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Effect of γ-Radiation on Optical Properties of (PMMA:Blue Methyl) Films

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Abstract

We have studied the effect of gamma radiation on the absorption spectra of Poly methyl methacylatc doped Blue methyl (PMMA:Blue methyl) films deposited for thickness (25 ± 1 μm) by using solvent casting method. Transmittance and Absorptance spectra have been recorded in order to determine reflectivity. These films show that the energy band gap has decreased from about (2.16eV) before irradation to about (1.97 eV) and (1.21 eV) after irradiation .

The optical constants such as refractive index , extinction coefficient , real and imaginary parts of dielectric constant have also been studied , It was seen that all the parameters under investigation were affected by gamma irradiation.

Key words: PMMA films , Optical Properties , casting method , effect of gamma radiation.

تأثير أشعة كاما على الخصائص البصرية لأغشية (PMMA:Blue methyl)

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الخلاصة

تم دراسة تأثير أشعة كاما على طيف الأمتصاص لأغشية (PMMA:Blue methyl)المحضرة بسمك (1 ± 25) μm بطريقة صب المحلول . سجل طيف النفاذية والامتصاصية وذلك لغرض تحديد الانعكاسية، أظهرت هذه الأغشية أن فجوة الطاقة تقل من (٢.١٦ eV) قبل التشعيع الى (١.٩٧ eV) ، (١.٢١ eV) بعد التشعيع .

تم دراسة الثوابت البصرية المتمثلة بمعامل الانكسار ومعامل الخمود وثابت العزل الحقيقي والخيالي . وجد أن جميع المعلمات التي تمت دراستها تأثرت بأشعة كاما .

الكلمات الدالة : أغشية PMMA ، الخصائص البصرية ، طريقة الصب ، تأثير أشعة كاما.

Introduction

Poly (methyl methacrylate) PMMA has considerable attention in recent year owing to its low cost, good tensile strength, hardness, high rigidity, transparency, low optical loss in the visible spectrum, low glass temperature, good insulation properties and thermal stability dependent on tactility [1-3]. It can be considered as a good host for inorganic nano particle due to their high surface to bulk ratio which can significantly affect the properties of PMMA matrix [4]. PMMA can be tailored chemically to fit wide range of photonics and optoelectronics applications, liquid crystal display [5]. High energy radiations, such as γ-rays , change the physical properties of the materials they internal structure of the absorbed substances. Studies on the changes in optical properties of thin film irradiated with ionizing radiations yield valuable information regarding the electronic processes in these materials [6].

In the present contribution we measure the transmission, absorptance of (PMMA:Blue Methyl) films under the effect of gamma ray and determination of the optical energy gap , reflectance, refractive index , extinction coefficient , real and imaginary parts of dielectric constant.

Experimental details:

Poly (methyl methacrylate) from (sigma Aldrich comblt Germany) , chloroform has purity of 99.8% (HPLC_ was used as a common solvent for (PMMA :Blue methyl) were dissolved separately in chloroform for 4 hour at room temperature. Appropriate mixtures of PMMA and 3% weight (blue methyl) solutions were mixed . The solution was poured into flat glass plate dishes. Homogenous films were obtained after drying the solution in an oven for 24 hours. The thickness of the prepared films was in the range of 25 ± 1 μm The prepared were cut down into small films with dimensions of (3x3) cm . the prepared samples were irradiated by gamma ray dose from (Cs^{-137}) with activity (0.5 μ Ci), for 2 and 8 days. The irradiation facility is at the physics department , College of Science , University of Diyala . Irradiation was carried out in air and at room temperature .

The optical studies were carried out using double beam spectrophotometer (Shimadzu UV-probe Japan) in the wavelength range (190-900) nm.

Results and discussion:

Figure (1) shows the variation of Transmittance [T%] with wavelength for unirradiated (PMMA: blue methyl) & irradiated one. The transmittance of irradiated (PMMA: blue methyl) is lower than that for as deposited one and there is a shift toward high wavelength. This might be attributed to the a decrease in light scattering losses [7], or the increase in roughness of the irradiated thin films contributed to the drastic decrease of optical transmittance [8].

