Optical Dispersion Parameters of (PMMA doped red methyl) Irradiated by Gamma Rays

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Abstract:-

The dispersions of the refractive indices of (PMMA doped red methyl) films Irradiated by Gamma Rays have been determined using the Wemple-DiDomenico model . The oscillator energy E_0 , dispersion energy E_d , absorption coefficient and skin depth are calculated before and after irradiated . Drude's theory of dielectrics used to calculate carrier concentration N_{opt} . It's found that N_{opt} increases after irradiation .

Introduction

Poly methyl methacylatc (PMMA) have been widely used due to its attractive physical and optical properties and its broad applications. It is thermoplastic material with a good tensile strength and hardness, high rigidity, transparency, good insulation properties and thermal stability [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], as a result of the above properties, PMMA has been extensively used in various industrial sectors such as : substrate material for precision optics components, in fabrication of electronic memories , gas sensing [5-9].

Irradiation with X-rays, alpha, beta and gamma radiation also have a significant effect on polymer properties and some physical properties are usually modified [10].

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 [11].

The aim of the present article is to study the Optical Dispersion Parameters of the γ-irradiated PMMA films doped with 8% red methyl .

Experimental details

Poly (methyl methacrylate) from (sigma Aldrich comblt Germany) , chloroform has purity of 99.8% (PMMA doped red methyl) were dissolved separately in chloroform for 4 hour at room temperature. Appropriate mixtures of PMMA and 8% weight (red 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 20 ± 1 µm. the prepared samples were irradiated by gamma ray dose from (Cs-137) with activity (0.5 µ Ci), for days. The irradiation facility is at the College of Science , University of Diyala . Irradiation was carried out in air and at room temperature .

Absorbance and transmittance measurements were carried out using double bean UV/VIS spectrometer (shimadzu Japan) in the wavelength range (190-900) nm .

Results and discussions

The optical absorption coefficient (α) before and after γ-ray irradiation for (PMMA- red methyl) films as a function of photon energy range 1.12- 6.5 eV is plotted in Figure (1) . From this figure α (After irradiated) > α (Before irradiated),this is attributed to increase the defect states which leads to increase absorption coefficient.

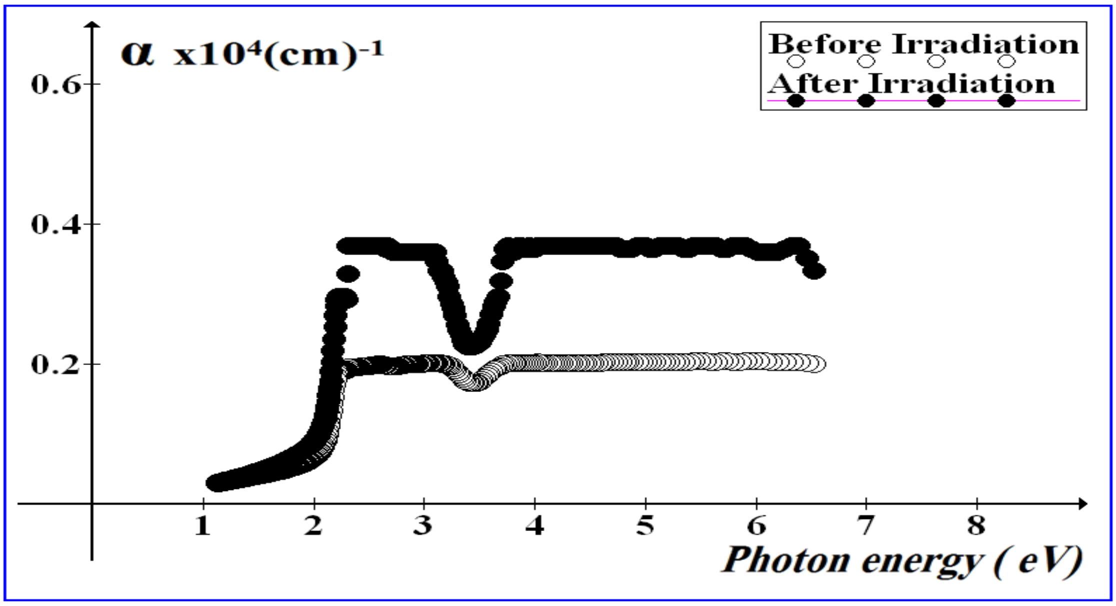


Fig. (1) Absorption coefficient versus Wavelength(nm)

