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Abstract

Poly(vinyl alcohol) doped Ag films with different thicknesses were prepared by casting method. The thickness of the prepared films were 10, 20, 30,and 40 µm. Transmission and absorption spectra have been recorded in order to study the effect of increasing thickness on some optical constants such as transmittance, reflectance, absorption coefficient, refractive index, extinction coefficient, and real and imaginary parts of dielectric constant. This study reveals that all these parameters affect by increasing the thickness.

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Introduction

Poly vinyl alcohol (PVA) has been used in many applications since its discovery in 1924 [1-3]. PVA is a crystalline polymer, highly soluble in water, its dissolution requires the breaking of the crystal structure and need to be carried out at elevated temperature [4]. One of the crucial features of the PVA consists in an existence of the promising acoustooptical effects determined by interaction of electron and phonon subsystems [5].

PVAs with certain additives used in order to modify their properties, are of particular interest to science and technology and there have been many applications in modern engineering. The electrical and optical properties of the polymer can be suitably modified by the addition of dopants depending on their reactivity with the host matrix. 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 [6]. PVA is a potential material having a very high dielectric strength, good charge storage capacity and dopant-dependent electrical and optical properties. It is reported that the water content in the PVA based electrolyte enhanced the conductivity while preserving the dimensional stability of the electrolyte [7].Literature studies reveal that the ammonium salts are excellent proton donors to the polymer matrix and ammonium salts doped with PVA are rare. The present paper discloses the effect of adding an organic salt, silver nitrate $AgNO_3$, on the optical properties of PVA. It's important to mention here that Poly(vinyl alcohol) doped with silver nitrate $AgNO_3$ have been prepared with water as a solvent.

Experimental procedure

Poly (vinyl alcohol) with molecular weight 10000 g/mol ,supplied by (BDH chemicals, England) with high purity were used as basic polymeric materials in this work., the aqueous solution of this polymer were prepared by dissolving PVA with different weight in a mixed of deionzed water and ethanol and thoroughly stirred using a magnetic stirrer for about one hour at room temperature until PVA was completely soluble. $AgNO_3$ solution was prepared by dissolving the salt in redistilled water. 5% concentrated of $AgNO_3$ were mixed with PVA

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matrix. The solution was poured into flat glass plate dishes. Homogenous films were obtained after drying in an oven for 24 hours at 313K .The thickness of the produced films was in the range of 10, 20, 30 and 40 µm. The absorbance and transmittance measurements were carried out using a Shimadzu UV/VIS-160A double bean spectrophotometer in the wavelength range (300-1100) nm

Results and Discussions

The optical transmission spectra as a function of wavelength in the range of (300-1100)nm is shown in Fig. (1). we can observe from this figure that the transmittance decreases with increasing the thickness and shifted to longer wavelengths. 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. One can observe from the figure that the transmission intensity decreases with the increasing of the film thickness. There are no absorption bands in the visible region since the films are transparent and this result agree with previous studies [8,9].
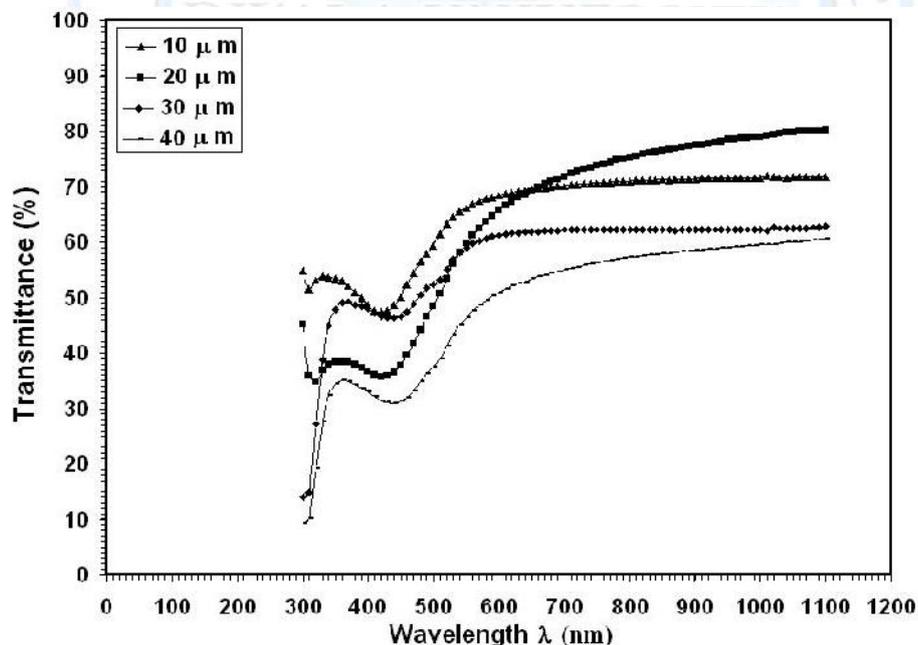

