Study the Effect of Thickness on Optical Properties of Polymer PMMA Thin Films Preparated by Spin CoatingMethod

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Abstract

In this research, study the effect of thickness on the optical properties for polymer poly(methyl methacrylate),that the films were prepared by spin coating method. Some of optical properties of poly(methyl methacrylate)film have studied, which includes (energy gap , absorbance spectrum, transmittance spectrum, reflectance ,extinction coefficient, refractive index, absorption coefficient, imaginary and real dielectric constant) ,this study shows that having different properties due to the difference in thickness .The measurements were taken for different thickness (206,116,87,66,47 nm) and different number of rotation (1000,2000,3000,4000,5000 rpm)respectively.

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Introduction

In recent year Poly (methyl methacrylate) PMMA has significant attention due to its good tensile strength , not expensive, and high rigidity, solidity, diaphanous,in the visible spectrum optical lossis low, glass temperature is low, insulation properties was good and thermal constancy dependent on sense of touch. The PMMA is a photovoltaic packaging material that has a good transmission mostly in the region where for solar cells the spectral response is higher and the diffusion coefficient is low (1). Poly methyl methacylatc(PMMA) used in medical applications and have been broadly used due to optical properties decisive about its wide applications and attractive physical(2).PMMA is one of the good organic optical materials also has It is widely used for making a variety of optical devices, such as optical lenses . The refractive index is known to change in ultraviolet light, both in pure and doped conditions, which provide a means of manufacturing structures, such as grid barriers or waveguides(3).Today these materials play a significant role in many areas of daily life on account of their unique advantages over traditional materials. Poly- (methacrylate) general is the polymers of methacrylate esters where it isthe most commonly used among them where is one of the earliest known and most famous polymers, with the chemical formula $(C_5H_8O_2)_n$ .It is naturally colorless and a transparent polymer with owned density(1.15-1.19 g/cm^3).

Available in the market in both pellet (granules) and paper form under the names Plexiglas, Altuglas, Acrylite, Perspex, Acryplast, Plazcryl,Lucite etc. It is usually called simply acrylic oracrylic glass (4)

Experimental part

Preparation of Membrane

Spin Coating method

A film is prepared by depositing a material on a glass sheet after washing, and a sedimentation process is performed using a spin coating method(5-7).Spin coating is efficient and a versatile technique in the preparation of membranes. It is an attractive method for obtaining a very wide range of powders and thin film materials for various and many industrial applications. Polymer films were prepared using this technique. Spin coating opens the possibility to control film morphology well.

Select the spin coating method based on the user's accessibility at work and the equipment and equipment available in the laboratory(8).The properties and quality of the films depend heavily on the process parameters. A spin coating system, (model V T C-100), this system is present in the laboratory of the department of general science, college of basic education, university of babylon, Used to prepare thin films. The system consists of several parts arranged so that they can be used to make different films on different layers . In this system the thickness of the prepared films can be controlled by increasing or decreasing the rotation speed of the system, where the increasing of the speed rotation of the system the thickness of the films are decreasing and vice versa. Also the homogeneity of the prepared films depends on the speed of rotation and on the balance and stability of the system, Fig.(1) shows the spin coating system.

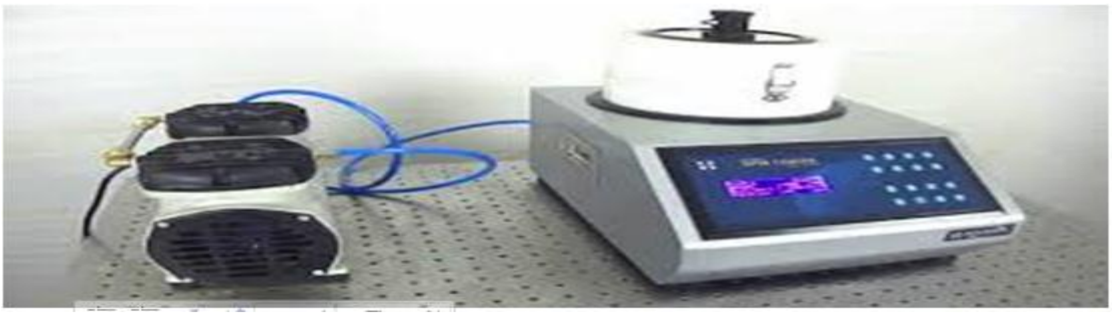

Figure. (1): Spin coating system with its control.