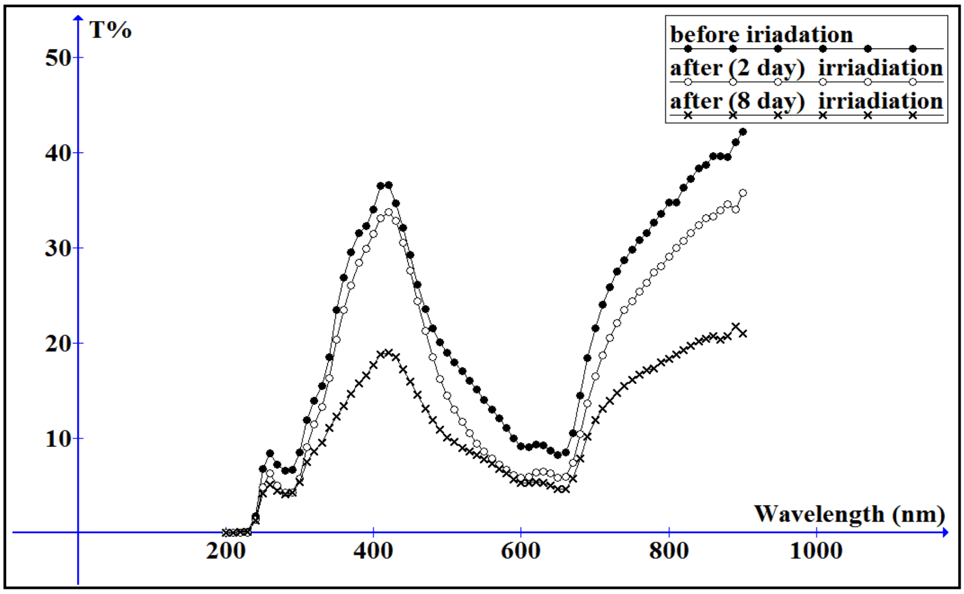

Figure (1) Optical transmittance as a function of wavelength.

The study of the optical absorption spectrum is one of the most productive methods in developing and understanding the structure and energy gap of polymers. The figure (2) show absorptance as a function of wavelength. It was found that the absorptance increased with irradiation days .

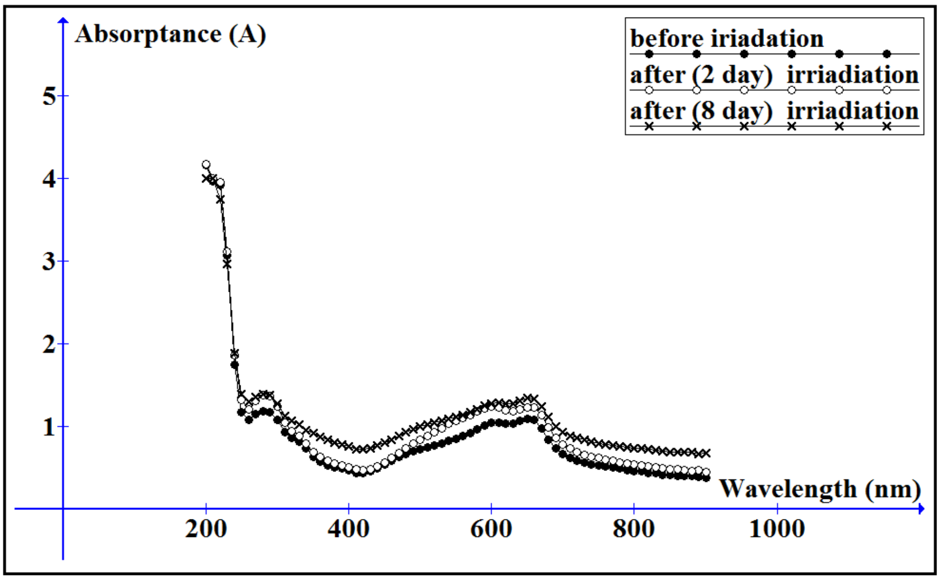

Figure (2) Absorptance as a function of wavelength.

Figure (3) shows the reflectance of unirradiated & irradiated (PMMA: blue methyl) films versus photon energy from this figure R [irradiated (PMMA: blue methyl)> R [unirradiated (PMMA: blue methyl)]. The irradiated thin film shows a much softer absorption edge, possibly indicating the presence of sub-band gap levels associated with defects.