Fig. (1) Transmission spectra of PVA different thickness films.

Also the reflectance for the prepared films as a function of wavelength is shown in Fig. (2). It is obvious that its behavior is opposite to that of the transmittance spectrum.

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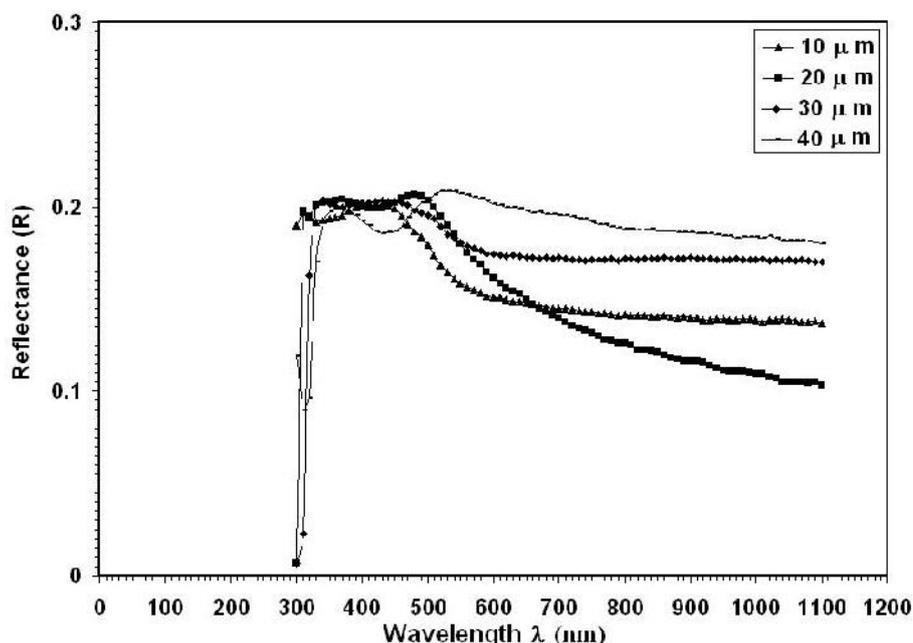**Muhammad Hameed Abdul-Allah**

Fig. (2) Reflectance spectra of PVA different thickness films.

The following relation could be use for calculating the absorption coefficient ( ) [10]:

$$r = \frac{2.303A}{t}$$ ------------- (1)

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

Fig. (3) shows the dependence of the absorption coefficient ( ) on the photon energy for the samples with different thickness. One can see from these figures that the absorption coefficient of the films is characterized by strong absorption at the shorter wavelength region between 300-650 nm and without sharp edge on the long wavelength side from 660–1100nm. In the shorter wavelength the absorption coefficient exhibits high values which means that there is a large probability of the allowed direct transition [11], and then ( ) decreases with increasing of wavelength. The values of absorption coefficient are nearly in agreement with values [12].