Optical measurements

Optical measurement Method is done by using the method of Lambda (LIMF- 10) system, the measurement system is easy to set up and use. It is suitable for both the manufacturing line and desktop measure with the ability to connect to your microscope to reduce the spot size or to dismantle for sole spectroscopic use. (Figure 2) show the optical measurement system used in our research, this instrument is present in the laboratory of the department of general science, college of basic education, university of Babylon.

Figure(2): Optical thin film measurement system.

Calculations and Results

Absorbance Spectra

From the figure (3) it can shown that the absorbance measurements of polymer poly(methyl methacrylate)thin film, were plotted against wavelength in the range of (295-1095) nm. From the figure it is noticed that the absorption value of a polymer poly(methyl methacrylate) is almost nearly(0.151,0.152,0.183,0.199 and 0.247)respectively for (1000,2000,3000,4000 and 5000 rpm) and strong absorption clear at295nm. This is consistent with the researcher(9, 10).

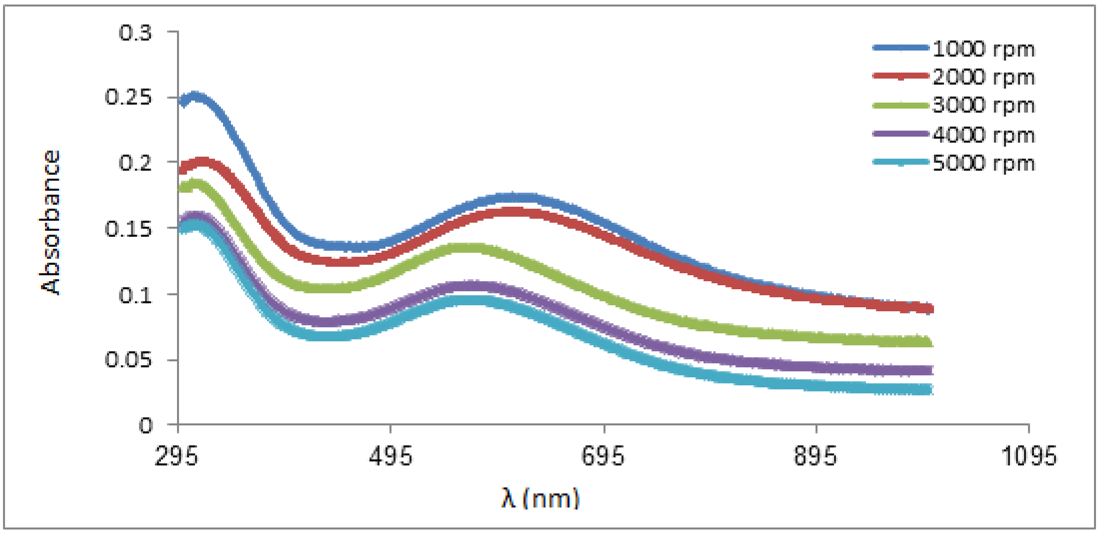

Figure (3). variation of absorption spectra of polymer(PMMA)thin filmwith wavelength .

Transmittance Spectra

From the figure (4) it can shown that the transmittance spectra of polymer(PMMA) thin film, were plotted against wavelength in the range of (295-1095) nm. From this figure it is noticed that transmittance spectra behaves as an opposite behavior of the absorbance spectra according to the following exponential relationship through the for both absorption and transmittance which

$A = \log (1 / T)$ .... (1)

This is consistent with the researcher(9, 10).

