

Effect of Thickness Variation on The Optical Properties of

PVA: Ni (CH₃COO)₂ films

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Abstract

(PVA: Ni (CH₃COO)₂) films with different thicknesses were prepared by casting method. The thickness of the prepared films were (15, 20 and 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 (CH₃COO)₂

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تأثير تغيير السمك على الخصائص البصرية لأغشية

PVA: Ni (CH₃COO)₂

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الخلاصة

حضرت أغشية بولي فينيل الكحول المشوبة بخلات النيكل بأسماء مختلفة باستعمال طريقة الصب. سمك الأغشية ، تم دراسة (190-900)nm بمدى الأطوال الموجية (T%). قيسَت النفاذية البصرية (25 , 20 , 15)µm المحضرة كان 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 اوريباخ 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 filtration 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.

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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 (CH₃COO)₂) films which was prepared by using solvent casting method.

Experimental procedure

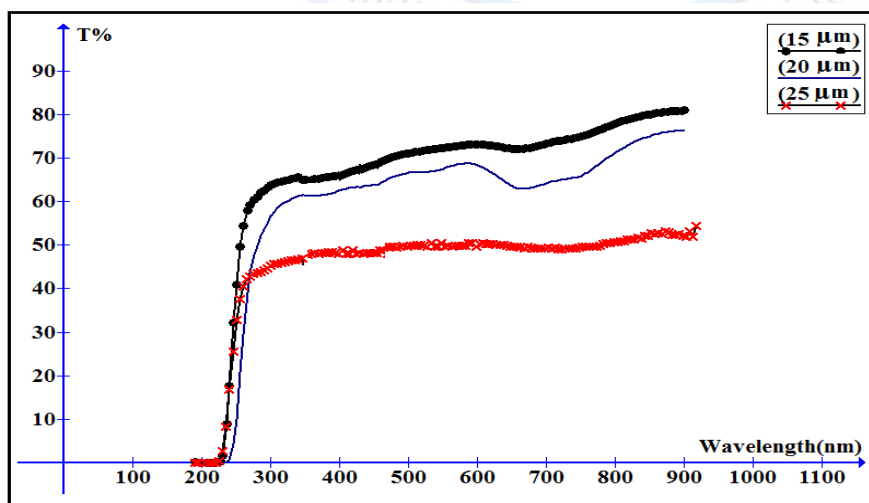
The materials used in this study are poly-vinyl alcohol with molecular weight 10000 g/mol, supplied by (BDH chemicals, England) with high purity were used as basic polymeric materials Ni (CH₃COO)₂. The weight percentages of Ni (CH₃COO)₂ are (10 wt.%). (PVA: Ni (CH₃COO)₂) composite films were prepared 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 cm²).

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 (CH₃COO)₂) versus wavelength at different thickness films.



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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.

