Effect of Thickness Variation on The Optical Properties of PVA: Ni $(CH_3COO)_2$ films

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Abstract

(PVA: Ni $(CH_3COO)_2$) films with different thicknesses were prepared by casting method. The thickness of the prepared films were (15, 20and 25) μm . The optical transmission (T %)was measured in the wavelength range of (190-900) nm .The effect of thickness increasing on optical properties such as transmittance, reflectance, absorption coefficient, refractive index, extinction coefficient in addition of the Real and Imaginary Part of dielectric constant was studied. This study reveals that all these parameters affected by the increasing of the thickness, and it also found that the optical energy gap has been increased with the increasing of the thickness, but the Urbach energy was decreased with the increasing of the thickness.

Keywords: PVA , optical properties , Ni $(CH_3COO)_2$

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تأثير تغيير السمك على الخصائص البصرية لاغشية

PVA: Ni $(CH_3COO)_2$

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الخلاصة

حضرت أغشية بولي فينيل الكحول المشوبة بخلات النيكل بأسماك مختلفة باستعمال طريقة الصب. سمك الأغشية المحضرة كان (25 , 20 , 15)µm. قيست النفاذية البصرية (T%) بمدى الأطوال الموجية (190-900)nm , تم دراسة تأثير زيادة السمك على الخواص البصرية مثل : النفاذية , الانعكاسية , معامل الامتصاص, معامل الانكسار , معامل الخمود , وثابت العزل بجزئيه الحقيقي والخيالي . توصلت هذه الدراسة إلى أن كافة هذه المعلمات قد تأثرت بزيادة السمك,كذلك وجدنا بأن فجوة الطاقة البصرية ازدادت بزيادة السمك. وتبين نقصان طاقة اورباخ مع زيادة سمك الغشاء.

الكلمات المفتاحية: بولي فينيل الكحول , الخصائص البصرية , خلات النيكل

Introduction

Attention has been focused on Poly vinyl alcohol (PVA) for more than (40 years) because of its unique chemical and physical properties as well as its industrial applications. The optical uses of (PVA) are concerned with the retardation, polarization and filteration of light, and with photography [1]. (PVA) is a hydrophilic biodegradable polymer which is mainly composed of C-C bonds [2,5].

It has been selected as polymer matrix in view of its film-forming capacities, hydrophilic properties and high density of reactive chemical functions favorable for cross-linking by irradiation, chemical or thermal treatments. (PVA) has been studied extensively due to its several interesting physical properties which are useful for scientific applications. Various research groups studied the effect of doping on optical, thermal, structural and other microstructural properties of (PVA) [3,4] .

The PVA is an important material regarding to its large scale of applications. It is used in surgical devices, sutures, hybrid islet transplantation, implantation, blend membrane [6], and in synthetic cartilage in reconstructive joint surgery. A new type of soft contact lens was developed from (PVA) hydrogel prepared by low temperature crystallization technique [7]. (PVA) is also used in sheets to make bags for premeasured soap, for washing machines, or to make longer bags used in hospitals.(PVA) was selected as the hydrogel component based on its favorable water soluble, desirable physicochemical properties, and its biocompatibility. Furthermore, chemically cross linked PVA hydrogel has been gaining increasing attention in the field of biomedics [8].

The aim of this work is to study the effect of thickness' variation on optical properties of (PVA: Ni $(CH_3OO)_2$) films which was prepared by using solvent casting method.

Experimental procedure

The materials used in this study are poly-vinyl alcohol with molecular weight 10000 g/mol ,supplied by (BDH chemicals, England) with high purity were used as basic polymeric materials Ni $(CH3COO)_2$. The weight percentages of Ni $(CH3COO)_2$ are (10 wt.%). (PVA: Ni $(CH3COO)_2$) composite films were prepared by solution casting method. Homogenous films were obtained after drying in an oven for (24 hours) at (40 C°) , The thickness of the produced films was in the range of (15, 20, and 25) µm and the average area of the sample was (3×3 cm^2).

The transmittance and absorbance measurements were carried out using a Shimadzu UV/VIS-160A double beam spectrophotometer in the wavelength range of (190-900) nm.