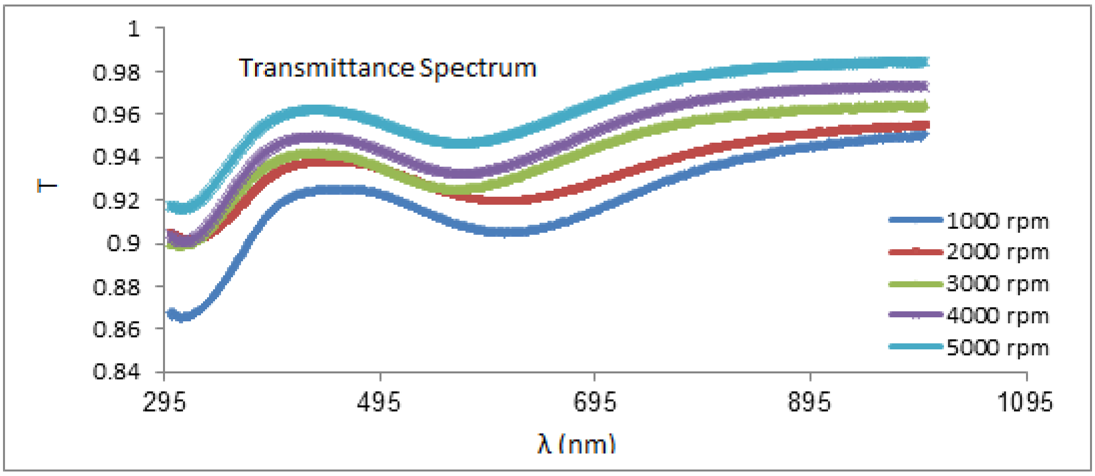

Figure (4). variation of transmittance spectra of polymer(PMMA) thin film with wavelength .

Optical Energy Gap

The optical energy gap for polymer(PMMA) thin films determined by using equation $\alpha h\nu=B\,(h\nu-E_g^{opt.})^r$...........(2).

The graph is shown between $(\alpha h\nu)^2$ photon energy (hν) indicates that polymer(PMMA) are direct transition type semiconductors for the thin films. Figure (5)and Figure (6)shows the relation of (αhν $)^2$ against photon energy, from a straight line can determine the energy gap allowed directly ., the energy gap value of a polymer (PMMA) is almost nearly (1.2, 2.59,3,3.04,3.08 eV) respectively for (1000 ,2000 , 3000 , 4000,5000 rpm), in general the energy gap values depend on films crystal structure, also the distribution and arrangement of atoms in the crystal lattice, it is influenced by crystal regularity. the direct band gap results in this research, are in good agreement with research(11, 12).

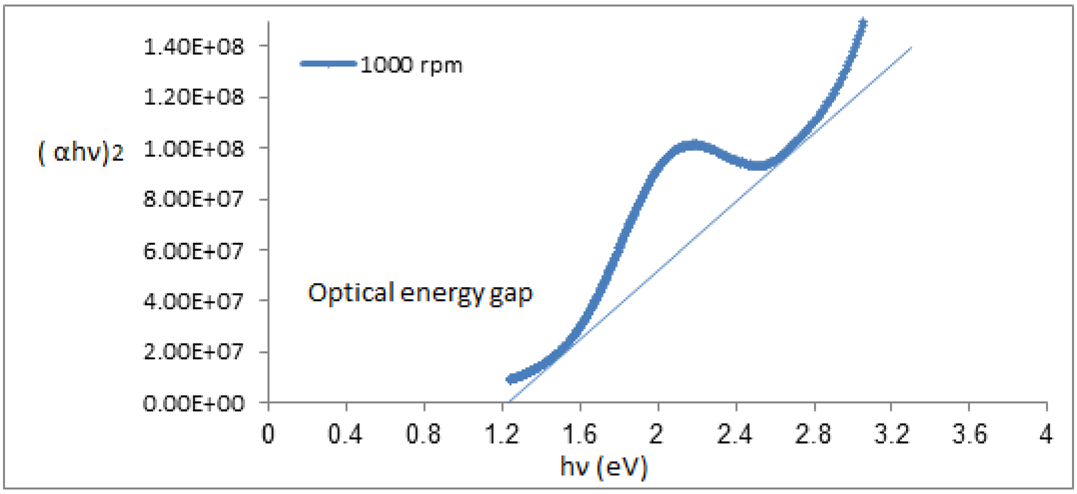

Figure (5). Variation of $(\alpha h\nu)^2$ vs. photon energy(hν) for polymer(PMMA) thin film.

