Effect of Gamma radiation on the Structural and Optical properties of PVA: CuO films.

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ABSTRACT

In this research, the study effect irradiation on structural and optical properties of film (PVA: CuO) by casting method, with thickness of (20±1) µm. And used Cs^{137} to obtained Gamma ray with energy (662)KeV and time irradiation(50)h and affectivity (4.3) ci. The investigation of (XRD) indicates that the (PVA: CuO) films are polycrystalline. The results of the measuring the grain size increasing after irradiation with gamma ray from (6.424-9.091)nm. The absorbance and transmittance spectra have been recorded in the wavelength range (300-1100) nm. Results show that the optical band gap for (PVA: CuO) increasing after irradiation with gamma ray from (2.3-2.7)eV. And the absorption coefficient, extinction coefficient, refraction index, the finesse coefficient and the optical conductivity are increase after irradiated with gamma ray .

Keywords: film PVA: CuO , irradiation

الخلاصة:

في هذه البحث تم دراسة تاثير التشعيع على الخواص التركيبية والبصرية لاغشية بوليمر فينال الكحول المشوبة باوكسيد النحاس والمحضرة بطريقة الصب وبسمك µm (20±1) ,وقد استخدم المصدر المشع Cs^{137} ذو طاقة 663KeV للحصول على اشعة كاما وكان زمن التشعيع (٥٠) ساعة وبفعالية ci(4.3) .

وباستخدام تقنية حيود الاشعة السينية وجد ان اغشية بوليمر فينال الكحول المشوبة باوكسيد النحاس ذات تركيب متعدد التبلور وتم حساب الحجم الحبيبي قد جد انه يزداد بعد التشعيع باشعة كاما من nm(6.424-9.091). اما طيف الامتصاصية والنفاذية فقد سجل

ضمن مدى الطول الموجي (300−1100) وقد وجد ان فجوة الطاقة تزداد بعد التشعيع باشعة كاما من 2.3−2.7)eV) اما معامل الامتصاص ،معامل الخمود ،معامل الانكسار،ومعامل الجودة والتوصيلية البصرية تزداد بعد التشعيع باشعة كاما.

Introduction

Poly(vinyl alcohol) (PVA) is one of the most important polymeric materials as it has many applications in industry and is of relatively low cost[1].

Polyvinyl alcohol (PVA) is molecular formula is $(C_2H_4O)_x$, and density is between (1.19 - 1.31) g/cm^3. PVA has a melting point of 230°C. It decomposes rapidly above 200°C, as it can undergo pyrolysis at high temperatures[2].

Polymer blend done by mixed two or three polymers or added materials to in order to improve the properties of polymers [3,4]. One of these materials metals or salts. A metal, in atomic or ionic state, introduced into a polymer matrix, generally improve the polymer behavior and as a rule of composite materials, new properties, different of both matrix and filler ones, could be evidenced.

Thin film dosimeters are of interest for use in radiation processing because of their convenient characteristics. The irradiation processing is being used for several purposes, i.e., food irradiation, sterilization of surgical equipment, polymerization and cross-linking of polymers [5]. Radiation indicators based on their radiation-induced color change have long been used for identification of irradiated and un irradiated products in radiation sterilization and food irradiation. Due to their sensitivity towards various influencing factors (dose rate, light, humidity, temperature etc.) these are used for quantitative purposes[6].

Sreelalitha et al [7] studied Optical Properties of Pure and Doped (KNO_3 and $MgCl_2$) Polyvinyl Alcohol Polymer Thin Films were synthesized using solution-casting method.

Antar[8],studied PVA doped with Crystal violet and carbol fuchsine films were prepared using dipping method. The spectral behavior and the effects of dose on the absorption coefficient, optical energy gap, refractive index and extinction coefficient were investigated. The optical energy gap estimated and found to be 1.85 eV and 1.65 at 70 Gy.

Meena et al[9] studied madean attempt to disperse CuO nanoparticles in the polyvinyl alcohol (PVA) and to understand the change in structural, optical and electrical properties of the polymer film. CuO nanoparticles were added in four concentrations(2.5, 5.0, 7.5 and 10) %.

