International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-4, April 2014

Optical Characterization of Red Methyl Doped Poly (Vinyl Alcohol) Films

Sabah A. Salman, Muhammad H. Abdu-allah, Nabeel A. Bakr

***Abstract*— The effect of doping by (red methyl) on the absorption spectra and the optical energy gap of poly (vinyl alcohol) PVA films have been studied. The optical transmittance (T %) in the wavelength range (190-1100) nm of films deposited by using solvent casting method was measured. The absorbance data reveals that the doping affected the absorption edge as a red shift in its values. The films show indirect allowed interband transitions that influenced by the doping, the optical energy gap has been decreased from about (4.49 eV) before doping to about (4.16 eV), (3.62 eV), (3.41 eV) and (3.19 eV) after doping. Optical constants like refractive index, extinction coefficient and real and imaginary part of dielectric constant calculated and correlated with doping.**

***Index Terms*— Polyvinyl alcohol films, casting method, optical properties, red methyl, doping effect.**

I. 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]. PVA is a potential material having a very high dielectric strength, good charge storage capacity and dopant-dependent electrical and optical properties. It was reported that the water content in the PVA based electrolyte enhanced the conductivity while preserving the dimensional stability of the electrolyte [2].

Over recent years PVA polymers have attracted attention due to their variety of applications. The physical properties of polymers may be affected by doping, On the other hand, red methyl is interesting in terms of optical, electronic and UV-absorbing properties and shows promise for a variety of applications including self-cleaning, UV blocking, purification and antibacterial applications [3].

In this research we try to combine the features of organic materials with those of inorganic materials such as poly (vinyl alcohol) PVA – red methyl composites in order to study some optical characteristics of the above composites.

II. EXPERIMENTAL PROCEDURE

Poly (vinyl alcohol) PVA with molecular weight (10000g/mol), supplied by (BDH chemicals, England) with high purity (99.999%) were used as matrix polymeric materials in this work, the aqueous solution of this polymer was prepared by dissolving PVA with different weight in a mixed of deionizer water and ethanol and thoroughly stirred using a magnetic stirrer for about one hour at room temperature until PVA was completely soluble. Red methyl solution was prepared by dissolving the salt in redistilled water. (2%, 4%, 6% and 8%) concentrated of red methyl were mixed with PVA 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 films was in the range of (30 ± 0.05) μm by using micrometer and the average area was (2.5 x 2.5) cm^2. The absorbance and transmittance measurements were carried out using a Shimadzu UV/VIS-160A double beam spectrophotometer in the wavelength range (190-1100) nm.

III. RESULTS AND DISCUSSION

The study of the optical absorption spectrum is one of the most productive methods in developing and understanding the structure and optical energy gap of polymers. The UV-VI-NIR absorbance spectra of pure as well as red methyl (rm) doped PVA are shown in the figure (1). It was found that the absorption edge shifts towards lower energies due to doping (red shift). Furthermore, the transmittance was found to decrease with doping by red methyl (rm) as shown in figure (2).

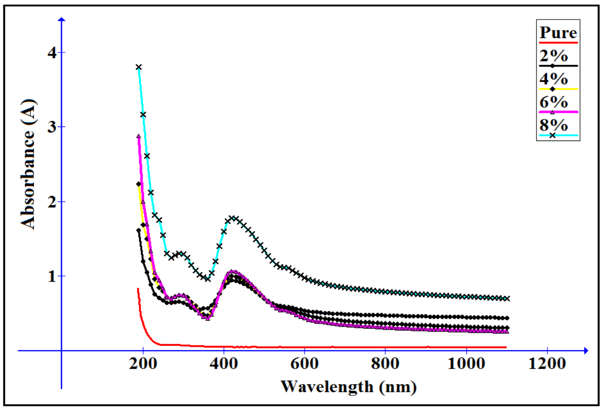


Fig. (1): Absorbance spectra of (PVA: red methyl).

