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Study the Optical Properties of Methyl Blue Doped Polyvinyl Alcohol

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Abstract

In this work, the effect of methyl blue doping on the optical properties of polyvinyl alcohol has been studied. By using casting method, we can prepare a pure and adopt methyl blue PVA films. Transmission and absorption spectra have been recorded and measured in the wave length range (200-1100) nm. Transmittance spectra of the films indicate that the films have high transparency. The optical absorption measurements were carried out of the samples at room temperature in the wavelength range from (200-1100) nm in order to calculate the band gap energies and the refractive index. It was found that all these parameters were affect by doping.

Keywords: Polyvinyl alcohol; Optical energy gap; Optical properties

Introduction

Recently, studies on optical and electrical properties of polymer films have increased enormously for their extensive applications in optical and electronic devices [1]. Doping of polymers attracted the scientific and technological researchers, because of their wide applications. The dopant in polymer can changes the molecular structure and hence the microstructure as well as macroscopic properties of the polymer [2]. A vinyl polymer, namely polyvinyl alcohol (PVA) has several interesting physical properties, which are very useful in material and technical application. PVA, as semi-crystalline water soluble material exhibits [3].

In general, the absorption spectra in UV region increase with increasing dose. In principle, photon with energy greater than the band gap energy will be absorbed. Electromagnetic wave packet interacts with electron in the valence band (VB), which is then raised across the band gap on the conduction band (CB) via two possible types of electronic transition, i.e. direct transition and indirect transition. In the direct transition the wave vector for the electron remains unchanged, while in the indirect transition the lattice vibration or phonons assist the transition so that the minimum of the CB lies in the different part of k-space from the maximum of the VB [4].

Experiment

In this work a solution of PVA (5% w/v) in water was used to prepare 40 m thickness of polymer films. The films were prepared by evaporation technique at room temperature for 24 hours, to remove the possible residual water solvent. After the PVA solution was prepared, and then pours them into glass frame. This frame was made by glue the laboratory glass slides onto a piece of regular glass, to obtain small sinks; their volume is (4 cm^3). The PVA films with different weight of methyl blue (MB) (0.01, 0.02, 0.03, 0.04g) mixed were prepared by dissolving PVA and MB in distilled water and with stirring the solution by using magnetic stirrer for about (one hour) at (80°C) for complete dissolution. The solution was poured in to a cleaned glass plate and kept till dried (24 hours) at (30°C), the thickness of the produced films was constant. The optical absorbance of the samples were measured as function of wavelength (λ) in the wavelength range 200-1100nm by using Shimadzu double-beam UV/VIS spectrometer.

Results and Discussion

The study of the optical absorption spectra is one of the most productive methods in developing and understanding the structure and energy gap of amorphous nonmetallic materials. The absorption spectrum of pure and MB doped PVA has been shown in Fig. (1), it is seen that at 300 nm all peaks had not clear relationship all peaks have overlapping behavior irrespective of the values of the doping percentage of MB. The second peaks it is clearly seen that the absorption increases as the doping percentage of MB increase.