Sayeda et al,[10]studied Ferrotitanium alloy polymer films, prepared by a simple technique of casting aqueous solutions of poly(vinyl alcohol) PVA containing ferrotitanium alloy on a horizontal glass plate, are useful as routine high-dose dosimeters

In the present work study the structural and optical properties of polyvinyl alcohol (PVA) doped with copper oxide (CuO) and irradiation effect, were exposed to Cs^{137} γ-radiation source.

Experimental

A poly vinyle alcohol (PVA) solution was prepared by adding deionzied distilled water to solid PVA ($- C_2 H_4O)_n$ (with average molecular weight 30,000 – 70, 000) and then stirred by a magnetic stirrer at 50 ℃ for (two) h., a solution of $CuCl_2H_2O$ was prepared by adding deionized distilled water to solid $CuCl_2H_2O$ and then stirred by a magnetic stirrer at room temperature for (one) h. Appropriate mixtures of PVA and $CuCl_2H_2O$ solution were mixed concentration of (6%).

The solution was poured into flat glass dish. Homogenous films were obtained after drying in an oven for (1 h) at 50 ℃ .the film thickness was measured with the help of thickness gauge (indicating micrometer) and was found to be 20 ±1μm. Investigate the structure of the polymer by X-ray diffraction studies were carried out using type (SHIMADZU Japan) XRD600,wave length 1.541 A˚.

Absorptance and transmittance measurement were carried out using (UV-visible 1800 spectra photometer) in the wavelength range (200 – 1100) nm.

And used Cs^{137} to obtained Gamma ray with energy(662)KeV and time irradiation(2day+2h) and effective(4.3)ci.

Results and discussion

XRD spectrum of CuO doped PVA films before and after irradiation are shown in figures (1). The diffraction pattern of PVA indicates a diffraction band at 2θ = 16.9729˚, 17.0734 . It is well known that the peaks at 2θ< 20˚ are due to crystalline nature of PVA polymer molecular. The intensity from films has been increased after the irradiation process and became sharper due to crystallinity The average size of grains has been obtained by use of the scherrers formula [11,12]:

$$D = \frac{K\lambda}{\beta cos\Theta} \quad ....(1)$$

Where D is the grain size, K is a constant equal to 0.94, **β** is the full width at half maximum (FWHM) and λ is the wave length (1.541) nm and 2θ is the Bragg angle.

obtained average grain size value (6.424) nm before the irradiation and(9.091) nm after the irradiation. The increase may be attributed to the improvement of growth crystalline that leads to crystallinity ..

Fig. (2) shows the relation between absorbance and wavelength, we found the behavior of curves is the same for each curves. The rapid increase of the absorption in the low energy and sudden increase in special energy , and the absorbance decrease after irradiation that it is related to changes in film structure

Fig. (3) shows the transmittance spectrum in the rang (300 – 1100)nm, It is clear from this figure that transmittance spectra for all films increased with increasing wavelength. and the transmittance increase after irradiation , it is clearly seen that the average optical transmission values in the visible region for films are low. The average optical transmittance in the wavelength region (from 500 to 1100 nm) of as- deposited PVA films is about 78%, while after irradiation about 88% This effect of on the transmission of PVA films may be due to the some physical effects such as structural, surface irregularity, and defect density.

The optical absorption coefficient (α) of PVA films is very important to determined kind of electronic transition if ($\alpha > 10^4$) the transition is direct and if ($\alpha \leq 10^4$) the transition is indirect [13].

