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RESEARCH ARTICLE

PREPARATION AND STUDY OF OPTICAL PROPERTIES OF PURE AND YELLOW METHYL -DOPED POLYVINYL ALCOHOL (PVA) FILMS

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ABSTRACT

In this study samples of pure polyvinyl alcohol (PVA) and polyvinyl alcohol films doped with methyl yellow with percentage doping of (0, 2, and 4 %) have been prepared by using solvent casting method. The optical properties, absorption and transmission of films were investigated through the transmission measurements at room temperature in wavelength range of (190-1100 nm). The films show indirect allowed transitions that influenced by the doping, the optical energy gap has been decreased from about (5.732 eV) before doping to about (4.821 eV) and (3.819 eV) after doping. Optical constants like refractive index, extinction coefficient calculated and correlated with doping.

INTRODUCTION

In recent years, studies on the optical properties of polymers have attracted much attention in view of their application in optical devices (Suriani Ibrahim *et al.,* 2012). Poly vinyl alcohol (PVA) is a cheap polymer having excellent film forming and adhesive properties, good chemical and mechanical stability and high potential for chemical cross-linking. However, PVA has highly swelling and low proton conductivity (Khadijeh Houshyari *et al.,* 2013). (PVA) is a polymer that has been studied intensively due to its several interesting physical properties, which are useful in technical applications including biochemical and medical and in recent years, the doped polymers have been the subjects of interest for both theoretical and experimental studies, because of the physical and chemical properties needed for specific application may be obtained by adding or doping with some dopant (Bhajantri *et al.,* 2006). Polyvinyl alcohol is a good insulating material with low conductivity and hence is of importance to microelectronic industry. It electrical conductivity depends on the thermally generated carriers and also on the addition of suitable dopants (Abdel-Malik *et al.,* 2008). In field of nanomaterials, the effect of the nanoparticles on the polymers attached to their surface, and on the bulk polymer itself, has not been systematically investigated. Such effects will play an important role in controlling the quality and properties of the fabricated polymer nanocomposites, with PVA attached to the nanoparticle surface, the nanoparticles are found not only to increase the PVA cross-linking with an increase in melting temperature but also to enhance the thermal stability of the PVA (Zhanhu *et al.,* 2010). The purpose of the current investigation was to study the effect variation of percentages of methyl yellow on the optical properties of PVA films.

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Experimental procedure

In this work Polyvinyl alcohol, used were obtained as a powder form (BDH chemicals, England) with molecular weight 10000 g/mol. The aqueous solution of this polymer were 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. Doped solution films were fabricated by dissolving methyl yellow in distilled water of ratios (0%, 2%, 4%) and added to the polymeric solution with continuous stirring. The important thing before the deposition of films is the careful cleaning of the glass substrate which is cleaned by using organic solvent such as- ethanol and Acetone, finally the glass substrate were dried before use. The solution was poured in to a cleaned glass plate (petri dish) and kept untill dried (23 hours) at (40 ^{o}C). The thickness of the produced films was (25 ± 0.05 µm) and average area (3x3 cm^{2}).

The absorbance and transmittance measurements were carried out using a Shimadzu UV/VIS-1800 double beam spectrophotometer in the wavelength range (190-1100) nm.

RESULTS AND DISCUSSIONS

The optical transmission spectra as a function of wave length in the range of (190-1100) nm are shown in Fig. (1). All the films showing the same behavior but the transmittance was decrease as the doping percentage increase and shifted to longer wavelengths. This may be attributed to the creation of levels at the energy band by increasing doping and this leads to the shift of peak to smaller energies and this result agree with previous studies (Sabah A. Salman *et al.*, 2014; Faisal A. Mustafa 2013).

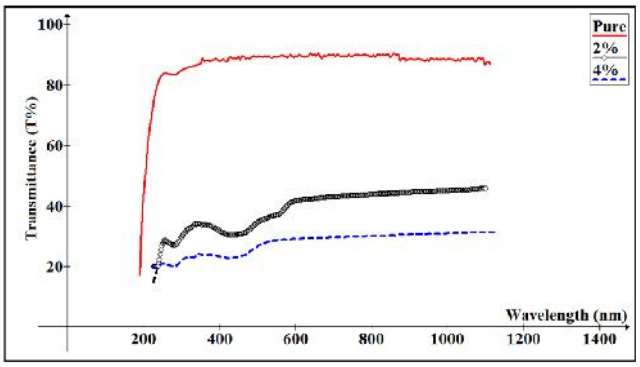

Fig. 1. Transmittance as a function of wavelength for pure and different concentrations of methyl yellow