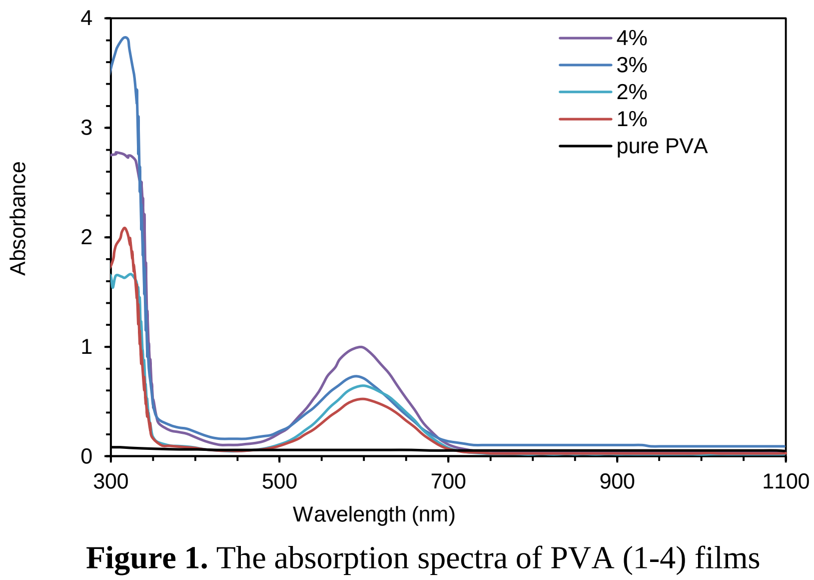

Figure 1. The absorption spectra of PVA (1-4) films

Figure (2) shows the transmittance spectrum in rang (200-1100) nm, It is clear that the transmittance spectra for all films increased with increasing wavelength till λ=500 nm, after that it's decreased rapidly until λ reach approximately 600 nm irrespective the values of concentration of MB. For pure PVA sample it is seen that its behavior take a constant shape because of the high values of MB concentration with PVA that lead to reduction the values of pure PVA seems to be constant. The Transmittance changed after addition of MB in the PVA samples, it is transmission intensity decreases with increasing MB concentration, and this indicates a considerable interaction between PVA and MB.

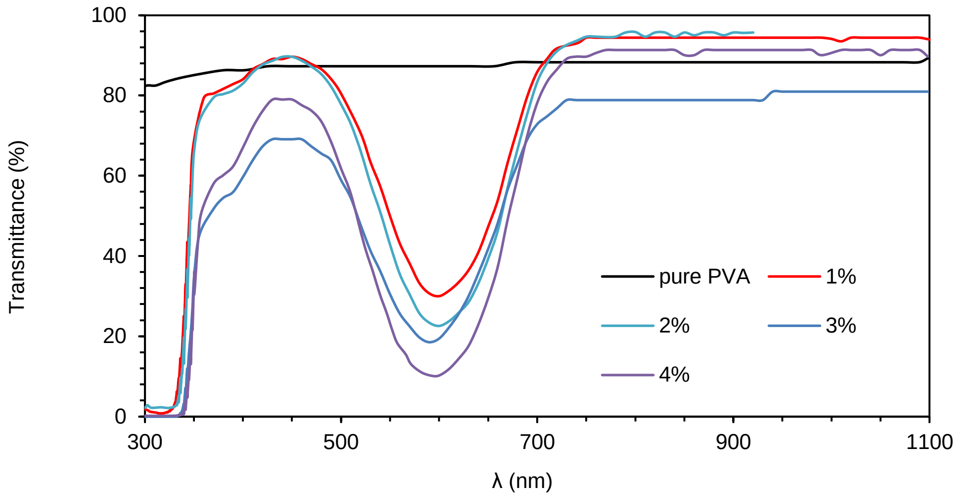

Figure 2. The transmission spectra of PVA (1-4) films

Moreover, the absorption coefficient (α) has been estimated for all samples from the following relation:

$$\alpha = \frac{2.30A}{d} \quad (1)$$

where A is the absorption and d is the film thickness [5].

The optical absorption coefficient (α) of PVA films is very important because it provides information on the electronic band structure, the band tail and energy gap. The marked increase of the absorption coefficient at higher energies may be attributed to extra transition from the bonding molecular orbit to nonbonding molecular orbit [6]. The observed increase of the absorption coefficient after exposure and with increase MB concentration of PVA films can be attributed to the existence of more transitions from higher vibration levels of the ground state to higher sublevels of the first excited singlet state [7].