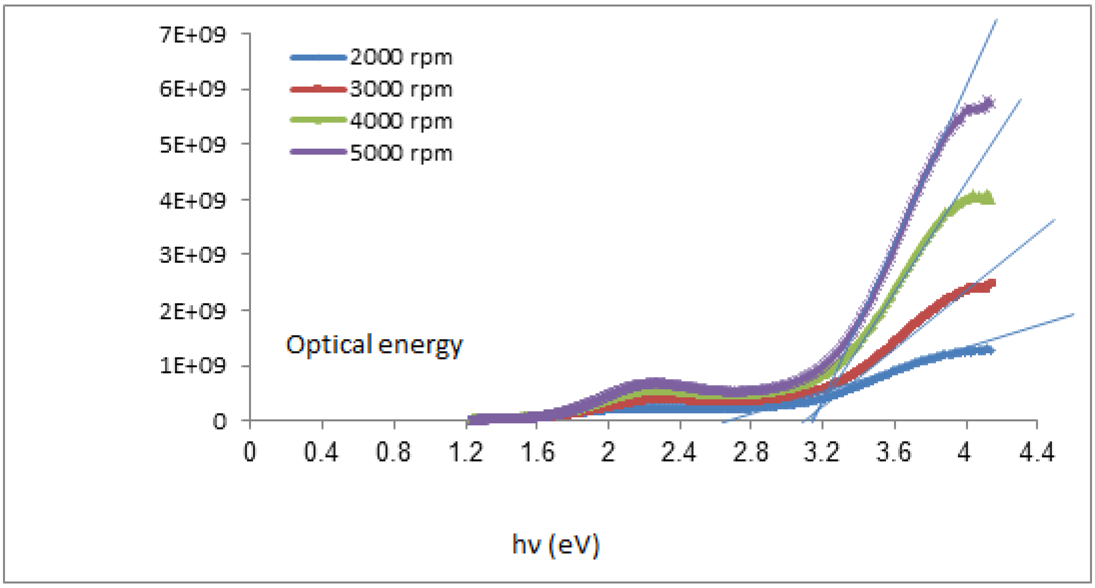

Figure (6). Variation of $(\alpha h\nu)^2$ vs. photon energy(hν) for polymer(PMMA) thin film.

Reflectance Spectra

From figures (7) it is noticed thatvariation of reflectance vs. with photon energy(hν), for polymer(PMMA) thin film, it can be attributed to the basis of reflectance that depend on the refractive index as the relationship $R=(n-1)^2+k^2/(n+1)^2+k^2$ ……..(3) therefore the reflectance behaves is same behavior to the refractive index. and this is consistent with the researcher (13).

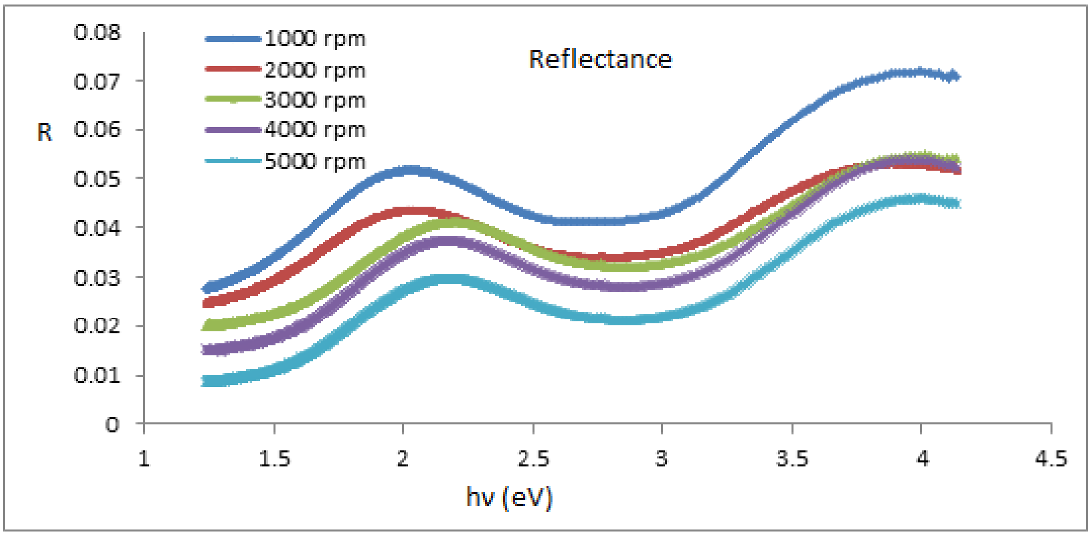

Figure (7). Variation of reflectance vs. with photon energy(hν), for polymer(PMMA) thin film.