Measured refractive indices were analyzed by using the Wemple-DiDomenico model in the region from visible to near-infrared By using equation (1) [12], we determined the dispersion parameters E_0 and E_d .

$$n^2 = 1 + \frac{E_d E_o}{E_o^2 - (h\upsilon)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where n is the refractive index, E_0 is the oscillator energy and E_d is the oscillator strength or dispersion energy.

The graph of $(n^2\text{-}1)^{-1}$ versus (photon energy)^2 were plotted and fitted to a straight line, as shown in Figure (2) for both films. The value of E_o and E_d can be directly determined from the slope $(E_o E_d)^{-1}$ and the intercept on the vertical axis, (E_o / d_o). The values of E_o and E_d are listed in Table (1).

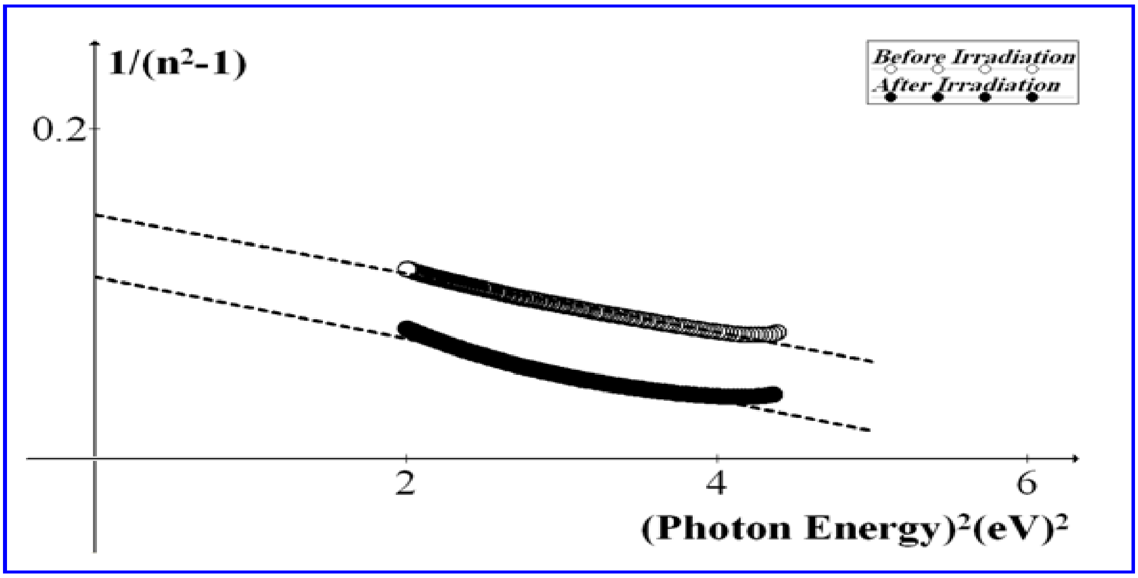


Fig. (2) $(n^2 \text{-}1)^{-1}$ as a function of (Photon energy)^2 .

We found that E_o value of the films is related empirically to the lowest direct band gap by $E_o \approx 2\, E_g$.The M_{-1} and M_{-3} moments of the optical spectra can be obtained from the relationship [13]:

$$E_o^2 = \frac{M_{-1}}{M_{-3}} \quad ; \quad E_d^2 = \frac{M_{-1}^3}{M_{-3}} \quad \text{------------- } \mathbf{(2)}$$

The obtained values are given in Table (1).