Results and discussions

The optical transmission spectra as a function of wavelength in the range of (190-900)nm is shown in Fig. (1). we can observe from this figure that the transmittance decreases with increasing the thickness. This may be attributed to the creation of levels at the energy band by increasing thickness and this leads to the shift of peak to smaller energies [9].

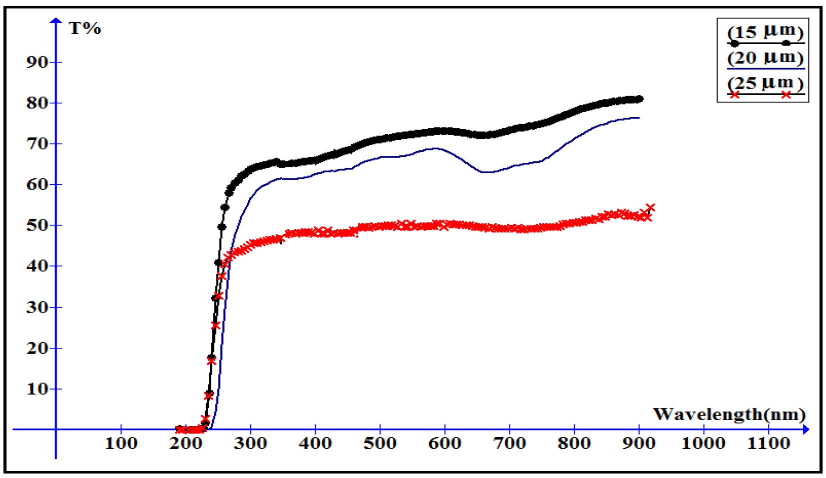

Fig. (1) Transmission Spectra of (PVA:Ni $(CH_3COO)_2$) versus wavelength at different thickness films.

From the Fig.(2) which illustrate the reflectance spectra versus wavelength for different sample. It appear that the films prepared at (25µm) have higher reflectance value than those prepared at (20 µm , 15 µm). And it is obvious that this behavior is opposite to that of the transmittance spectrum.

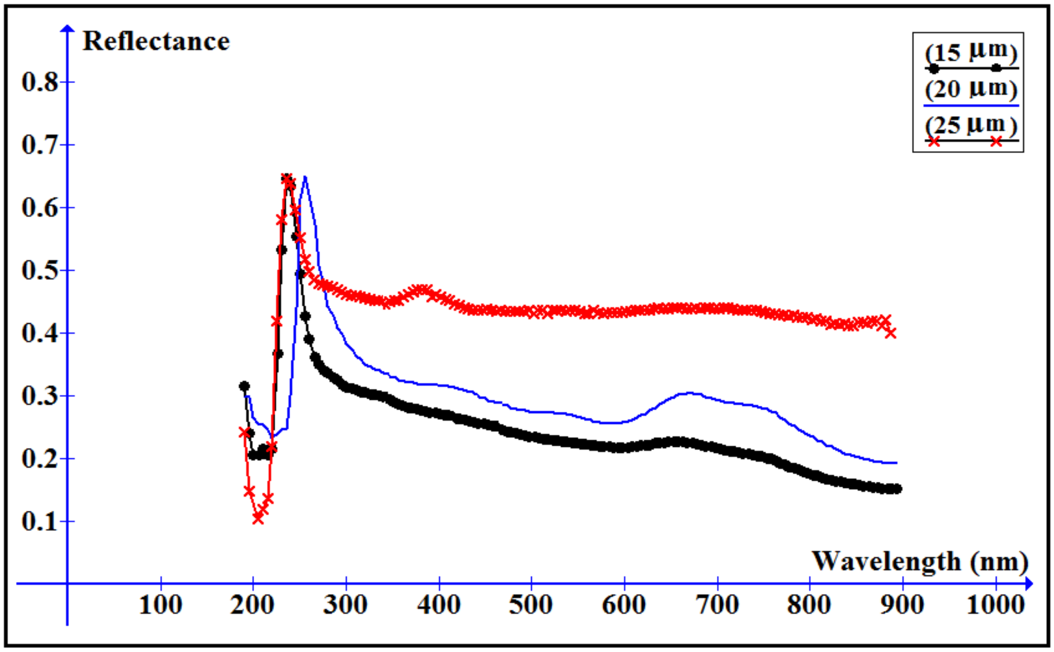

Fig. (2) Reflectance Spectra of (PVA:Ni $(CH_3COO)_2$) versus wavelength at different thickness films.