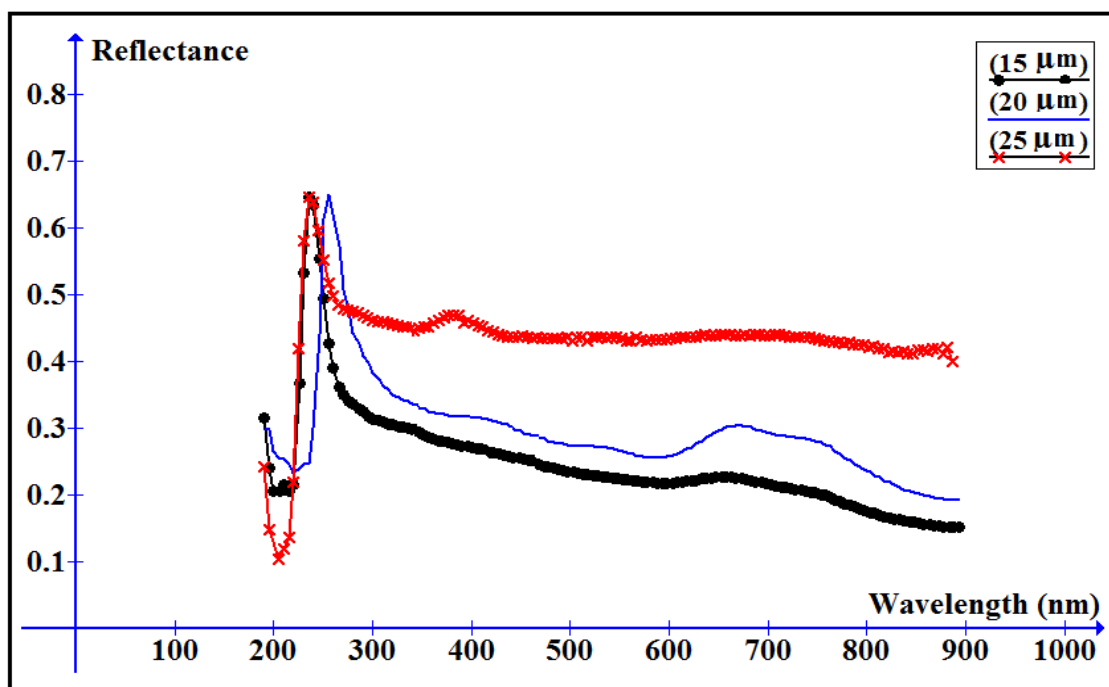


Fig. (2) Reflectance Spectra of (PVA:Ni (CH₃COO)₂) versus wavelength at different thickness films.

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]:

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

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.

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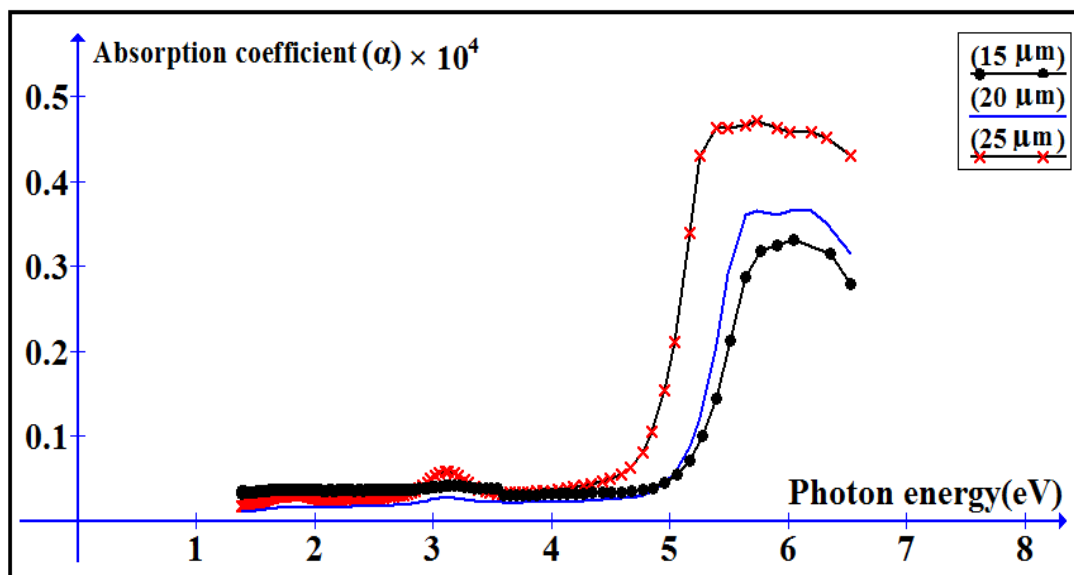


Fig. (3) Absorption Coefficient of (PVA: Ni (CH₃COO)₂) versus photon energy for different thickness films.

As an indirect band gap, (PVA- Ni (CH₃OO)₂) films has an absorption coefficient (α) obeying the following relation [11,12].

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

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

The variation of $(\alpha h \nu)^{1/2}$ versus photon energy for (PVA- Ni (CH₃OO)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.