We used the following equation to determine the absorption coefficient [13]:

$\propto = \frac{2.303\,A}{d}$ ....(2)

Where A is the absorbance, d is the film thickness

Fig. (4) shows the dependence of the absorption coefficient on the photon energy for samples before and after irradiation

The optical energy band gap is determined by the following equation [14]:

$\propto E = B(E - E_g)^r$ ....(3)

Where B is a constant and the exponent (r) is an empirical index, which is equal to 2, 3, ½ and 3/2 depending on the nature of electronic transition responsible for the absorption. The plot of the product of absorption coefficient and photon energy $(\alpha h\nu)^{1/2}$ versus the photon energy hν at room temperature shows a linear behavior, which can be considered as an evidence for direct transition [14]. Extrapolation of the liner portion of this curve to a point $(\alpha h\nu)^{(1/2)} = 0$ gives the optical energy band gap E_g for the PVA: CuO films before and after irradiation which can be considered as an evidence for indirect transition.
The optical properties parameters including , absorption coefficient , optical energy gap, and optical constants (refractive index, extinction coefficient ,) at wavelength equals to 400 nm for PVA(before) and PVA(after) irradiation are listed in table (2).
Fig. (6) shows the dependence of the extinction coefficient on the photon energy the extinction coefficient can be related by the equation [15].

$K = \frac{\propto\lambda}{4\pi}$ ....(4)

The extincstion coefficient (k) behaves just like the absorption coefficient(α) because they are joined by previous relation(2). this is due to increase in absorption coefficient the extinction coefficient values increased.
The refraction index n value provides the optical properties of the film and it is related by the fallowing equation [16].

$n = \frac{(1+\sqrt{R})}{(1-\sqrt{R})}$...(5)

Where R is the reflectance was calculated depended energy save law using the relation: [16,17]
R + T+ A = 1 .... (6)
The refraction index n value provides the optical properties of the film and it is related by the equation (5) , the value of refractive index within the

constant range was varying from (1.998 – 2.027) as the irradiation. Fig.(7) shows the relation between refractive index and photon energy.

Also, the finesse coefficient is given by[4]:

$$F=\frac{4R}{(1-R)^2} \ldots\ldots(7)$$

the finesse coefficient is given by the equation (7) fig. (8) shows the relation between finesse coefficient and photon energy. we found the behavior of curves is the same for curves of refractive index

The optical conductivity was calculated using the relation[16-18]

$$\sigma =\frac{\alpha n c}{4\pi} \ldots\ldots(8)$$

where c:the velocity of light in the space
fig. (9) shows the relation between optical conductivity and photon energy. The optical conductivity increased after irradiation in low photon energy and decreased in the visible range.

The increased optical conductivity at low photon energies is due to high absorbance of film in that region. The optical conductance and band gap indicated that the films are transmittance within the visible range.

Conclusions:

1- increase in band gap for PVA after irradiation.

2-The optical constants of polyvinyl alcohol (absorption coefficient, refractive index extinction coefficient, real and imaginary dielectric constant) are changing after irradiation.

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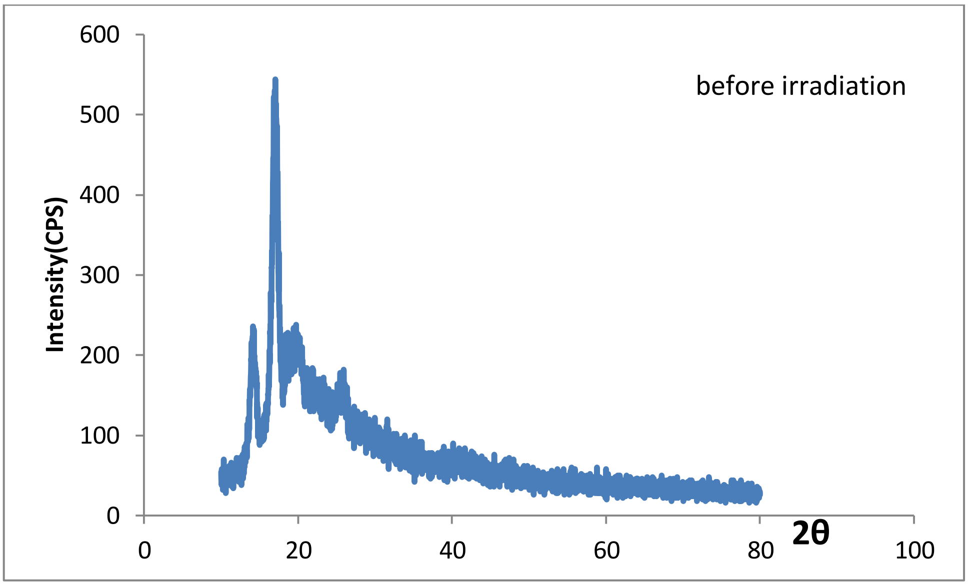
Table 1: grain size and band gap for PVA(before) and PVA(after) irradiation