The absorption coefficient (α) of the present materials strongly depends on optical transmission, reflection, and thickness of film which is evaluated using the relation[10]:

$$\alpha = \frac{2.303\ A}{t} \qquad \text{------------- (1)}$$

Where (A) is the absorption and (t) is the film thickness.

From Fig. (3) absorption coefficient increased with increases of thickness, at higher photon energy (α) takes higher value and then increases with increasing photon energy.

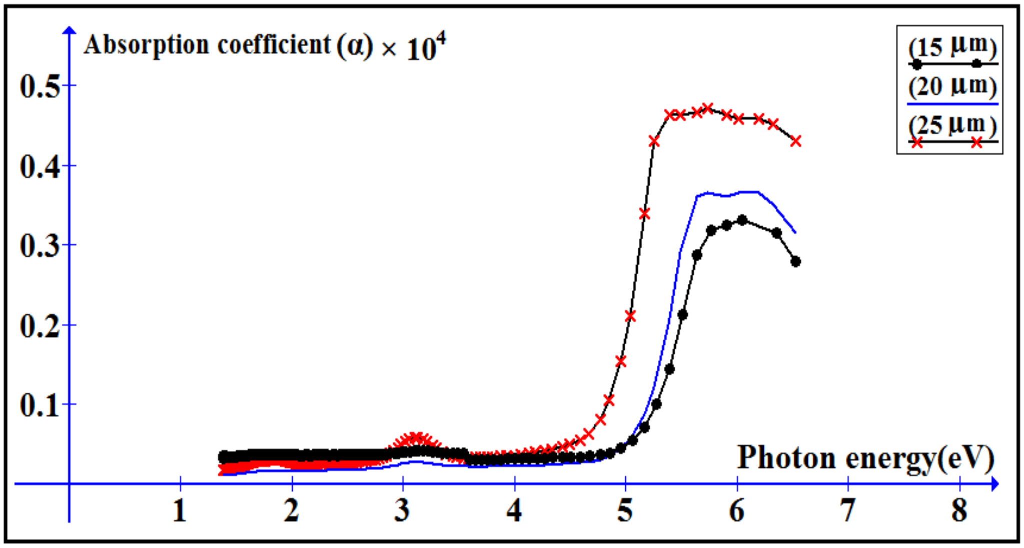

Fig. (3) Absorption Coefficient of (PVA: Ni $(CH_3COO)_2$)versus photon energy for different thickness films.

As an indirect band gap, (PVA- Ni $(CH_3OO)_2$) films has an absorption coefficient (α) obeying the following relation [11,12].

$$(\alpha h \upsilon)^{1/2} = A \ (h \upsilon - E_g) \qquad \text{------------- (2)}$$

Where (E_g) is the optical band gap of the films, (A) is a constant and (hν) is the incident photon energy.

The variation of $(\alpha h\nu)^{1/2}$ versus photon energy for (PVA- Ni $(CH_3OO)_2$) films at different thickness (15, 20, 25) μm are plotted in Fig. (4) , and (E_g) can be evaluated by extrapolation of the linear part to (4.49 eV), (4.87 eV), (4.90 eV) respectively. The existence and variation of energy gap (E_g) may be explained by invoking the occurrence of local cross linking within the amorphous phase of the polymer, in such a way as to increase the degree of ordering in these parts [13]. In general optical energy increases with increases thickness as illustrated in Fig. (5) which shows the relationship between thickness films and the energy gap.