Table (1)

Type of Samples	E_o(eV)	E_d(eV)	E_g (eV)	M_{-1}	$M_{-3}$$(eV)^{-2}$
doped (PMMA)	2.88	19.6	1.44	6.8	0.82
Irradiation (PMMA)	2.43	22.13	1.215	9.1	1.54

When $(n_0)^2 >> (k_0)^2$ and $1 << \omega\tau$. where ω is the angular frequency of the lattice atoms , The real dielectric constant can be expressed as [14]:

$$\varepsilon_r = \varepsilon_L - [\frac{\varepsilon_L \omega_p^2}{\omega^2}] \quad ; \quad \omega_p^2 = \frac{e^2 . [N/m^*]}{\varepsilon_0} \quad \text{-----------} \quad (3)$$

Where ε_L is the lattice dielectric constant (or limiting value of the high frequency dielectric constant), ω_p the plasma frequency, e is the electronic charge, N/m^* carrier concentration to the effective mass ratio, and ε_o is the dielectric permittivity 8.85×10^{-12} F/m. Therefore, plotting ε_r vs. ω^{-2} in the NIR spectral region allow us to determine the values of the plasma frequency ω_p and lattice dielectric constant ε_L from the slope and intercept, respectively, the diagram is illustrated in Figure (3). These calculated values are listed in Table (2).

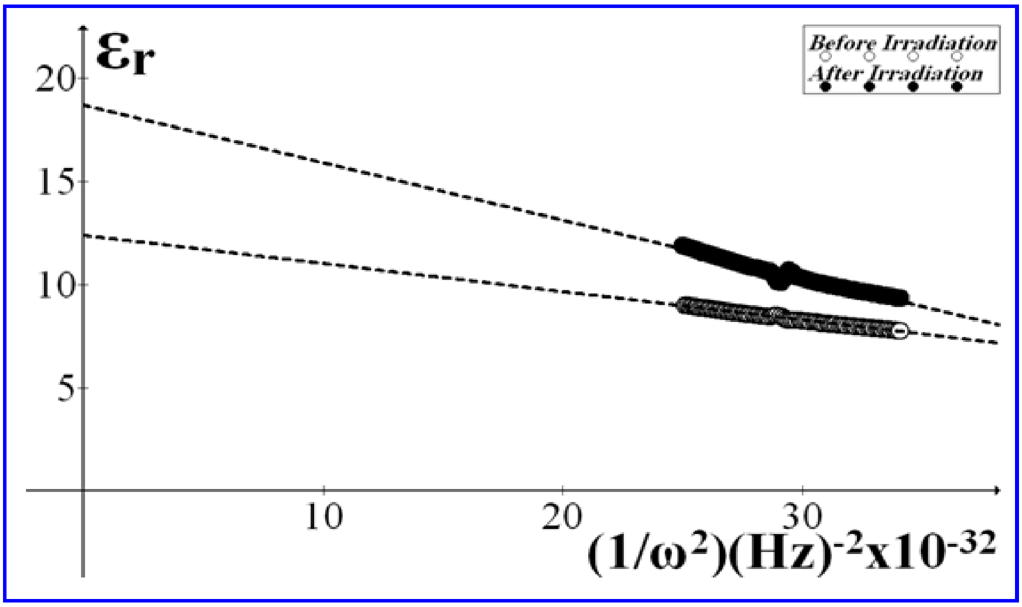


Fig.(3) Real dielectric constant vs. Reciprocal of square of angular frequency.

Table(2)

Type of samples	ε_L	$n=(\varepsilon_L)^{1/2}$	$\omega_p * 10^{15} s^{-1}$
doped (PMMA)	12.39	3.51	1.047
Irradiation (PMMA)	18.7	4.32	1.22

The refractive index can be analyzed to determine the long wavelength refractive index n_∞ and average oscillator wavelength λ_0 and oscillator length strength S_0 of the film. These values can be obtained using the single term Sellmeier oscillator [15].

$$n^2 - 1 = \frac{S_0 \lambda_0^2}{1 - \lambda_0^2/\lambda^2} \quad \text{-----------(4)}$$

Where $(n_\infty)^2=1+ S_0(\lambda_0)^2$ [8]. By drawing $(n^2-1)^{-1}$ versus $1/\lambda^2$ Figure (4) , we obtained the values of λ_0 , S_0 and n_∞ for both films, which are written in table (3).