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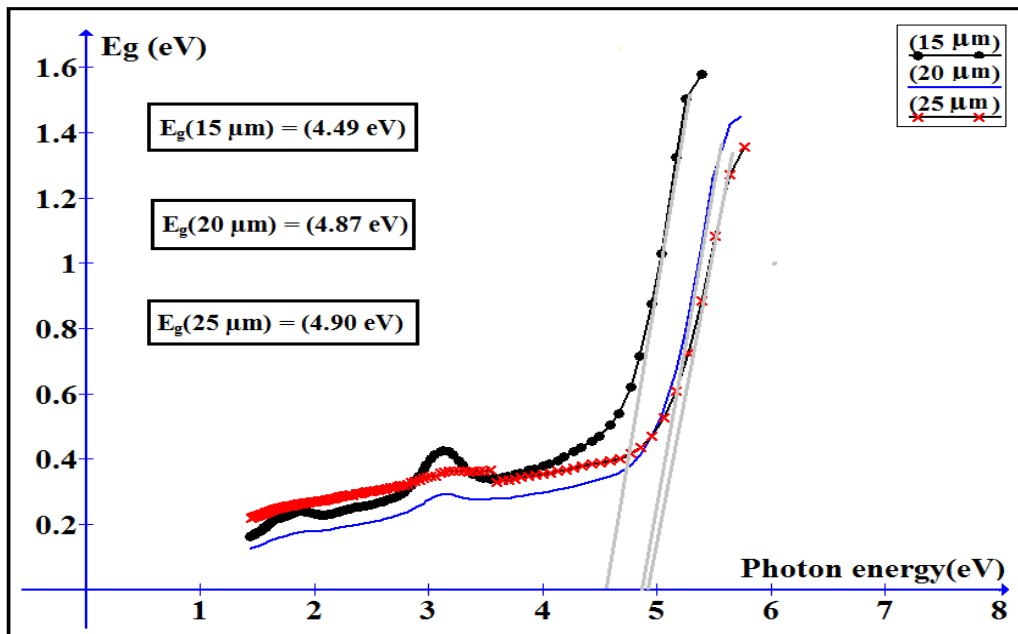


Fig. (4) Optical Energy Band Gap of (PVA: Ni (CH₃COO)₂) versus photon energy for different thickness films.

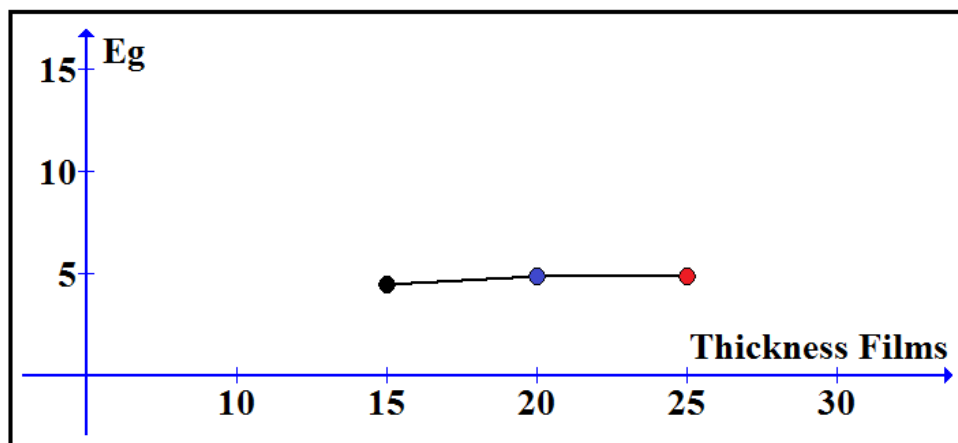


Fig. (5) The dependence of energy gap on Thickness Films for (PVA: Ni (CH₃COO)₂) samples

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]:

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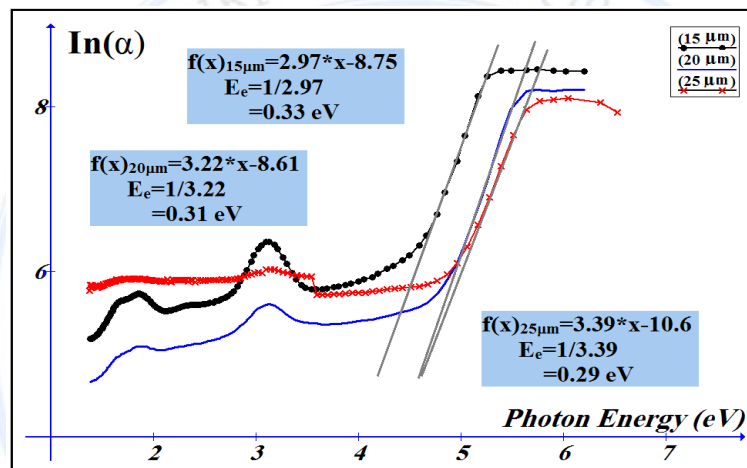
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$$\alpha = \alpha_0 (h\nu/E_e) \text{ ----- (3)}$$

Where (E_e) is the Urbach energy, $h\nu$ is photon energy. Fig. (6) shows the relationship between $\ln(\alpha)$ and photon energy. The value of $E_{e(15\mu\text{m})} = (0.33 \text{ eV})$, $E_{e(20\mu\text{m})} = (0.31 \text{ eV})$ and $E_{e(25\mu\text{m})} = (0.29 \text{ eV})$, 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).

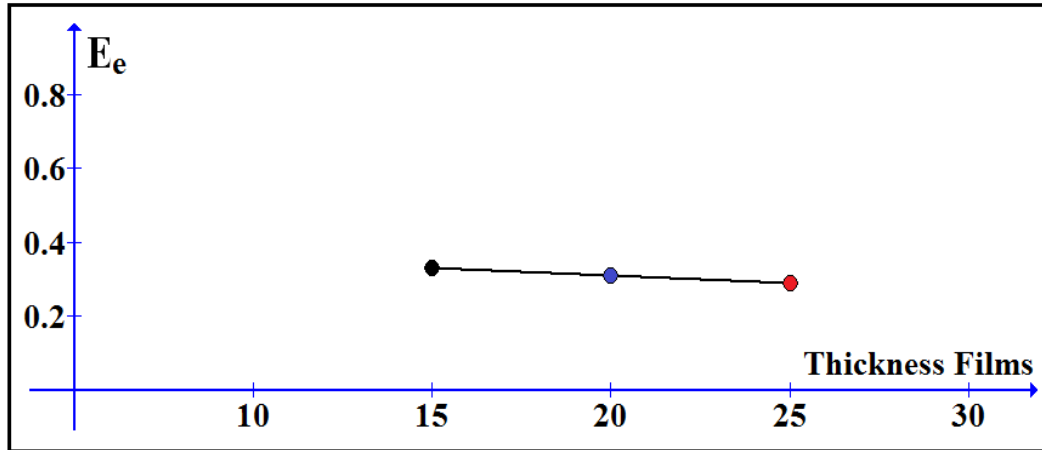
Fig. (6) Relation between $\ln(\alpha)$ and photon energy of (PVA: Ni (CH₃COO)₂) with different thickness films



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Fig. (7) The dependence of Urbach energy on Thickness Films for
(PVA: Ni (CH₃COO)₂) samples



Table(1)

Type of samples	E _g (eV)	E _e (eV)
PVA: Ni (CH ₃ OO) ₂ For 15 μm	4.49	0.33
PVA: Ni (CH ₃ OO) ₂ For 20 μm	4.87	0.31
PVA: Ni (CH ₃ OO) ₂ For 25 μm	4.90	0.29

Fig (8) shows the variation of refractive index (n₀) 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 (CH₃COO)₂) films increases with increases of thickness films.