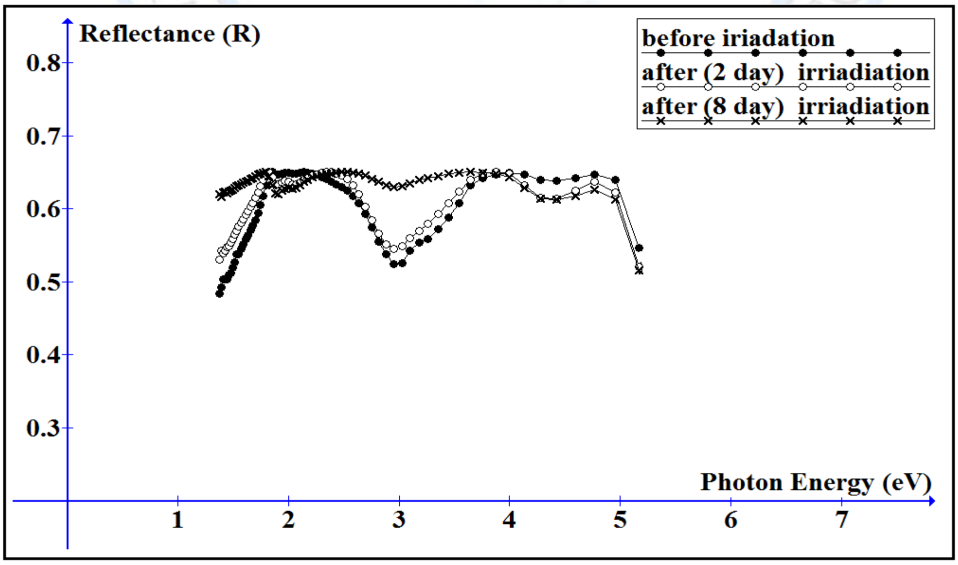

Figure (3) Reflectance as a function of Photon energy.

The plot of the product of absorption coefficient and photon energy $(\alpha hf)^{1/2}$ versus the photon energy at room temperature shows a linear behavior, which can be considered as an evidence for indirect allowed transition. Extrapolation of the linear portion of this curve to a point $(\alpha hf)^{1/2}=0$ gives the optical energy band gap E_g for the (PMMA: blue methyl) before and after irradiated. Fig.(4). Show the decreasing energy band gap from about (2.16eV) before irradation to about (1.97 eV) and (1.21 eV) after irradiation.

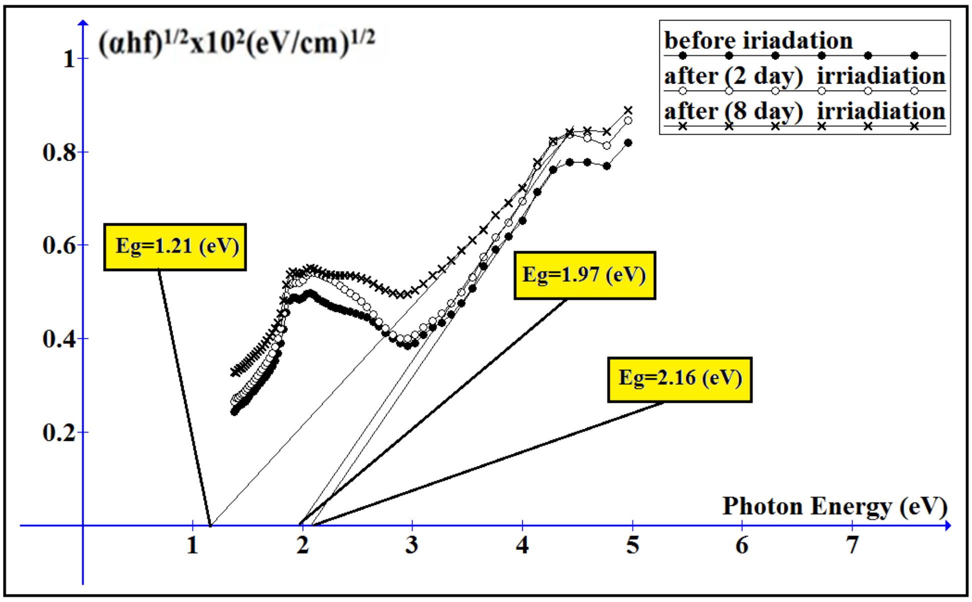

Fig. (4): Optical band gap Eg as a function of Photon energy.

Refractive index is one of the fundamental properties for an optical material, because it is closely related to the electronic polarizability of ions and the local field inside materials. The refractive index (n◦) of (PMMA: blue methyl) before and after irradiated were determined using the relation [9]:

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

Where (R) is the reflectance and (k) is the extinction coefficient, Fig. (5) Shows the variation of (n_0) as a function of photon energy , The evaluation of refractive index of optical material is important for many applications especially in optical device, the value of the refractive index increase with irradiated .