Sa	Gs nm	Eg eV
Before	6.424	2.3
After	9.091	2.7

Table 2: The optical properties parameters of PVA(before) and (after) irradiation

at λ=400					
Sa.	$\alpha(cm^{-1})$	n	K	F	$\sigma_{o.p}$ x10^{11}
PVA(before)	253.3	1.998	0.0008	1.049	7.229
PVA(after)	302.8	2.0276	0.00096	1.169	8.763



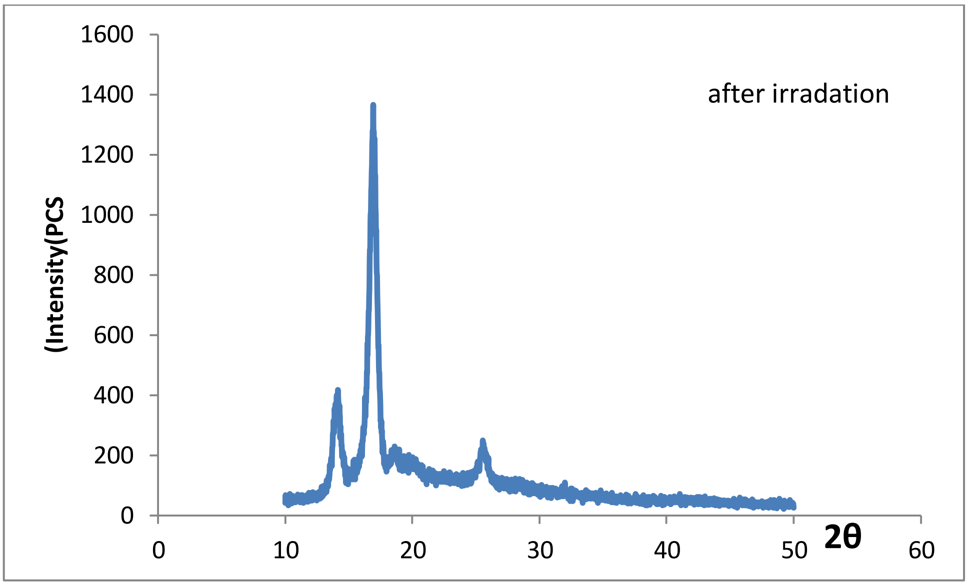


Fig.(1) The X-ray diffraction (XRD) for the polyer before and after (rad.).