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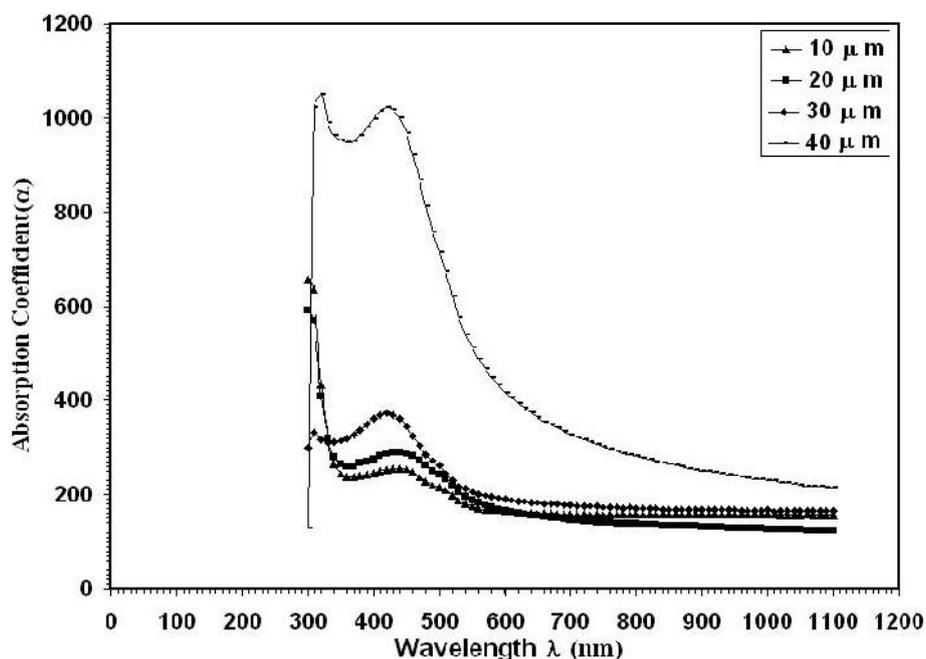**Muhammad Hameed Abdul-Allah**

Fig. (3) Absorption coefficient versus photon energy for the PVA different   thickness films.

The refractive index is a suitable state parameter directly correlated to the material density. Fig. (4) Shows the variation of the refractive index with the films thickness. It is clear from this figure that the films are influenced by the film thicknesses, The refractive index of these films is slightly increases with the increase in the films thickness. The refractive-index measurements can have a correlation with the electrical properties of the prepared films. The refractive index (n) can be determined from the reflectance (R) using the relation [13]:

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

Since the pure PVA is partially crystalline, the selective absorption of the photon energies of the incident light indicates that such energy is devoted to breaking up and hence deforming the partially crystalline structure of the polymers. Since the refractive index depends on the strength of the bonds, on density, and on molecular weight, increasing the thickness may alter all these parameters in a manner which increases the corresponding refractive index.

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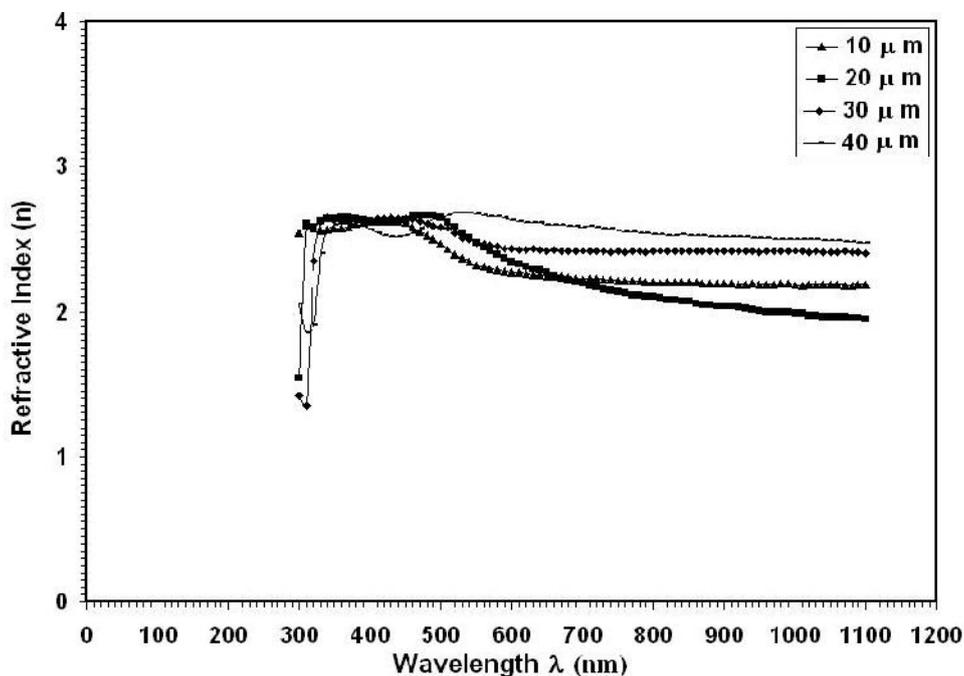**Muhammad Hameed Abdul-Allah**

Fig. (4) Refractive index versus wavelength for the PVA different thickness films.