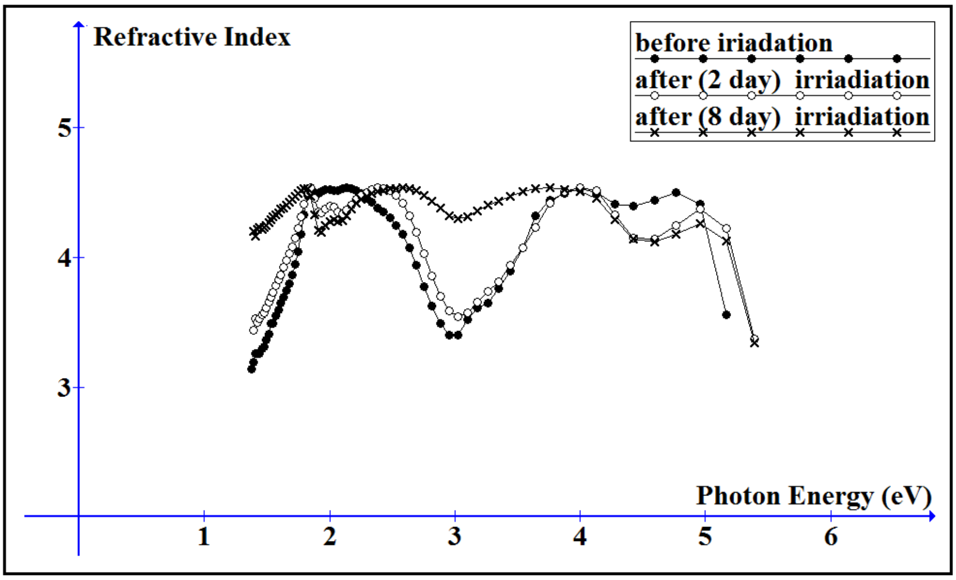

Figure (5) Refractive Index as a function of Photon energy

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

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

Extinction Coefficient (K_0) represents the imaginary part of complex refractive index and it can be defined as the amount of energy losing as a result of interaction between the light and the charge of medium, figure (6) shows the (k_0) as a function of Photon energy, the behavior of (k_0) is increases with irradiated .

The real (ε_r) and imaginary (ε_i) parts of the dielectric constant related to the (n) and (k) values. The (ε_r) and (ε_i) values were calculated using the form [11]:

$$\varepsilon_r = n_o^{\ 2} - k_o^{\ 2} \qquad \text{------------- (3)}$$

$$\varepsilon_i = 2 n_o k_o \qquad \text{------------- (4)}$$

the real and imaginary parts dielectric constant for (PMMA: blue methyl) before and after irradiated 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_r)and (ε_i) that the value of them The dielectric constants consists of real part (ε_r) and imaginary part (ε_i) ,the variations of them with photon energy were determined and shown in figure (7) and (8).

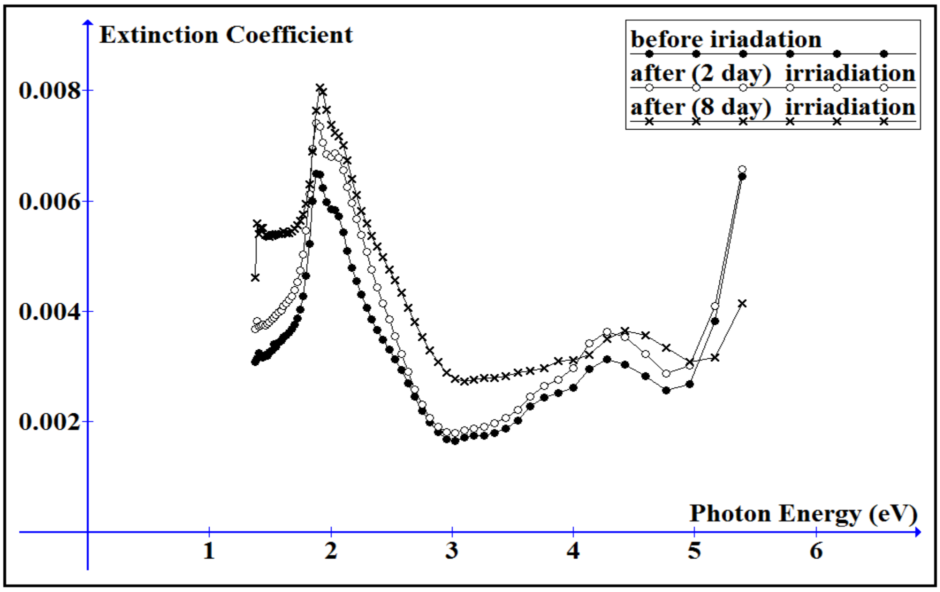

Figure (6) Extinction coefficient as a function of Photon energy.