The following relation could be use for calculating the absorption coefficient (α) [4]:

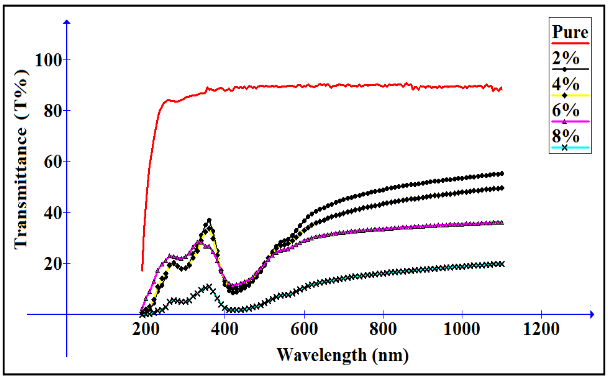
Manuscript received April 12, 2014.

Sabah A. Salman, Department of Physics, College of Science, University of Diyala, Diyala, Iraq.

Muhammad H. Abdu-allah, Department of Physics, College of Science, University of Diyala, Diyala, Iraq.

Nabeel A. Bakr, Department of Physics, College of Science, University of Diyala, Diyala, Iraq .

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



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

Fig. (2): Transmission spectra of (PVA: red methyl).

Figure (3) shows the reflectance spectra for all the prepared samples.

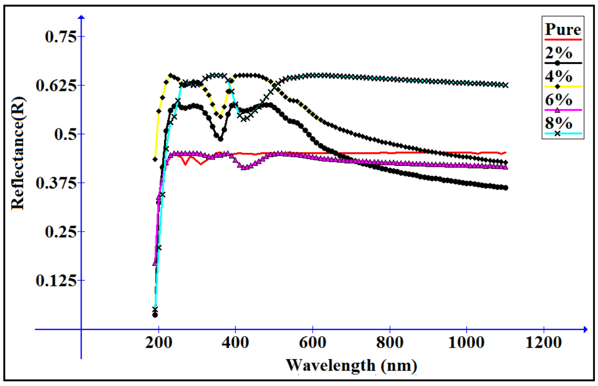


Fig. (3): Reflectance spectra of (PVA: red methyl).

Figure (4) shows the dependence of the absorption coefficient (α) on the photon energy for the samples. One can see from these figures that the absorption coefficient of the films is characterized by strong absorption at the higher photon energy region between (5-6.3) nm. In the shorter wavelength the absorption coefficient exhibits high values ($\alpha < 10^4\ \text{cm}^{-1}$) which means that there is a large probability of the indirect allowed transition [5]. The marked increase of the absorption coefficient at higher energies may be attributed to extra transition from the bonding molecular orbit to anti bonding molecular orbit [6].

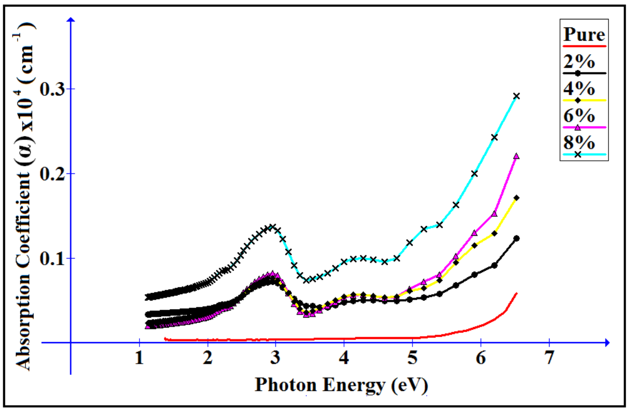
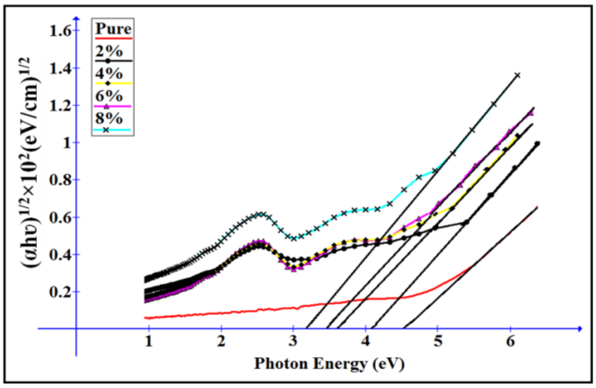


Fig. (4): Absorption Coefficient of (PVA: red methyl).