The behavior of extinction coefficient (k) is nearly similar to the corresponding absorption coefficient at different thicknesses. We can observe from Fig.(5) that extinction coefficient increases with increasing of films thickness. This is attributed to the same reason mentioned previously in absorption coefficient.

The extinction coefficient (k) can be determined by using the relation [14]:

$$k = \frac{\alpha\ \lambda}{4\ \pi}$$

------------ (2)

Where (α) is the absorption coefficient and ( ) is the wavelength of the incident photon. Fig. (5) Shows the variation in K as a function of the wavelength, It can be notice that the extinction coefficient increases as the film thickness increase.

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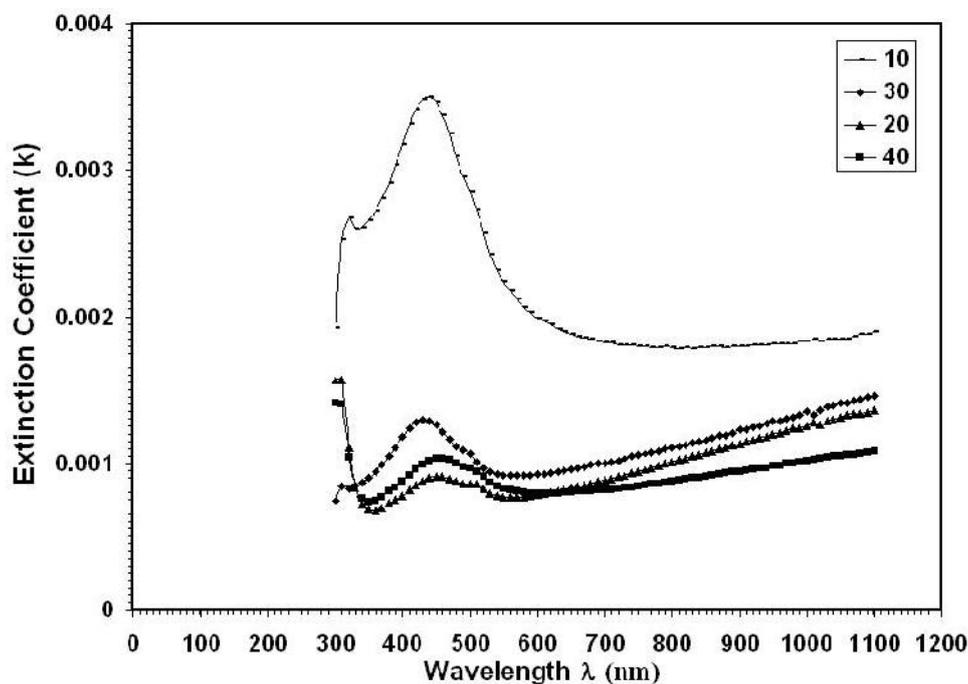**Muhammad Hameed Abdul-Allah**

Fig. (5) Extinction coefficient versus wavelength for the PVA different thickness films.

The variation of the real (ε_r) and imaginary (ε_i) parts of the dielectric constant values versus wavelength in the range 300 – 1100nm at different thicknesses (10, 20, 30 and 40)µm are shown in Figs.(7 and 8). The behavior of ε_r is similar to that of refractive index because the smaller value of k^2 compared with n^2:

$$\varepsilon_r = n^2 - k^2 \qquad \text{------------- (4)}$$

while ε_i is mainly depends on the k values, which are related to the variation of absorption coefficient:

$$\varepsilon_i = 2nk \qquad \text{------------ (5)}$$

It is found that ε_r and ε_i increases with increasing of films thickness. The real and imaginary parts of the dielectric constant indicate the same pattern and the values of real part are higher than imaginary part [15]:

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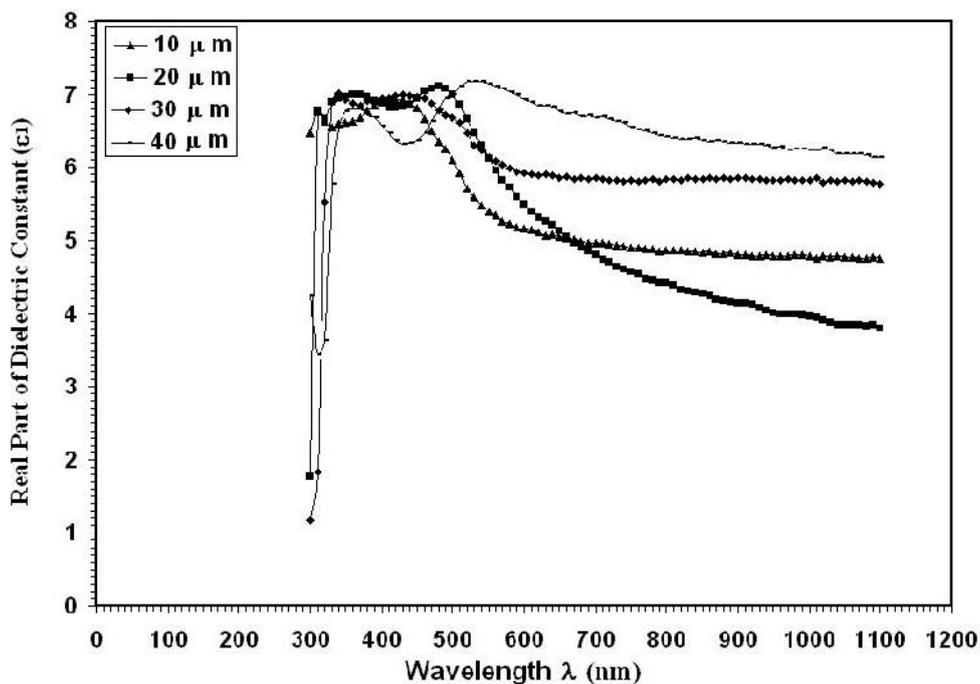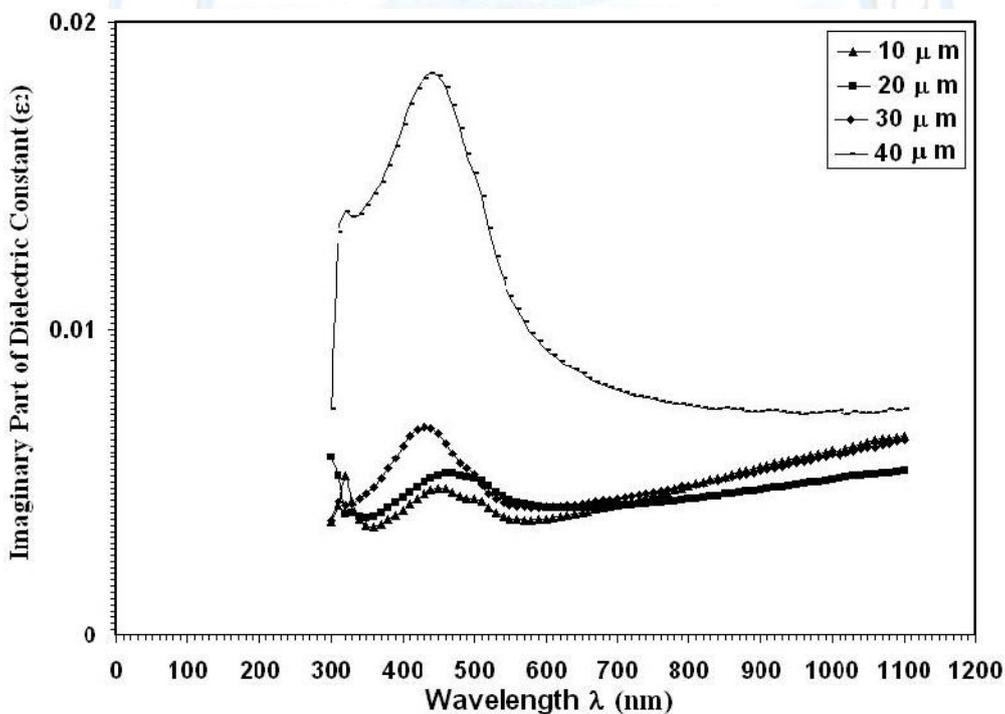**Fig. (6) Real part of dielectric constant versus wavelength.**

Fig. (7) Imaginary part of dielectric constant versus wavelength.Conclusions

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The detailed study of the PVA doped Ag films thickness effect on some optical parameters has shown that all the optical constant 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.

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