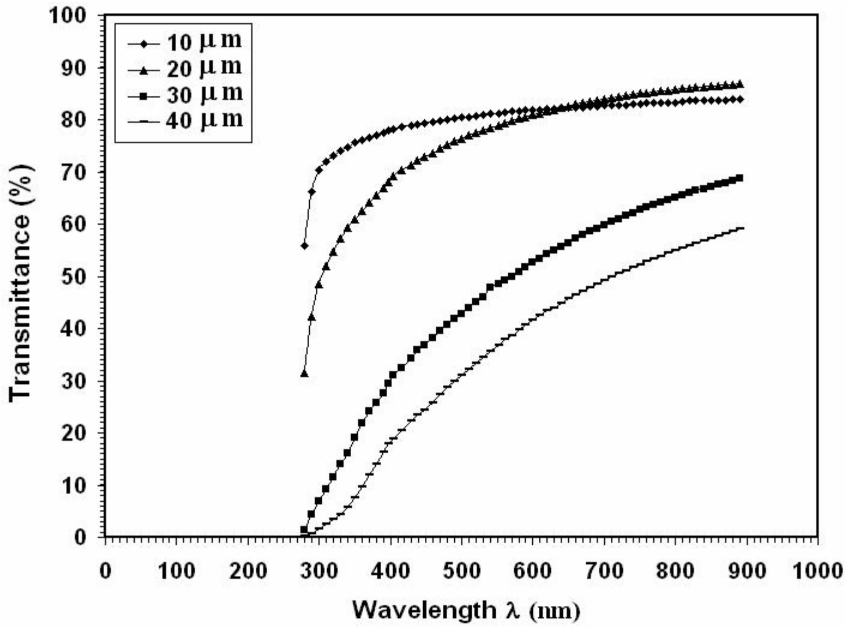

Figure (2): Transmittance versus wavelength for the as deposited films.

The refractive index (n) can be determined from the reflectance (R) data using the relation [9]:

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

As shown in Fig. (3) the refractive indices of the films are influenced by the film thicknesses. The refractive index increase as the thin films thickness increase which may be related to an increase of the compactness of the films. The obtained results show that the refractive index of the films decreases as the wavelength increase until 500 nm and then be com nearly constant with increasing wavelength.

The extinction coefficient (k) using the following relation [10]:

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

Where □□□ 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, which is found to increase with increase film thickness for the as deposited films.

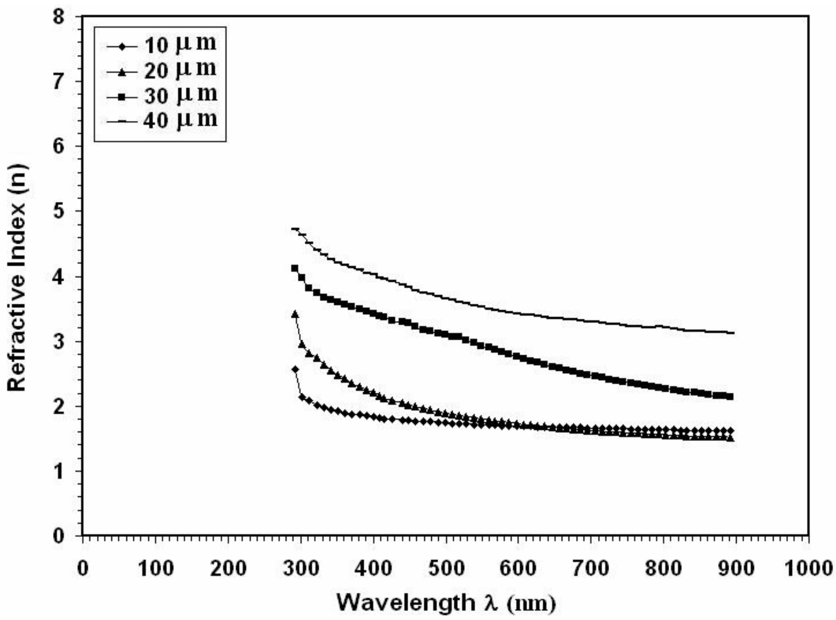

Figure (3): Refractive indices versus wavelength for the as deposited films.

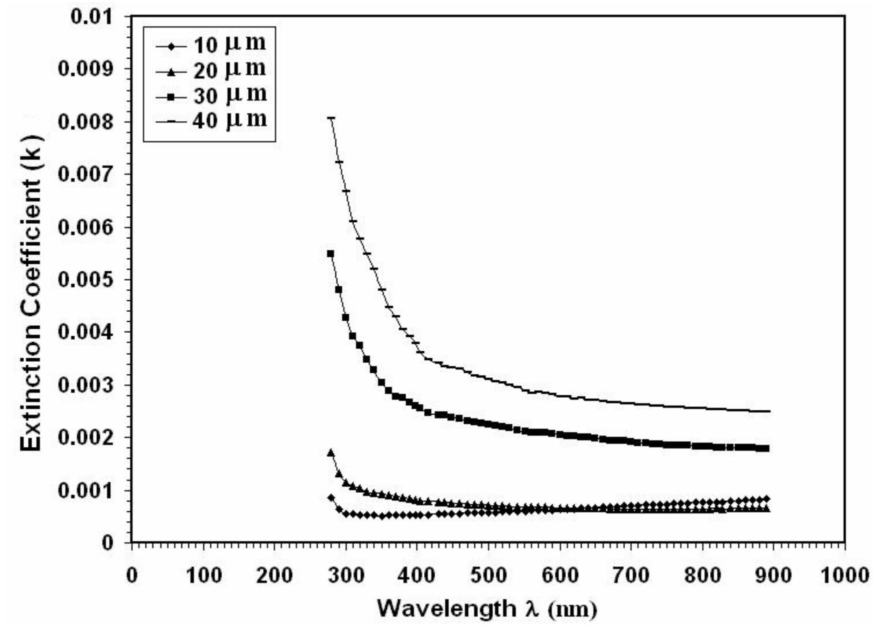

Figure (4): Extinction coefficient versus wavelength for the as deposited films.