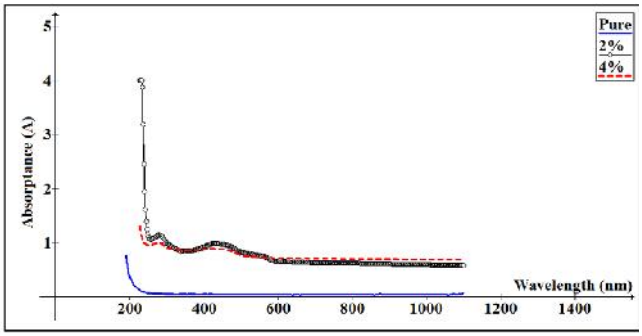

Fig. 2. Absorptance as a function of wavelength for pure and different concentrations of methyl yellow

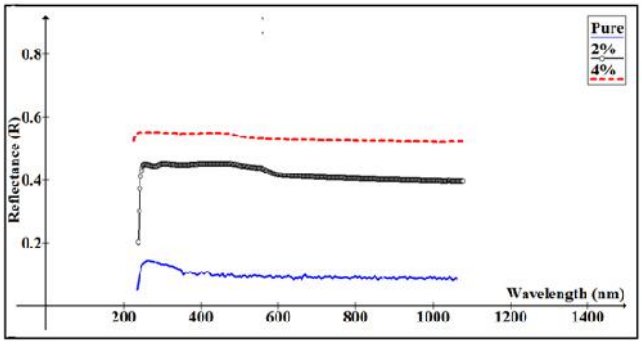

Fig. 3. Reflectance as a function of wavelength for pure and different concentrations of methyl yellow

The behavior of Absorbance curves of all samples are shown in Fig. (2), it is obvious that absorptance behavior is opposite to that of the transmission spectrum. It was found that the absorption edge shifts towards lower energies due to doping (red shift). From the plot of reflectance spectra in Figure (3) for different sample, the films prepared at (4%) have higher reflectance value than those prepared at (0% and 2%). Fig (4) shows the absorption coefficient (α) which was determined from transmittance and reflectance spectra and the film thickness and the following relation could be use for calculating the absorption coefficient (Muslm Fadhel Al-Zubadi and Waseem Najeeb Ibrahim 2009):

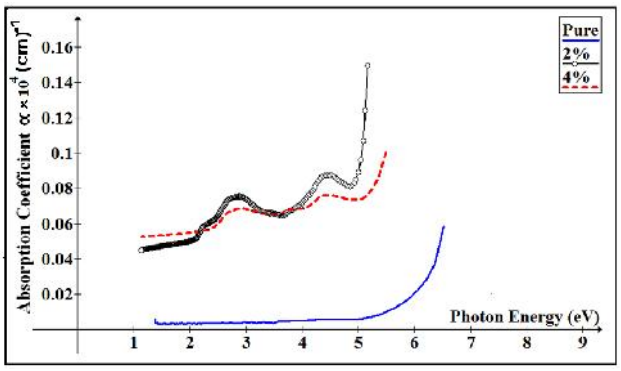

Fig. 4. Absorption Coefficient as a function of Photon energy for pure and different concentration of methyl yellow

$$\alpha = \frac{2.303A}{d} \quad \text{.....(1)}$$

Where (A) is the absorption and (d) is the film thickness. One can see from Figure (4), that in the shorter wavelengths the absorption coefficient exhibits high values ($\alpha < 10^4$ cm^{-1}) which means that there is a large probability of the indirect allowed transition and may be attributed to electronic transitions from the bonding molecular orbit to nonbonding molecular orbit (Abd El-Kader *et al.*, 2002). As an indirect band gap, all films has an absorption coefficient (α) obeying the following relation (Bagheri Khatibani and Rozati 2013)

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

Where E_g denotes the band gap, hν the energy of the incident photon and A is a constant. The exponent p is a number which characterizes the transition and band gap E_g is suitable value of p The experimental data were fitted to the theoretical Eq (2) for different values of P and the best fit was obtained for P=1/2 this behavior indicated that the transitions are allowed indirect transitions (Bagheri Khatibani and Rozati 2013; Prabahar *et al.*, 2010). The plot $(\alpha hf)^{1/2}$ 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 plots of the $(\alpha h\upsilon)^{1/2}$ as a function of hυ for various films with varying concentrations of methyl yellow are shown in Fig.5, as the methyl yellow increased from (0% , 2% , 4%) we obtained optical energy gap of (5.732 ,4.821, 3.819 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 decrease the degree of ordering in these parts (Ashour *et al.*, 2006). In general optical energy gap decreases with doping percentages this is attributed to the presence of doping and its interaction results in the creation of new molecular dipoles, which could be results of point defects created within the band gap.