Figure (5) shows the plot of the product of absorption coefficient and photon energy $(\alpha hf)^{1/2}$ versus the photon energy at room temperature shows a linear behavior, which can be considered as an evidence for indirect allowed transition. Extrapolation of the linear portion of this curve to a point $(\alpha hf)^{1/2} = 0$ gives the optical energy band gap (E_g) for the films. The existence and variation of optical energy band gap (E_g) with the photon energy, as the red methyl increased (0% , 2%,4% ,6%, 8%) we obtained optical energy band gap of (4.49, 4.16, 3.62, 3.41, 3.19) eV, respectively, 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 [7]. In general optical energy band gap decreases with doping percentages.

Fig. (5): Optical energy band gap of (PVA: red methyl).



The refractive index (n_o) of the films can be determined from the following equation [8]:

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

Where (R) is the reflectance and (k_o) is the extinction coefficient.

Figure (6) shows the variation of refractive index (n_o) with photon energy, for all samples refractive index is behavior similar to reflectance. This figure reveals a tendency for an increase in refractive index with doping. The variation of refractive index in investigated frequency range shows that some interactions take places between photons and electrons. Refractive index changes with variation of the wavelength of the incident light beam are due to these interactions [9].

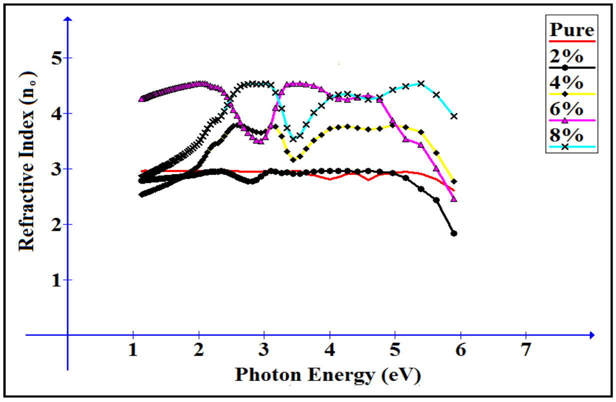


Fig. (6): Refractive Index of (PVA: red methyl).

The extinction coefficient ($k_\circ$) represents the imaginary part of complex refractive index and it can be defined as the amount of energy losing as a result of interaction between the light and the charge of medium [10].

From figure (7), the behavior of extinction coefficient is increases with increasing red methyl concentration because it is directly proportional to the absorption coefficient as see in relation [11]:

$$k_o = \frac{\alpha\ \lambda}{4\ \pi} \qquad \text{-------------} (3)$$

Where (λ) is the wavelength of the incident photon.

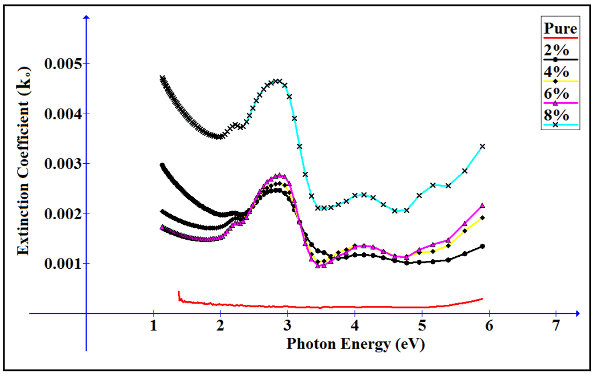


Fig. (7) Extinction Coefficient of (PVA: red methyl).

The variation of the real (ε_r) and imaginary (ε_i) parts of the dielectric constant values versus wavelength in the range (190–1100) nm are shown in Figures (8 and 9). The behavior of (ε_r) is similar to that of (n_o) because the smaller value of (k_o^2) compared with (n_o^2) [12]:

$$\varepsilon_r = n_\circ^2 - k_\circ^2 \qquad \text{-------------} (4)$$

While the (ε_i) is mainly depends on the (k_o) values, which are related to the variation of absorption coefficient [12]:

$$\varepsilon_i = 2\, n_\circ\, k_\circ \qquad \text{-------------} (5)$$

It is found that (ε_r) and (ε_i) increase with increasing of doping. The real and imaginary parts of the dielectric constant indicate the same pattern and the values of real part are higher than imaginary part [13].