Refractive Index

Figures (8) show that the change of refractive index (n) , as a function of photon energy(hν)for polymer(PMMA) thin film, it can be attributed to the basis of refractive index that depend on the reflectance as the relationship **:**

$$n = \left[\left(\frac{1+R}{1-R}\right)^2 - (k_o^2 + 1)\right]^{\frac{1}{2}} + \frac{1+R}{1-R} \qquad (4)$$

,note that the most thickness (206) nm has the highest refraction this is consistent with the researcher's findings(12).

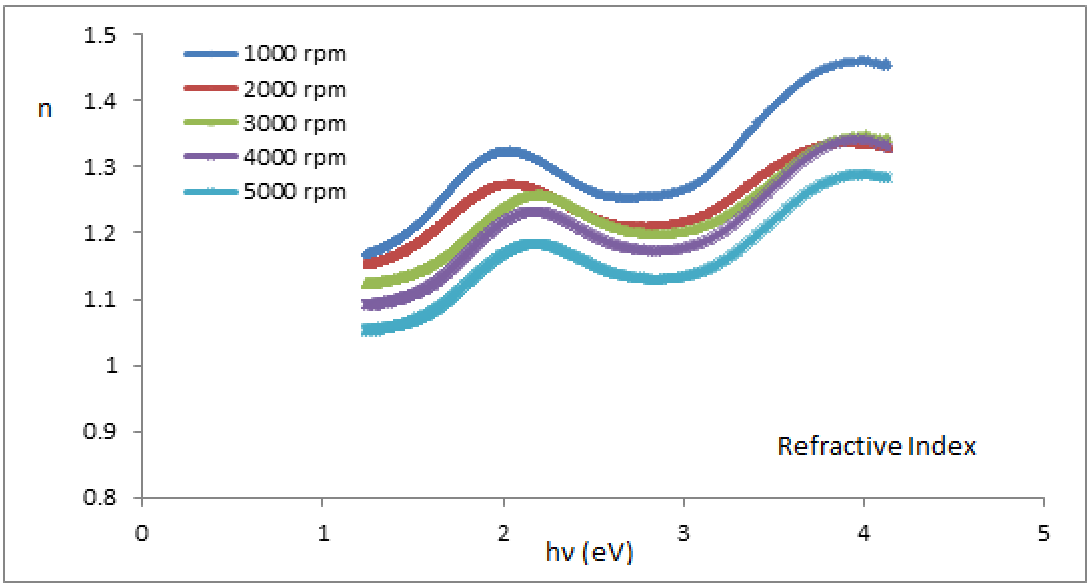

figure (8). Shows the change **of refractive index (n), as a function of photon energy(hν)for polymer(PMMA) thin film.**

Extinction Coefficient

Figure (9) shows the change of extinction coefficient as a function of photon energy(hν)for polymer(PMMA) thin film(10, 12).

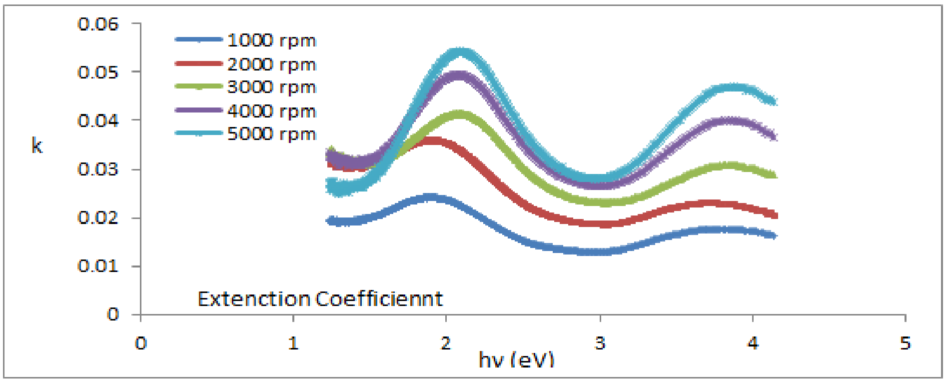

figure (9) .shows the change **of extinction coefficient as a function of photon energy(hν) polymer(PMMA) thin film.**