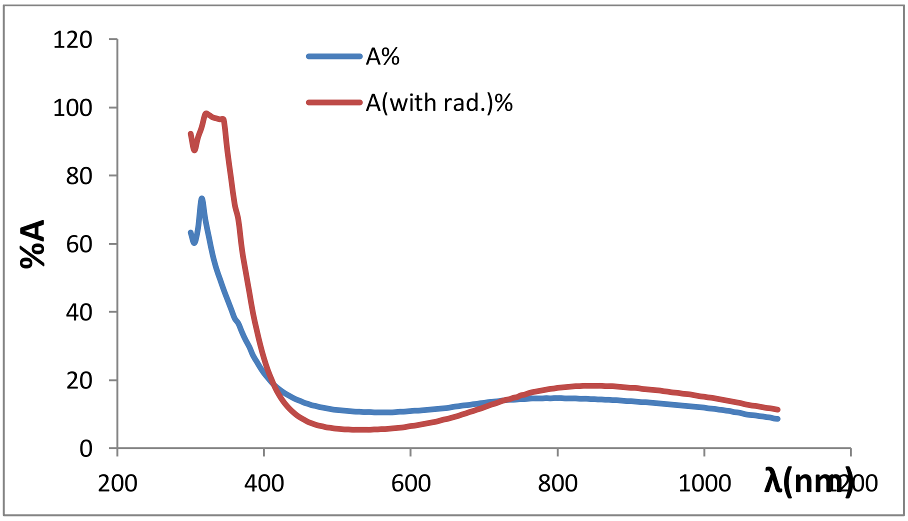


Fig. (2)The relation between absorbance and wave length

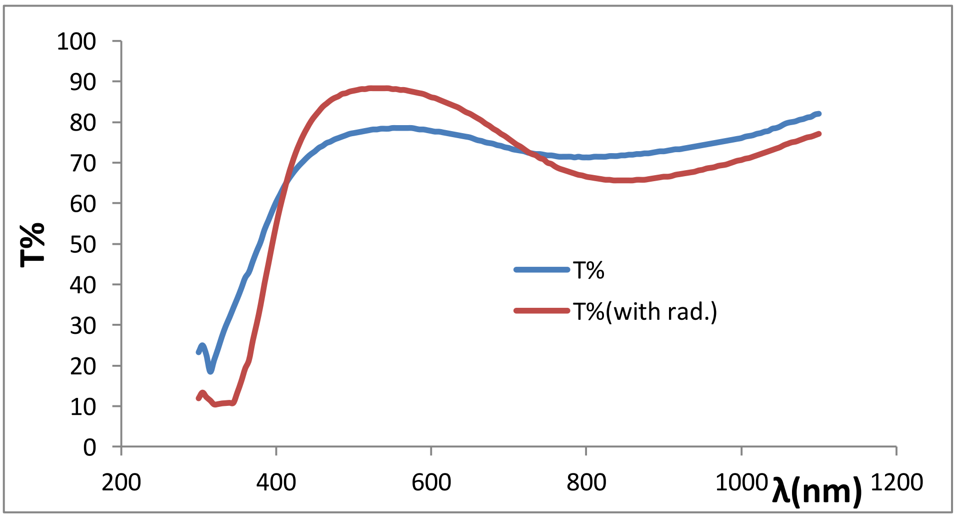


Fig.(3) The relation between transparent and wave length

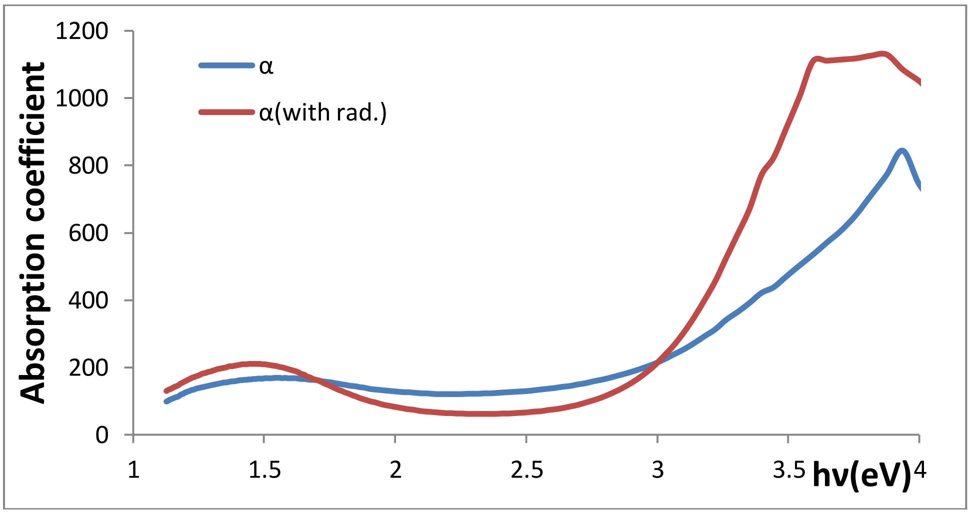


Fig. (4) The relation between absorption coefficient and photon energy