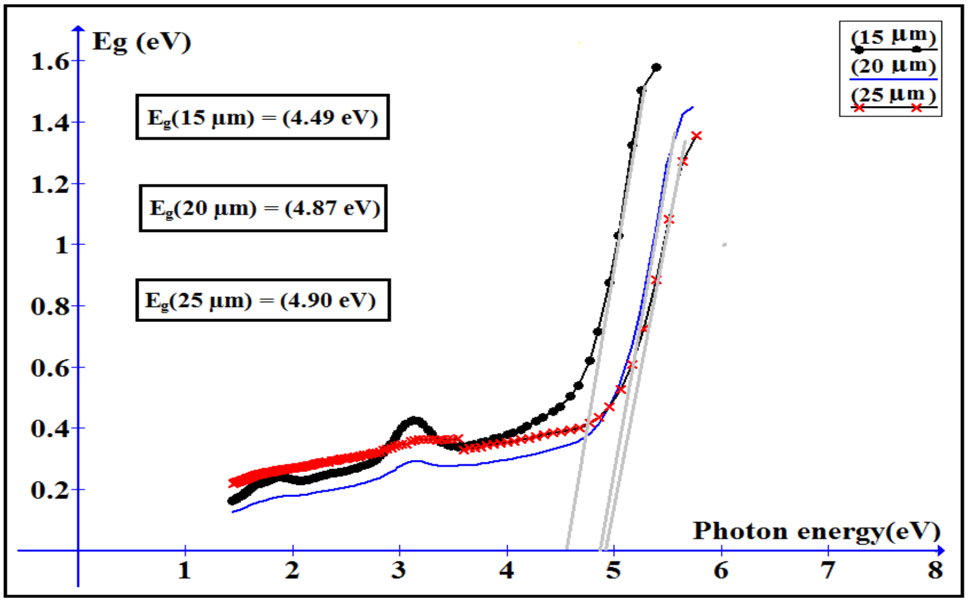

Fig. (4) Optical Energy Band Gap of (PVA: Ni $(CH_3COO)_2$)versus photon energy for different thickness films.

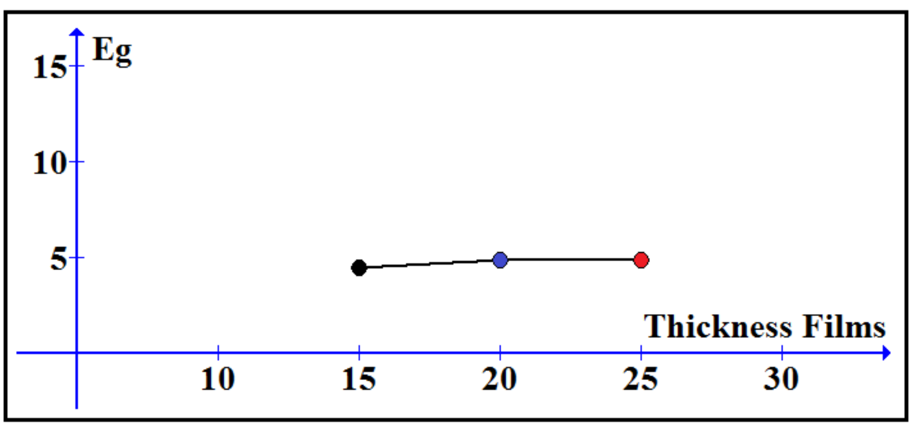

Fig. (5) The dependence of energy gap on Thickness Films for (PVA: Ni $(CH_3COO)_2$) samples

the absorption is due to electronic transitions between valence-band-tail and conduction-band states and depends exponentially on photon energy according to the Urbach relation as follows [14,15]:

$$\alpha = \alpha_0^{\,(h\upsilon/E_e)} \text{ ------------- } (3)$$

Where (E_e) is the Urbach energy, hν is photon energy. Fig. (6) shows the relationship between ln(α) and photon energy. The value of $E_{e\,(15\mu m)}$= (0.33 eV) , $E_{e\,(20\mu m)}$= (0.31 eV) and $E_{e\,(25\mu m)}$= (0.29 eV) , this might due to decrease dangling bonds, defects and the trapping of the generated carriers as a result of increasing thickness. Fig. (7) shows the relationship between thickness films and the Urbach energy.And the values of

(E_g)and (E_e)are listed in Table (1).