Absorption Coefficient

Figures (10) illustrates the change in the values of the change of absorption coefficient (α), as a function of photon energy(hν)for polymer(PMMA) thin film,(14, 15).Note that behavior ofabsorption coefficient is almost similar to behavior ofextinction coefficientand so depending on the relationship :

$$k_o = \frac{\alpha\lambda}{4\pi} \quad ....(5)$$

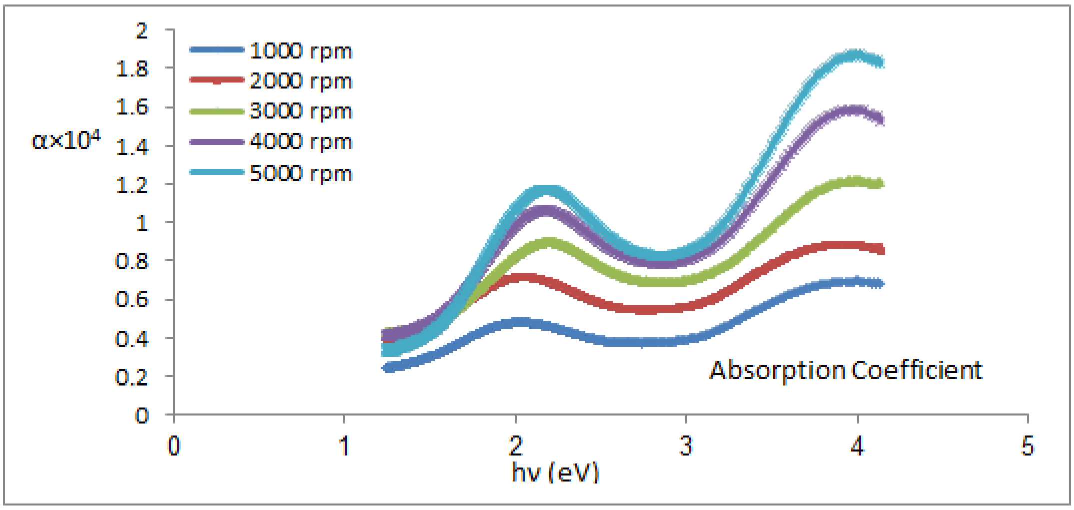

Figure (10). Shows the change of absorption coefficient (α), as a function of photon energy(hν) polymer(PMMA) thin film.

Real and imaginary dielectric constant

The imaginary (Ɛ i) and real (Ɛ r) dielectric constant polymer(PMMA) thin film system is determined by using equations (6), (7) respectively. The change of imaginary (Ɛ i) and real (Ɛ r) parts of dielectric constant values versus of photon energy(hν).From figures((11) , (12)), it is found that the behavior of εr is similar to that of the refractive index because of the smaller value of k^2 compared with n^2, while εi is mainly depended on the k values according to equation (7). This behavior is in agreement with the results of (4). From following relationship can be calculated real and imaginary dielectric constant

$$\varepsilon_r = n^2 - k^2 \quad ....(6)$$

$$\varepsilon_i = 2nk \quad ....(7)$$

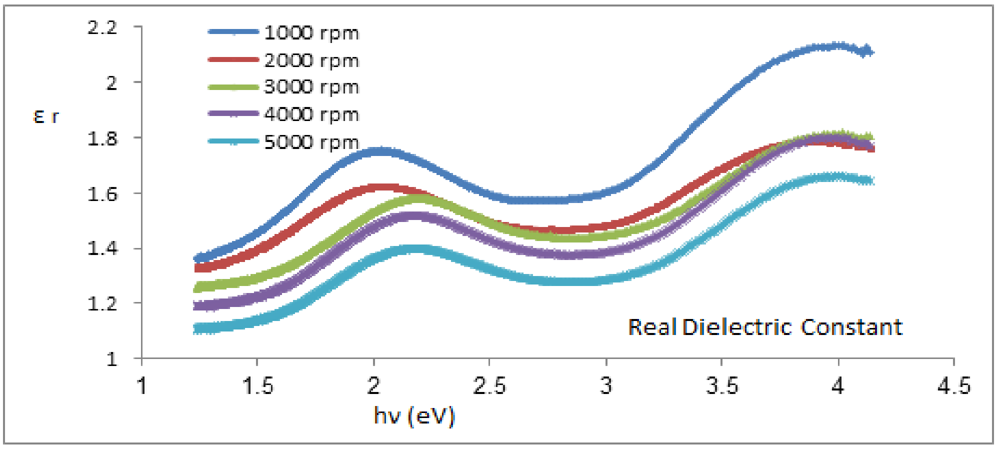

Figure (11). Shoes the change of real dielectric constant, as a function of photon energy)hν) for polymer (PMMA) thin film