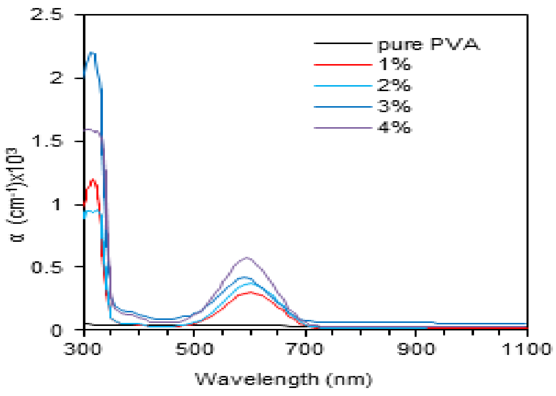

Figure 3. The absorption coefficient

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 [8]. The refractive index of PVA films is found to increase after exposure of MB as well as increasing with increase MB concentration. The polymers with high refractive index are very useful in optics and photonics due to their ability to reduce reflection losses at interfaces and, hence, increase light output [9]. The (n) depends on the strength of the bonds, on density, and on molecular weight [10]. As shown from figure (4), the refractive index increases as the wavelength increase until (440-730) nm. All the samples after exposure showed bands at the same position (589,600,581, 592) nm for samples (1, 2, 3, 4) respectively with increased wavelength as the impurity percentage increased, which indicates that the samples have the no same structure. Hence, the change in the doped percentage gave change in the chemical composition of the polymer [11].

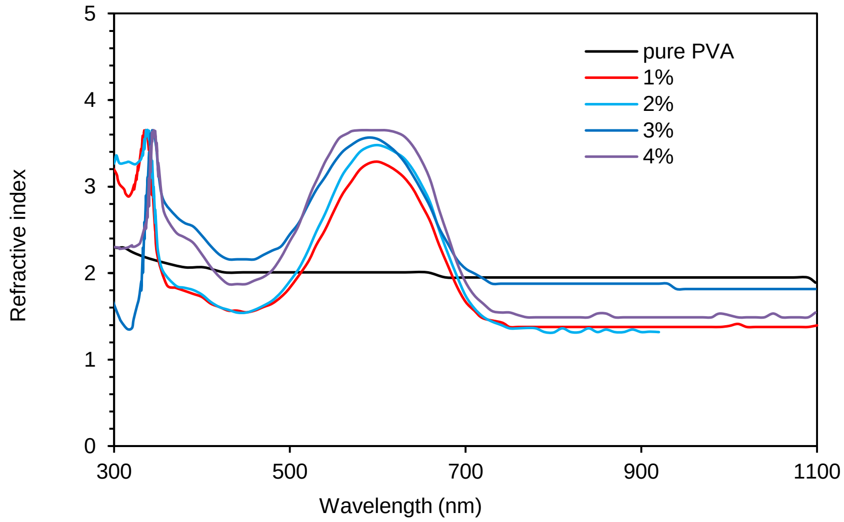

Figure. 4 Variation the refractive index (n) as a function of wavelength

Figure (5) shows the dependence of the extinction coefficient on wavelength, it is seen that the extinction coefficient decreases until 440 nm and then became to increase showing a peak around600nm then decrease again until 700 nm then became nearly constant, this means that the graph that K increased as doping percentage values increased. Extinction coefficient then increased for PVA films after exposure and with increase impurity concentration because the increase in absorption coefficient (α) where the extinction coefficient depending on absorption coefficient by the equation [5, 12]:

$$K = \frac{\alpha\lambda}{4\pi} \quad (2)$$

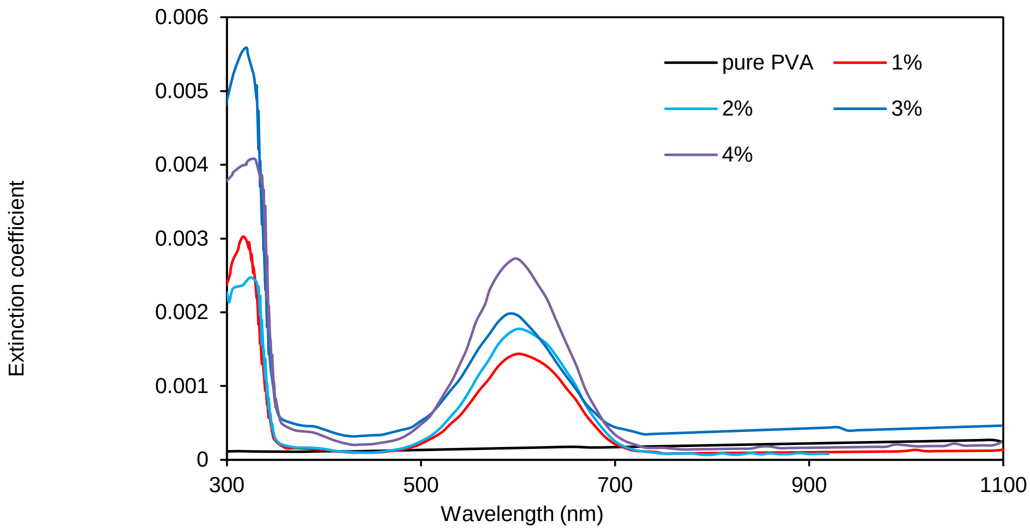

Figure 5. Variation the extinction coefficient (k) as a function of wavelength

The best definition of the energy gap is the minimum energy difference between the lowest minimum of the conduction band and the highest maximum of the valance band. The value and shape of the mobility gap in PVA depend on the proportion conditions such as substrate temperature, degree of impurity, and defect of the material [13]. Figure (6) represent the behavior of the variation of $(\alpha h\nu)^{1/2}$as a function of energy gap E_g (eV) it takes a swinging behavior for all values percentage MB concentrations and the decrease in E_g with increasing MB concentration can be understood by considering the mobility gap variation in the doped polymer. Also, this decrease in the band gap may be attributed to be the presence of unstructured defects, which increase the density of localized state in the band gap and consequently decrease the energy gap.These values are in good agreement with the values obtained by other workers concerning PVA films [12].

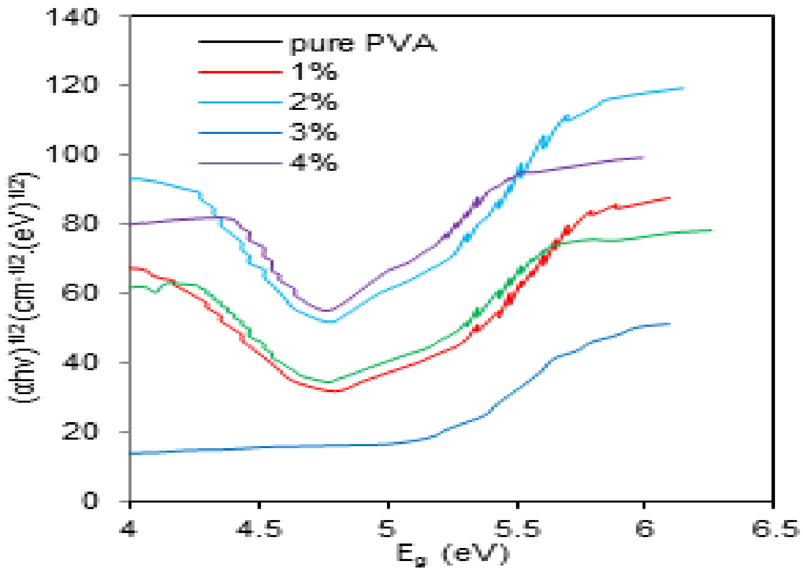

Figure. 6: The variation of $(\alpha h\nu)^{1/2}$ as a function of E (eV)

Conclusions

In this research PVA and MB were prepared by casting technique. The optical energy gap decrease as the doping percentage increase. The Absorption, absorption coefficient, refractive index and extinction coefficient were increased while the Transmission decrease as MB concentration increased.

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