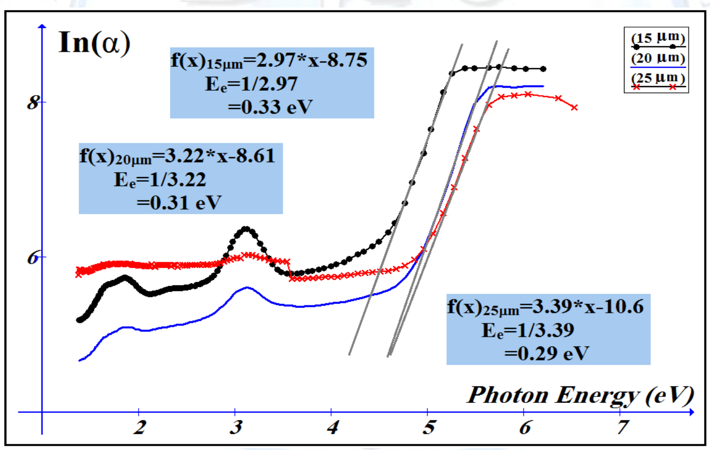

Fig. (6) Relation between ln(α) and photon energy of (PVA: Ni $(CH_3COO)_2$)with different thickness films

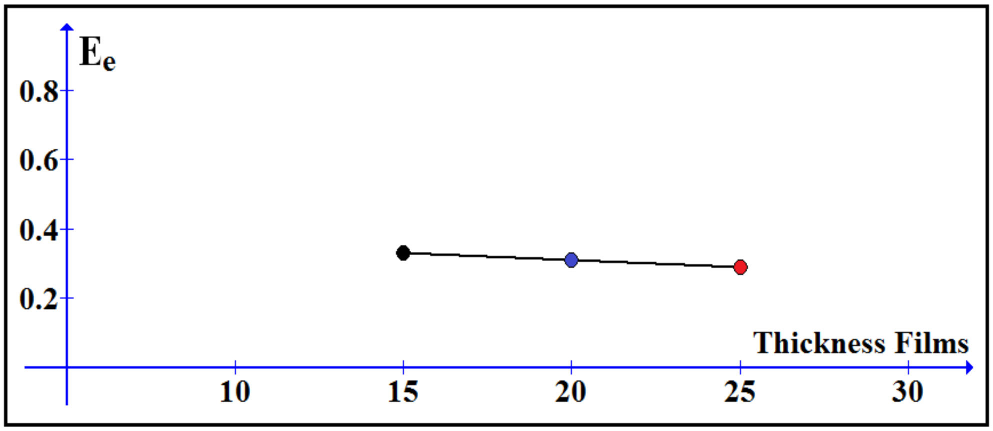

Fig. (7) The dependence of Urbach energy on Thickness Films for

(PVA: Ni $(CH_3COO)_2$) samples

Table(1)

Type of samples	E_g(eV)	E_e(eV)
PVA: Ni $(CH_3OO)_2$ For 15 µm	4.49	0.33
PVA: Ni $(CH_3OO)_2$ For 20 µm	4.87	0.31
PVA: Ni $(CH_3OO)_2$ For 25 µm	4.90	0.29

Fig (8) shows the variation of refractive index (n_o) as function of wavelength (λ) . The refractive index (n) can be determined from the reflectance (R) using the relation [16]:

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

Where k_o is Extinction Coefficient

It is clear that (n) of (PVA- Ni ($CH_3COO)_2$) films increases with increases of thickness films.