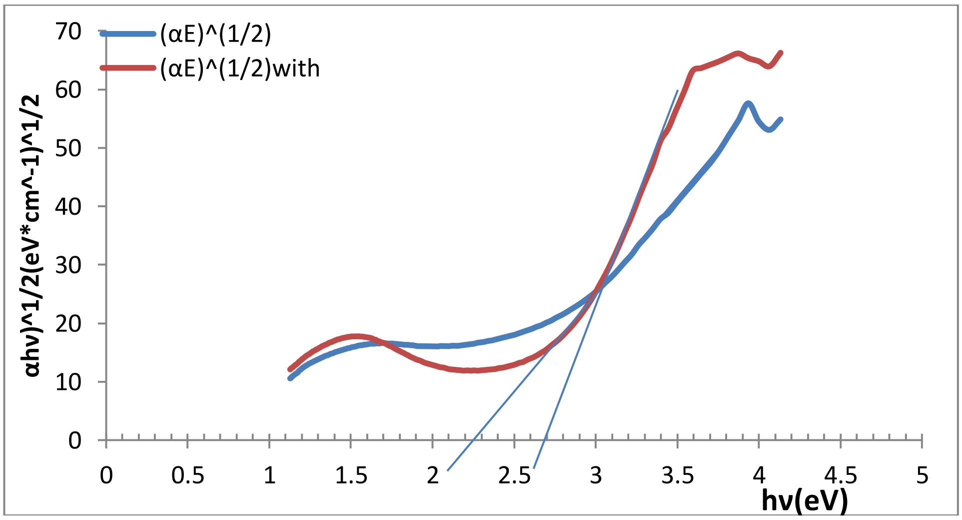


Fig.(5) The relation between$(\alpha h\nu)^{(1/2)}$and photon energy

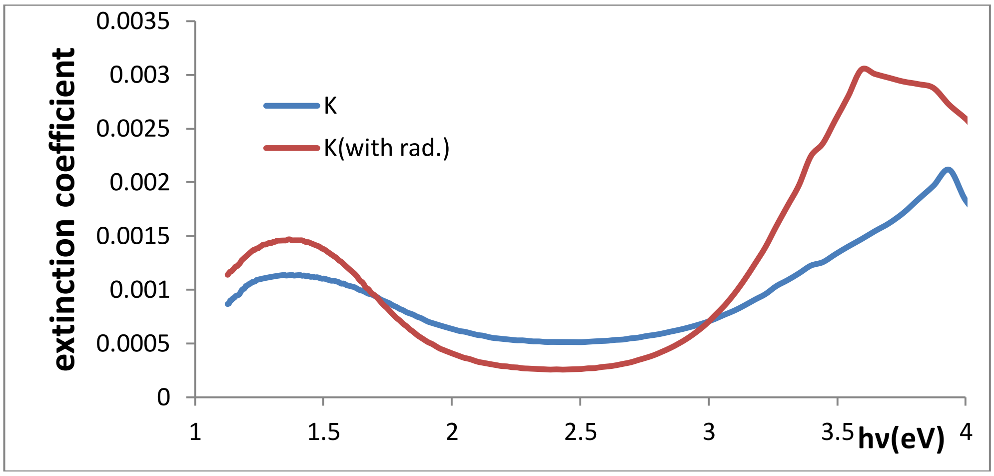


Fig. (6)The relation between extinction coefficient and photon Energy

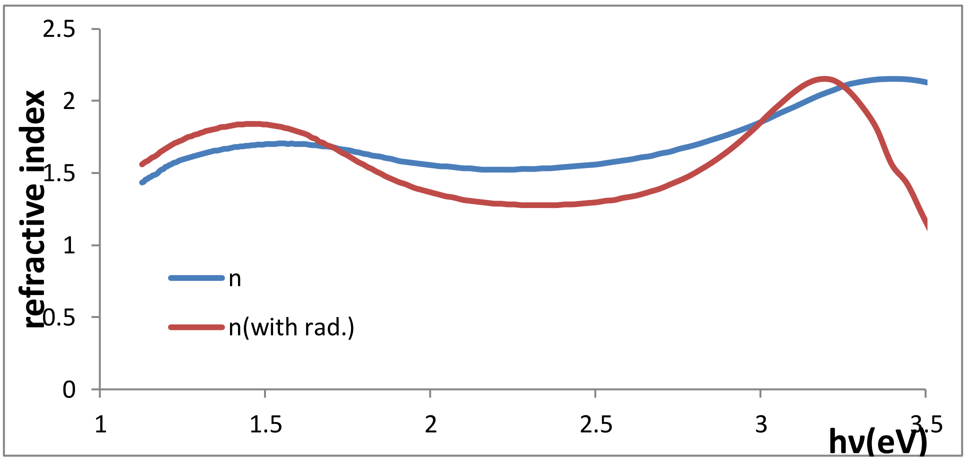