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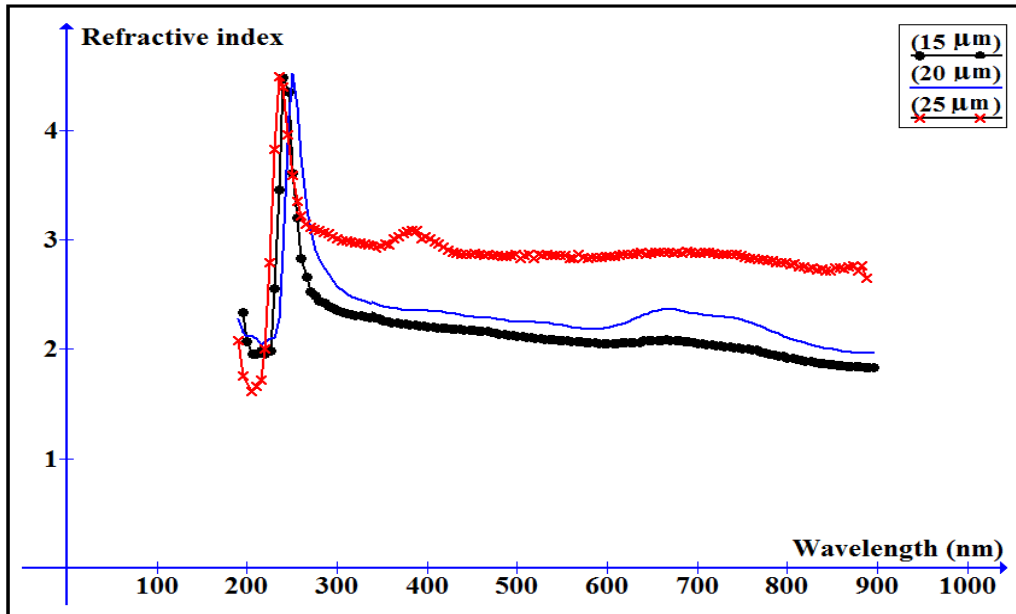


Fig. (8) Refractive Index of (PVA: Ni (CH₃COO)₂) versus wavelength for different thickness films.

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 (CH₃COO)₂) at different thickness films. The extinction coefficient (k_o) is directly proportional to the absorption coefficient as seen in relation [17]:

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

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

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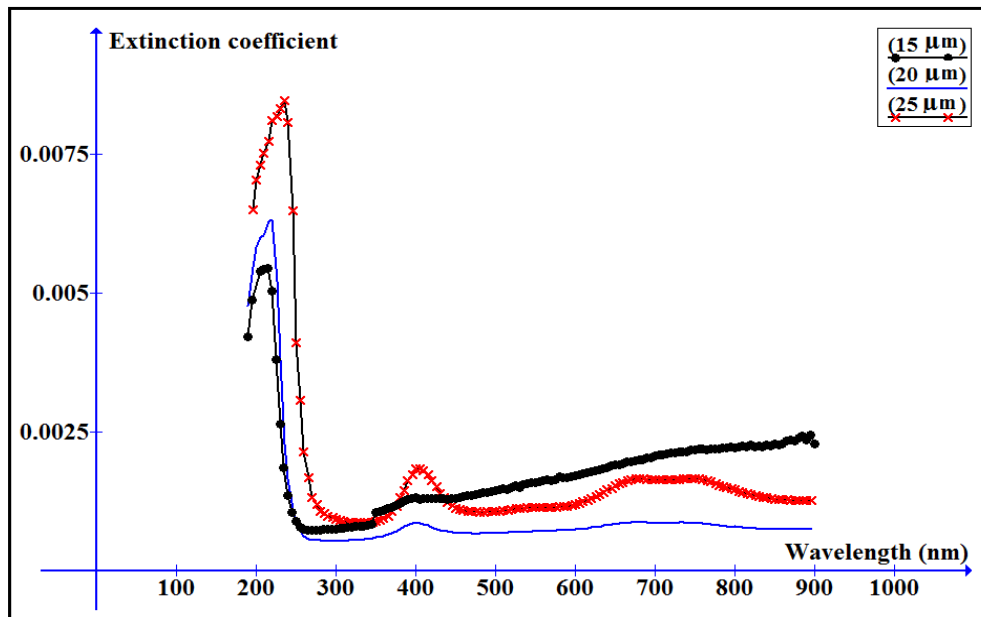


Fig. (9) Extinction Coefficient of (PVA: Ni (CH₃COO)₂) as a function of wavelength for different thickness films.