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 alas [11]:

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

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

Fig. (5) and Fig. (6) Shows (ε_1) and (ε_2) values dependence of wavelength. (ε_1) and (ε_2) values of the films increases as the film thickness increase. The real and imaginary parts of the dielectric constant indicate the same pattern and the values of real part are higher than imaginary part it can be seen that in the thickness of 30 ❍m and 40 ❍m the real and imaginary parts decrease as the wavelength increase, on the contrary of films thickness 10 ❍m and 20 ❍m its value to be constants with the increasing in wavelength.

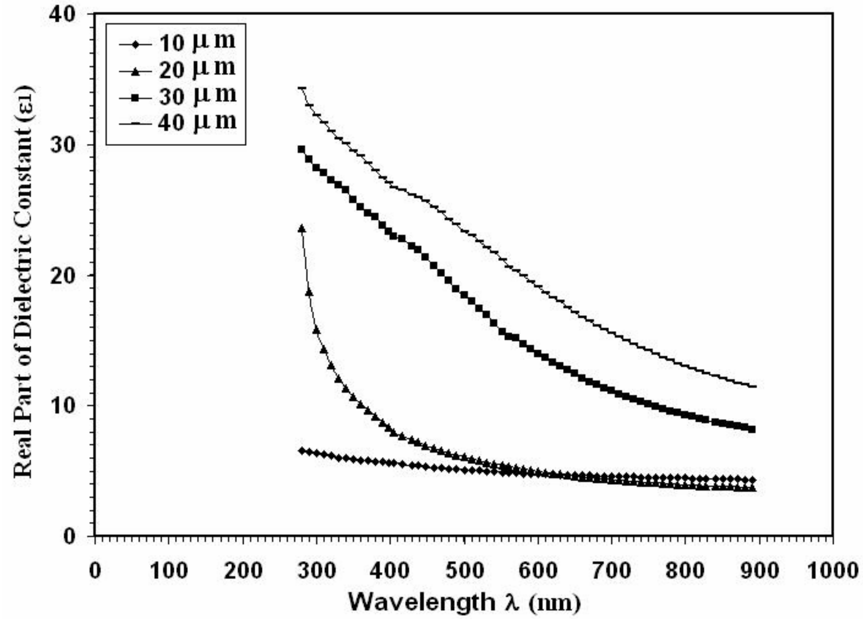

Figure (6): Real part versus wavelength for the as deposited films.

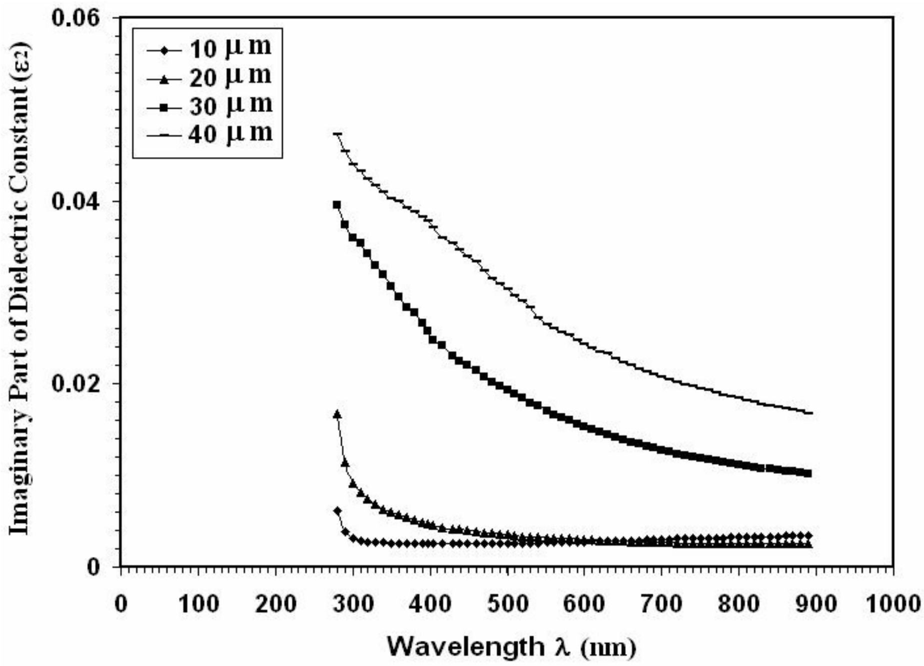

Figure (7): Imaginary part versus wavelength for the as deposited films.

Conclusions

The effect of thickness on the some optical parameters have been studied it can be seen from the absorptance data that the optical absorption edge shift toward short wavelength which confirm a blue shift. The thickness effect all the parameters under investigation by increasing their values as the thickness increased except the transmittance values which decrease as the thickness increase.

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