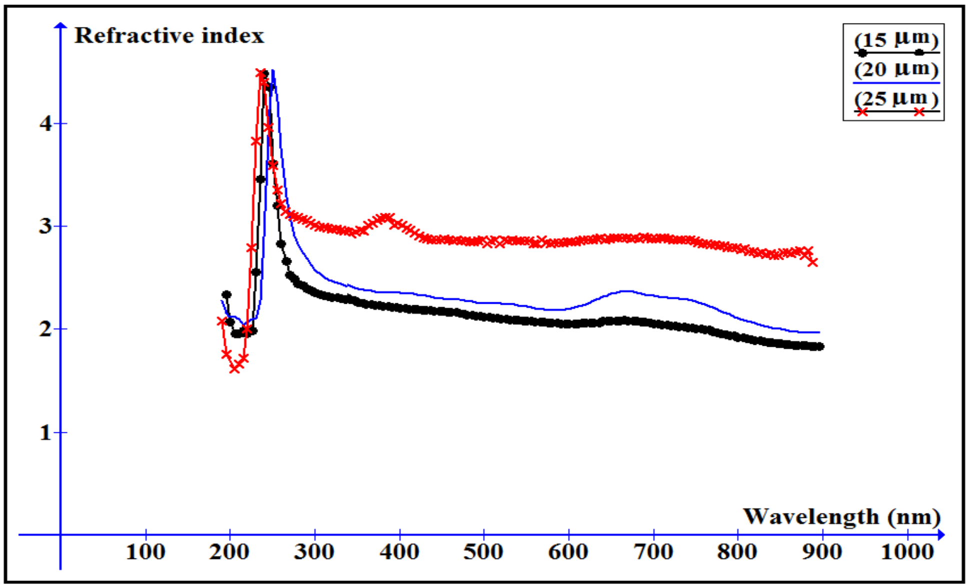

Fig. (8) Refractive Index of (PVA: Ni ($CH_3OO)_2$)versus wavelength for different thickness films.

The extinction coefficient (k_o) describes the properties of the material to light of a given wavelength and indicates the amount of absorption loss when the electromagnetic wave propagates through the material [6], Fig. (9) shows the variation in the extinction coefficient with wavelength of (PVA- Ni (CH3OO)$_2$)at different thickness films. The extinction coefficient (k_o) is directly proportional to the absorption coefficient as see in relation [17]:

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

It can be notice that the extinction coefficient increased as the film thickness increase.

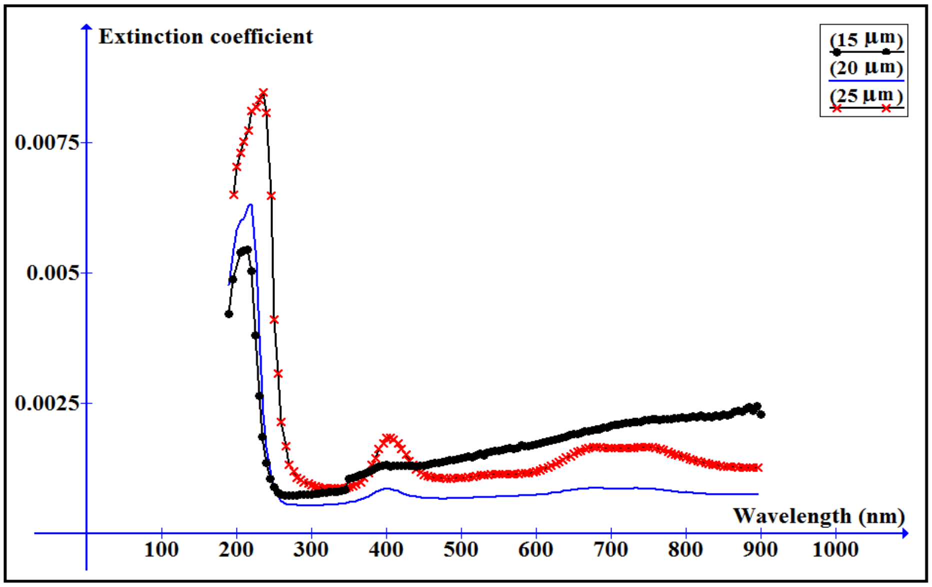

Fig. (9) Extinction Coefficient of (PVA: Ni $(CH_3COO)_2$)as afunction of wavelength for different thickness films.

The real (ε_r) and imaginary (ε_i) parts of the dielectric constant related to the (n) and (k_o) values. The (ε_r) and (ε_i) values were calculated using the form [17]:

$$\varepsilon_r = n^2 - k_o^2 \quad \text{------------- (6)}$$

while ε_i is mainly depends on the k_o values, which are related to the variation of absorption coefficient [17]:

$$\varepsilon_i = 2n\, k_o \quad \text{------------- (7)}$$

It is found that ε_r increases as the film thickness increase , and the ε_i is decreases 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 [18]. 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 (10)and (11).