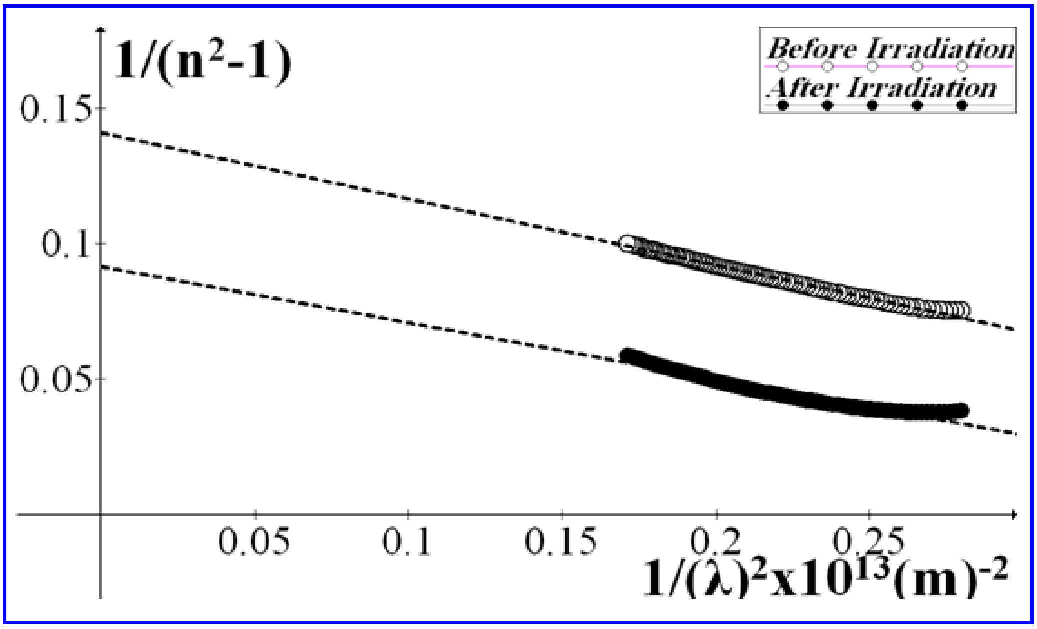


Fig. (4) $(n^2-1)^{-1}$ versus $(1/\lambda^2)$.

Table(3)

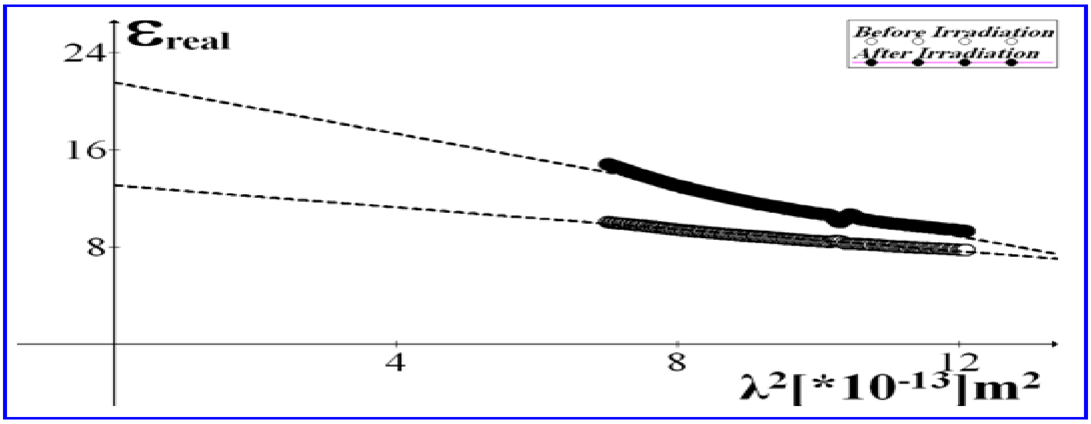
Type of samples	n_∞	λ_0[nm]	$S_0[m^{-2}]$
doped(PMMA)	3.44	475	4.83×10^{13}
Irradiation(PMMA)	2.84	416	4.103×10^{13}