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]:

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

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

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

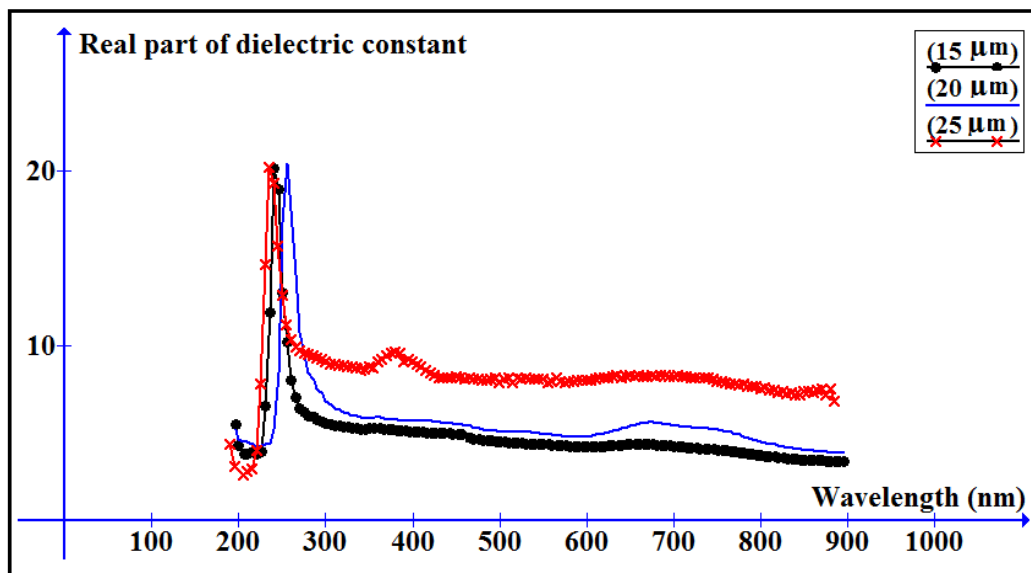
It is found that ϵ_r increases as the film thickness increase, and the ϵ_i is decreases as the film thickness increase.

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

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imaginary part (ϵ_2), the variations of them with photon energy were determined and shown in figure (10) and (11).

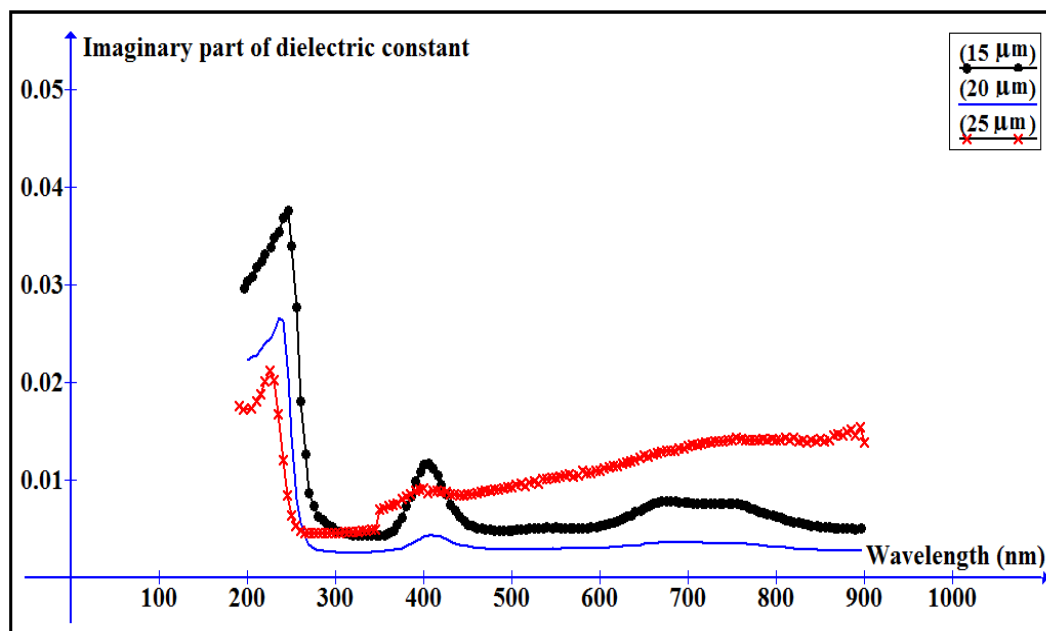
Fig. (10) Real part of Dielectric Constant of (PVA: Ni (CH₃COO)₂) versus wavelength for different thickness films.