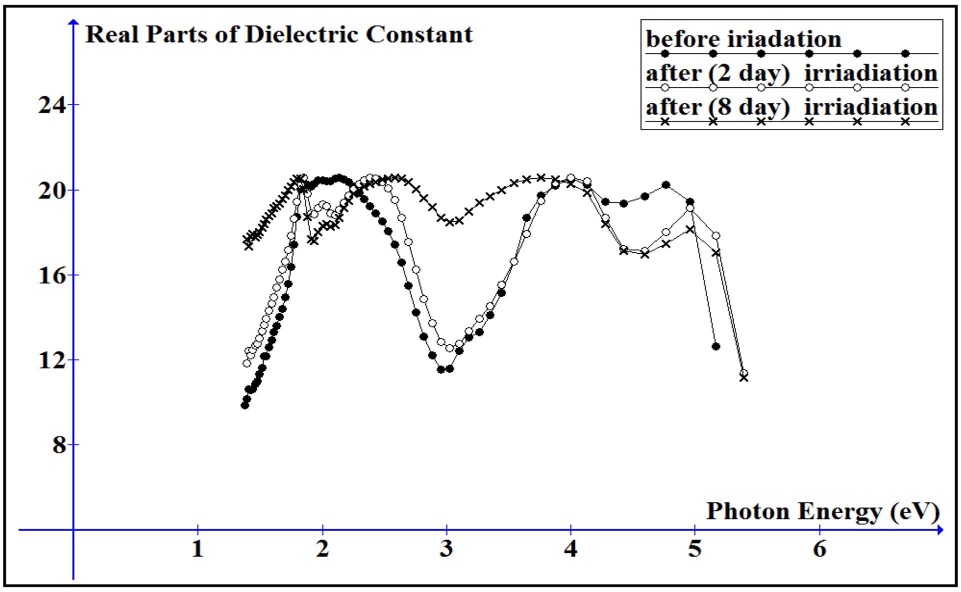

Fig. (7): Real part of the dielectric constant versus Photon energy.

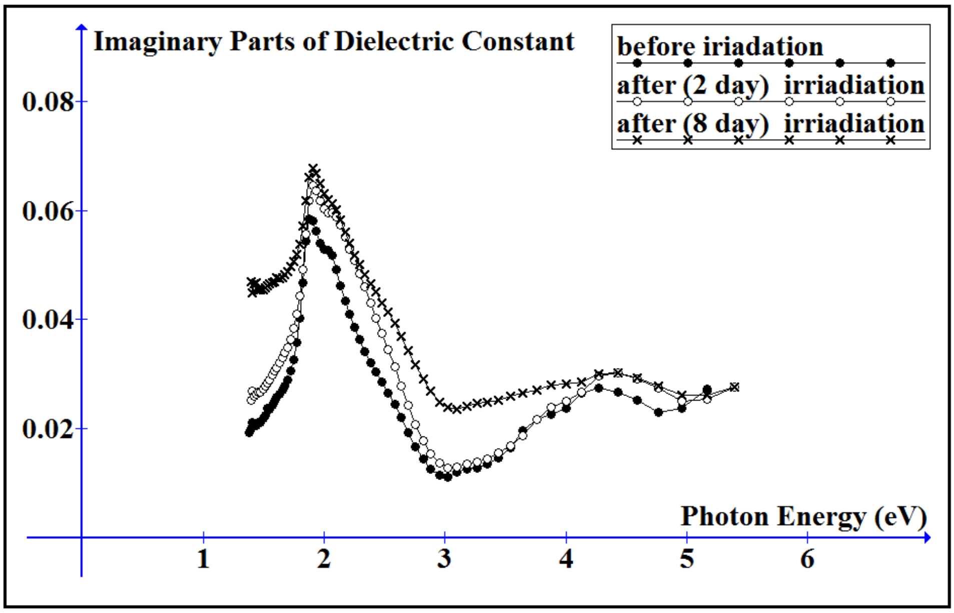

Fig. (8): Imaginary part of the dielectric constant versus Photon energy.

Conclusions:

Organic films of (PMMA: Blue methyl) are prepared by casting method. The actions of irradiation by gamma ray on (PMMA- Blue methyl) films are: decreasing the transmittance and energy gap from about (2.16eV) before irradation to about (1.97 eV) and (1.21 eV) after irradiation , and increasing the reflectance, refractive index , extinction coefficient and real part and imaginary part of dielectric constants after irradiation

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