The real dielectric constant ε', which results due to the contribution from the free carrier electric susceptibility, can be written by the following relation [16]:

$$\varepsilon' = \varepsilon_i - [(e^2/4\pi^2c^2\varepsilon_0)(N/m^*)]\lambda^2 \qquad \text{---------(5)}$$

where ε' is real part of dielectric constant, ε_i is the residual dielectric constant due to the ion core.

According to the free electron Drude model, ε_1 should be a linear function of λ^2 as it shown in Fig. (5).

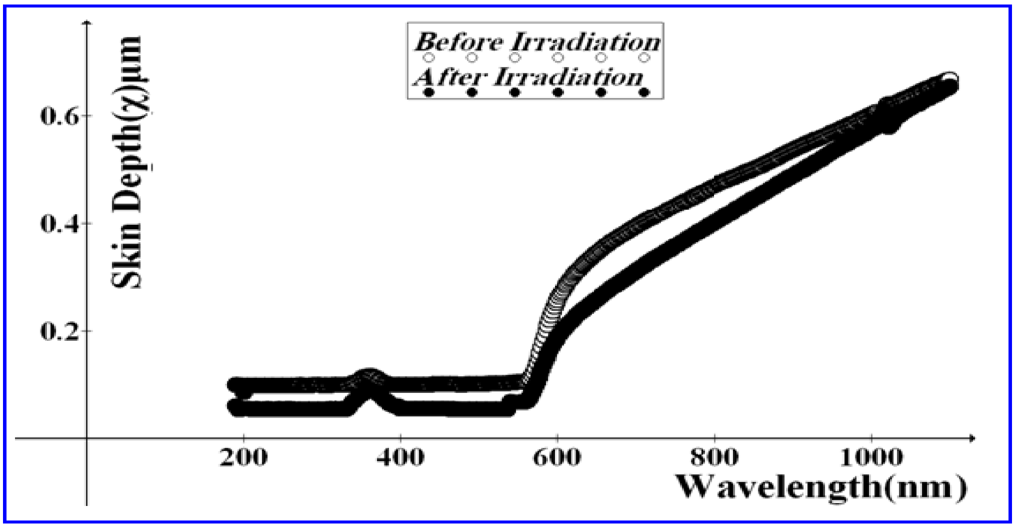


{ $N_{opt(8\%)}$=3.189*10^{24} m^{-3}, $N_{opt(8\%)}$=5.25*10^{24} m^{-3}}.

The electromagnetic will have its amplitude reduced by a factor 'e' after traversing a thickness (called the skin depth) such that:

$$\chi = \lambda / 2\pi k \qquad \text{----------(6)}$$

Which may be the order of 100 to several thousand angstroms, depending on the material [12]. skin depth decreases with irradiation as shown in figure (6), this might be due to increase the probability of absorption with irradiation .



Conclusions

The actions of irradiation by gamma ray on (PMMA doped red methyl) films are : increasing the absorption coefficient , concentration N_{opt} and dispersion energy E_d . oscillator energy E_0 and Skin depth decreased after irradiation .

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معلمات التفريق البصرية لـ(PMMA doped red methyl) المشععة بأشعة كاما

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<u>الملخص :</u>

حسبت معلمات التفريق لمعاملات الانكسار لأغشية (PMMA doped red methyl) والمشععة بأشعة كاما بأستخدام نموذج Wemple-DiDomenico. قيم طاقة الاهتزاز E_0 ، طاقة التفريق E_d ، معامل الامتصاص وعمق الاختراق حسبت قبل وبعد التشعيع . استعملت نظرية درود للعوازل لحساب تركيز الحاملات N_{opt} ووجد أنها تزداد بعد عملية التشعيع .