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Fig. (11) Imaginary Part of Dielectric Constant of of (PVA: Ni (CH₃COO)₂) versus wavelength for different thickness films.



Conclusions

The PVA doped Ni (CH₃COO)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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References

- [1] K.A.M. Abd El-Kader, S.F. Abdel Hamied, A.B. Mansour, A.M.Y El-Lawindy, F. El-Tantaway, Polymer Testing 21, (2002) ,p.p.847–850.
- [2] Jing Fu, Jinli Qiao, Xizhao Wang , Jianxin Ma , Tatsuhiko Okada ,Synthetic Metals 160 ,(2010),p.p. 193–199.
- [3] Prichard GJ, Poly(vinyl alcohol): basis principles and uses. Gordon and Breach, New York, (1970).
- [4] R. F. Bhajantri, V. Ravindrachary, Ismayil, A. Harisha and Manjunath Pattabi, 11th International conference on Advanced Materials , Rio de Jaaneiro Brazil ,September,(2008),p.p.20-25.
- [5] Zhao Guohua , Liu Ya , Fang Cuilan , Zhang Min , Zhou Caiqiong and Chen Zongdao , Polymer Degradation and Stability, 91 , (2006),p.p. 703-711.
- [6] Osiris W. Guirguis , Manal T. H. Moselhey, J Mater Sci.,46, (2011), p.p.5775–5789.
- [7] Eaga CM, Kandukuri JM, Allenki V, Yamsani MR (2009) Der Pharm Lett 1:21
- [8] Kim SJ, Lee YM, Kim IY, Kim SI (2003) React Funct Polym55:291.
- [9] M. Krumova, D. Lopaz, R. Benavente, C. Mijangos, J.M. Perena, Polymer ,41, (2000) ,p.p.9265.
- [10] Han, X., Liu, R., Chen, W. and Xu, Z, Thin Solid Films, 516(2008), p.p.4025-4029.
- [11] L. Leonite, M. Roman, F. Brinza, C. Podaru and G. I. Rusu , Synthetic Metals, 138,(2003), p.p.157
- [12] [J.B. Yadav](#) , [R.K. Puri](#) , [Applied Surface Science](#) ,(2007), p.p. 1382–1388,
- [13] A. Ashour, M. A. Kaid, N. Z. El-Sayed and A. A. Ibrahim, Applied Surface Science, 252,(2006),p.p. 7844.
- [14] J. Tauc, A. Menth, J. Non-Cryst. Solids, 8-10 (1972) 569-585.
- [15] F. Urbach, Phys. Rev 92,(1953),p.p.1324.
- [16] Ezekoye, B. A. ; Okkek ,C. E., ,the pacific journal of science and technology, (2006) ,p.p. 7,108.
- [17] A. K. Baker and P. E. Dyer, journal applied physics materials science and processing,. 57 , (1993), p.p.543.
- [18] E. Elangovan and K. Ramamurthi, Cryst. Res. Technol., 38, 9 ,(2003), p.p.779.