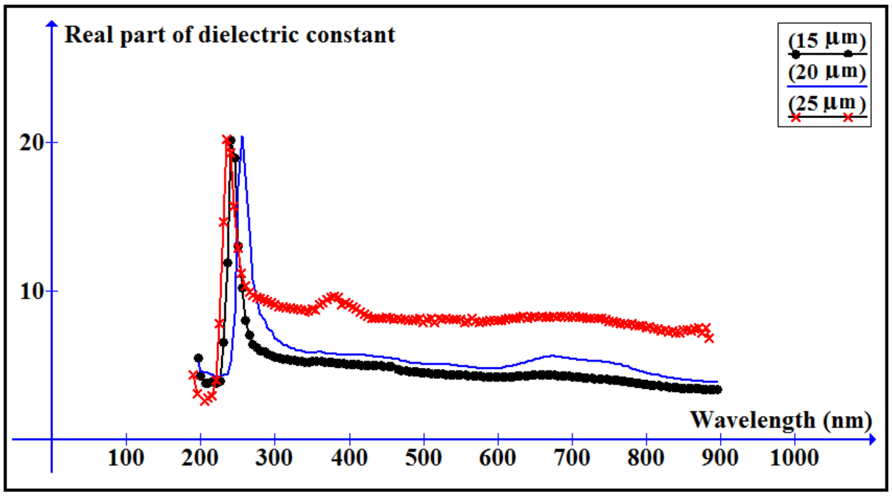

Fig. (10) Real part of Dielectric Constant of of (PVA: Ni $(CH_3COO)_2$) versus wavelength for different thickness films.

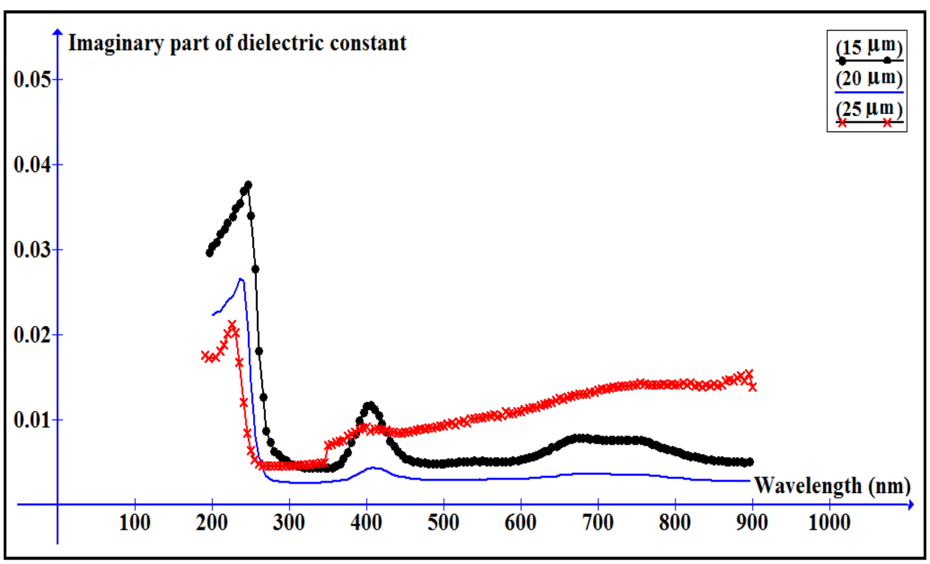

Fig. (11) Imaginary Part of Dielectric Constant of of (PVA: Ni $(CH_3COO)_2$) versus wavelength for different thickness films.

Conclusions

The PVA doped Ni $(CH_3COO)_2$ films have been prepared successfully by casting method , The study of effect of thickness on optical properties has shown that all the optical properties such as transmittance, reflectance, absorption coefficient, refractive index, extinction coefficient, and the real and imaginary parts of dielectric constant have been affected by increasing the thickness. The optical energy gap increased and the Urbach energy decreased when the thickness of films was increased.

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