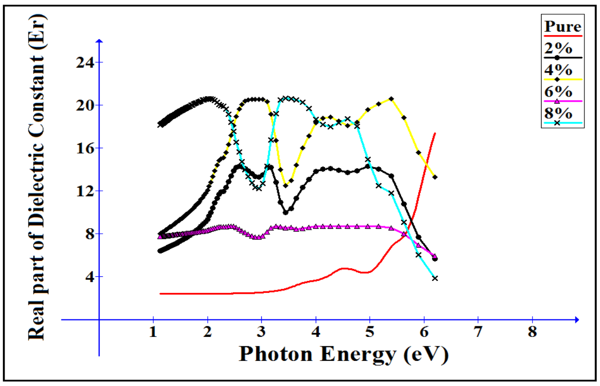


Fig. (8): Real part of dielectric constant of (PVA: red methyl).

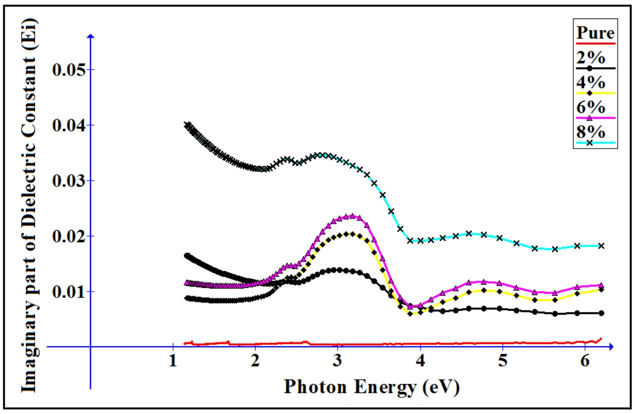


Fig. (9): Imaginary part of dielectric Constant of (PVA: red methyl).

IV. CONCLUSIONS

Based on the experimental results obtained the following conclusions can be drawn:

1- The doping process decreases the transmittance.
2- The type of electronic transition was indirect allowed transition.
3- In general energy band gap (E_g) decreases with doping.
4- Refractive index ($n_\circ$), extinction coefficient ($k_\circ$), real (ε_r) and imaginary (ε_i) parts of the dielectric constant increases with doping.

REFERENCES

[1] M. A. El-Sherbiny, N. Saich and A. El-Rehim, Polymer Test, Vol. 20 (4) (2001), p. 371.
[2] P. R. Somani, A. B. Mandale and S. Radharkrishnan, Acta Mater, Vol. 48, (2000), p. 2859.
[3] P. R. Somani, Mater Chem. Phys., Vol. 77, (2002), p. 81.
[4] W. Han, X. Liu, R. Chen and X. Zhen, Thin Solid Films, Vol. 516, (2008), p. 4025.
[5] J. I. Langford and A. J. C. Wilson, J. Appl. Cryst., Vol. 11, (102), (1978).
[6] K. A. M. Abdel-Kader, S. F. Abdel Hamied, A. B. Mansour, A. M. Y El-Lawindy and F. El-Tantaway, Polymer Testing, Vol.21, (2002), P. 847.
[7] M. A. El-Shahawy, Polymer International, Vol. 52, (2003), p. 1919.
[8] B. A. Ezekoye, C. E. Okkek, The Pacific Journal of Science and Technology, Vol. 108, (7), (2006), p. 311.
[9] F. Yakuphanoglu and H. Erten, Optica Applicata, Vol. XXXV., (4),)2005(, p. 145.
[10] Firas Hashem Ahmed, M.Sc. Thesis, University of Al-Mustansiriay, (2003).
[11] A. K. Baker and P. E. Dyer, Journal Applied Physics Materials Science and Processing, Vol. 57, (1993), p. 543.
[12] S. R. Bhattacharyya, R. N. Gayen, R. Paul and A. K. Pal, Thin Solid Films, Vol. 517, (2003), p. 5530.
[13] E. Elangovan and K. Ramamurthi, Cryst. Res. Technol., Vol. 38, (9), (2003), p. 779.