Fig.(7)The relation between refractive index and photon energy

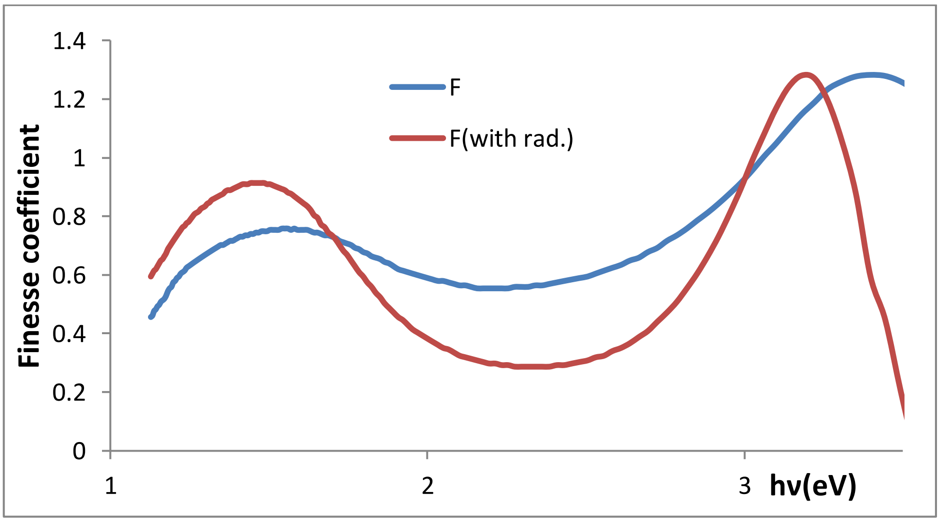


fig. (8)The relation between the finesse coefficient and photon energy

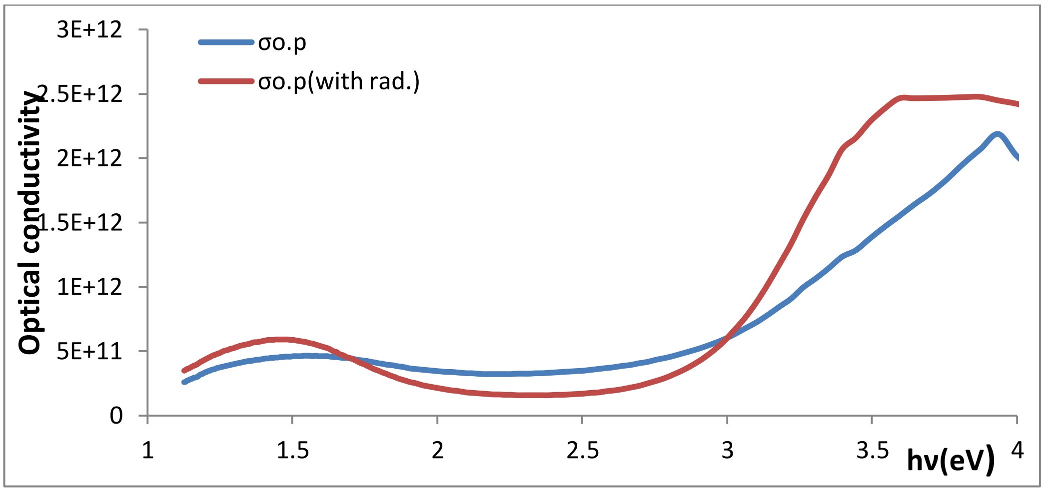


fig.(9) The relation between optical conductivity and photon energy