The refractive index (n)is a fundamental optical property of polymers that is directly related to other optical, electrical and magnetic properties, and also of interest to those studying the physical, chemical, and molecular properties of polymers by optical techniques (Gao *et al.*, 2007). The refractive index (n_o) of pure and doped PVA with yellow methyl were determined using the relation (Prabahar *et al.*, 2010):

$$n_o = \left(\frac{1+R}{1-R}\right) + \sqrt{\frac{4R}{(1-R)^2} - K_o^2} \quad \text{-------} (3)$$

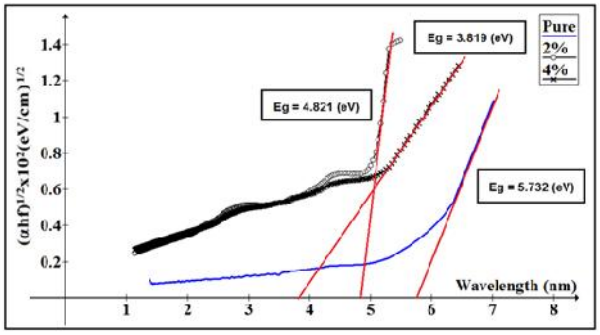

Fig. 5. Optical energy gap as a function of photon energy for pure and different concentration of methyl yellow

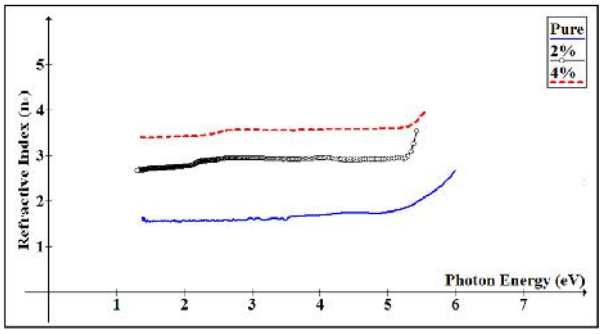

Fig. 6. Refractive index as a function of photon energy for pure and different concentration of methyl yellow

Where (R) is the reflectance and (k_o) is the extinction coefficient, Fig. (6) Shows the variation of (n_o) as a function of wavelength, where for all samples refractive index is behavior similar to reflectance, the value of the refractive index increase as the doping percentage increased. The extinction coefficient (k_o) represents the imaginary part of complex refractive index. The extinction coefficient (k) is directly proportional to the absorption coefficient as see in relation (Nabeel A.Bakr *et al.*, 2011):

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

Where α is the absorption coefficient and (λ) is the wavelength of the incident photon. Fig. (7) Showes the variation in (k_o) as a function of the wavelength. The behavior of the pure PVA is different in comparison with doping films, for PVA it seems that the extinction coefficient remains nearly constant as the wavelength increased but for doping, the attenuation coefficient increase in comparison with the undoped one.

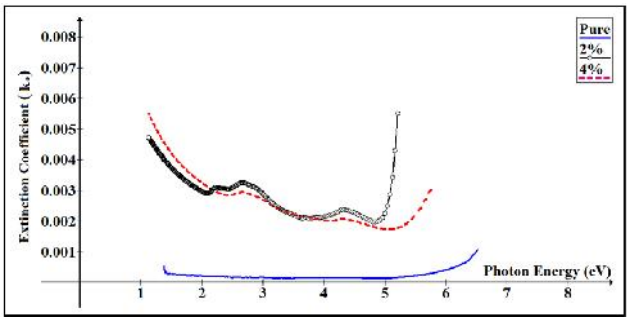

Fig. 7. Extinction Coefficient as a function of Photon energy for pure and different concentration of methyl yellow

Conclusion

It was concluded that:

1- Pure PVA and (methyl yellow) doped PVA have been prepared successfully by casting method.
2- The doping process decreases the transmission slightly.
3- The type of electronic transition was indirect allowed transition.
4- In general optical energy gap decreases with doping.
5- Refractive Index (n_o) and Extinction Coefficient (k_o) increases with doping.

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