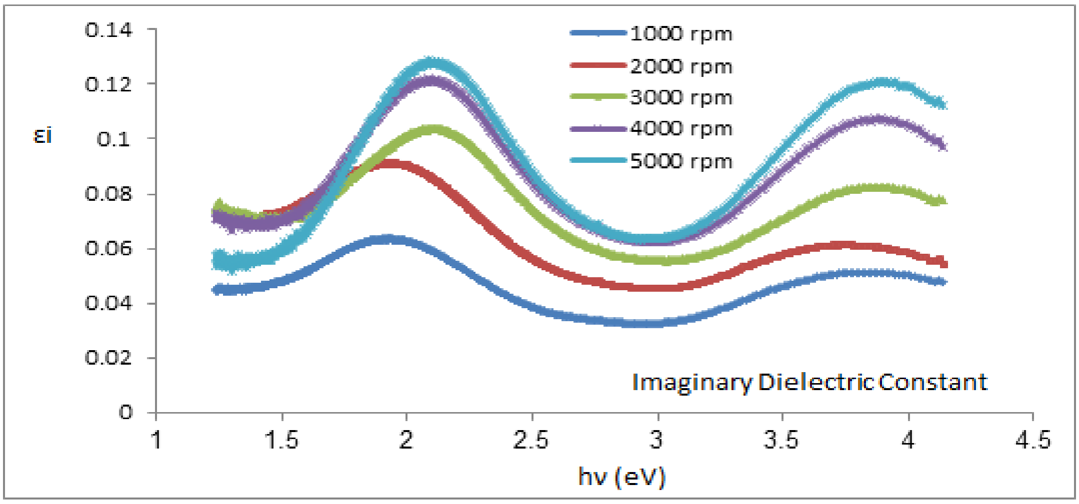

Figure (12). Shows the change **of imaginary dielectric constant, as a function of photon energy(hv)for polymer(PMMA) thin film.**

Conclusions

1- Note that the value of optical measurements have been measured (absorption, refractive index ,reflectance ,real dielectric constant) behave the same behavior, while the (transmittance , extinction coefficient, absorption coefficient , imaginary dielectric constant)behave the same behavior due to the impact of thickness.
2- Effect of thickness variation and number of rotation on optical measurements.
3-Note that the value of the energy gap is as high as possible and reaches to (3.08eV)at 5000 rpm with thickness (47) nm.
4-Note that the highest refraction at the value that the thickness (206) nm .

CONFLICT OF INTERESTS

There are no conflicts of interest.

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دراسة تأثير السمك على الخواص البصرية لأغشية البوليمر (PMMA) الرقيقة والمحضرة بطريقة الطلاء بالبرم

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الخلاصة

تم في هذا البحث دراسة تأثير السمك على الخواص البصرية لأغشية البوليمر (PMMA) الرقيقة والمحضرة بطريقة الطلاء بالبرم. وتم دراسة الخواص ألبصرية لهذه الأغشية والتي تتضمن فجوة الطاقة وطيف الامتصاصية والنفاذية ومعامل الانعكاس والانكسار ومعامل الخمود ومعامل الامتصاص والجزء الخيالي والحقيقي . إن هذه الدراسة بينت لنا اختلاف الخواص مع اختلاف السمك وان الأسماك التي تم قياسها كانت (٢٠٦ , ١١٦, ٨٧, ٦٦, ٤٧ , نانو متر)ولعدة سرع للدوران (١٠٠٠ , ٢٠٠٠ , ٣٠٠٠ , ٤٠٠٠ , ٥٠٠٠ rpm) على التوالي.

الكلمات الدالة: PMMA ,اغشية رقيقة , الخواص البصرية.