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Preparation and Optical Characterization of Poly (Vinyl Alcohol): Eosin-Y Films Synthesized by Solvent Casting Method

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Abstract

It was found that the effect of PVA-doped Eosin-Y on the optical properties of the composite films was intentional as the PVA films were deposited by a solvent casting process with a thickness of 25 ± 1 μm and were grafted with different absorptions of Eosin-Y. The optical diffusivity (%) was described within the wavelength range of (200-900 nm), as well as the effect of the doping ratio on the optical properties of the prepared films. The results showed that layers with indirect developments are acceptable in the interband that are affected by the doping ratio . The band gap of the doped films decreased to (2.20 eV), (2.17 eV), and (2.13 eV) for doping ratios of (2%, 4%, and 6%), respectively, compared to the pure film's 3.89 eV.

Keywords: molding process, Poly (Vinyl Alcohol), Optical Characterization, Effect of Eosin-Y.

التحضير والتوصيف البصري للبولي (كحول الفينيل): أفلام Eosin-Y المُصنّعة بطريقة الصب بالمذيبات

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الخلاصة

وجد أن تأثير Eosin-Y المشوب بـ PVA على الخواص البصرية للأغشية المركبة كان مقصوداً حيث تم ترسيب أغشية PVA بواسطة عملية صب المذيبات بسماكة 25 ± 1 ميكرومتر وتم تطعيمها بامتصاصات مختلفة من Eosin-Y. تم وصف الانتشار البصري (٪) في مدى الطول الموجي 200-900 نانومتر وكذلك تأثير نسبة المنشطات على المعلمات البصرية

للأغشية المحضرة. أظهرت النتائج أن الطبقات أظهرت تطورات غير مباشرة مقبولة في النطاقات البينية التي تتأثر بنسب التشويب. انخفضت فجوة النطاق للأفلام المخدرة إلى 2.20 فولت، و2.17 فولت، و2.13 فولت لنسب المنشطات البالغة 2%، و4%، و6% على التوالي، مقارنة بـ 3.89 فولت للفيلم النقي.

الكلمات المفتاحية: عملية صب المذيبات ، البولي (كحول الفينيل)، التوصيف البصري، تأثير الأيوسين-Y.

Introduction

Given that polymeric materials have distinctive properties and many applications in many areas of life, polymers have received the attention of scientific researchers and companies, as they are multifunctional materials[1,2]. Poly(vinyl alcohol) is a polymeric material that possesses outstanding properties in wide industrial applications such as medical and biochemical fields, chemical and thermal stability, excellent flexibility and doping-based optical and electronic properties [3] .

As a semi-crystalline (PVA) polymer including amorphous and crystalline phases in the nanostructure range, a crystalline polymer can remain considered as a shapeless phase containing minor crystallites distributed arbitrarily. To generate amorphous interfacial phenomena, the optical properties of PVA must be improved [4].

Many studies conducted on the optical properties of (PVA) polymer coated with different elements, such as iron, manganese, nickel, and cobalt salts, have demonstrated that the type, ratio, and density of the method of manufacturing the grafting material greatly affect the optical properties.

PVA polymer becomes an electrical conductor after being an electrical insulator when it is coated with certain chemicals. It is assumed that doped PVA is synthesized as a result of interactions between polymer chains containing hydroxyl groups through hydrogen bonding as a result of complex formation [5,6,7].

In 2008 found that the addition of gelatin has a significant effect on the optical, microscopic, thermal and electrical properties of PVA. The results indicate that adding gelatin to PVA changes the thermal behavior, such as the melting temperature of PVA, and this indicates that the mixtures are compatible with each other. This also shows that the interaction of gelatin and PVA molecules changes the crystallographic parameters and degree of crystallinity, which supports the XRD results. The UV optical study also reflects the composition of the compound and its effect on the microstructure of the blend film. Moreover, the addition of gelatin also induces changes in the electrical properties of the PVA/gelatin blend films.[5].

In 2012, the effect of concentration on absorption was studied Fluorescence spectra of eosin in methanol at different concentrations and then absorption spectra were measured to those concentrations. [6].

In 2016, the effect of ultraviolet radiation and doping on the electrical properties of PVA was studied. It was shown that the polymer molecule of the system has a certain photostability after exposure to UV radiation. The variation of electric current with temperature shows two regions corresponding to different values of activation energy.[7].

Organic dyes (xanthenes family) have been widely utilized as a medium for the tunable dye laser beam to set up at a range of wavelength. Eosin-y is organic dyes that are emitted in the visible domain of electromagnetic spectrum, with chemical composition $C_{20}H_6Br_4Na_2O_5$ Tetra-bromo fluorescein in sodium salt as presented in figure (1) [8,9].

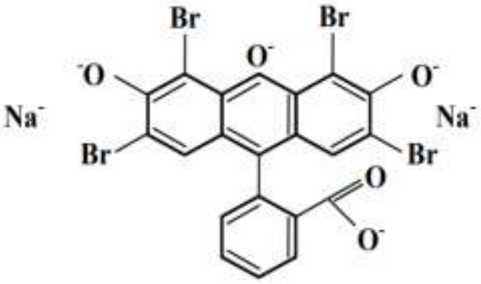

Figure 1: The chemical structure of eosin-y.

Organic polar polymers are formed when doping is combined, as changes appear in the properties of the polymers formed. The reason for the doping processes is to develop and improve optical properties, and to obtain a new material with multi-functional properties [10]. In this work, we prepared polyvinyl alcohol (PVA) films doped with variable eosin-Y concentration and studied the effect of the doping ratio on the optical properties of the obtained films. The solvent casting method was used, and the results showed that the optical properties of the films differ depending on the depletion percentage.

Experimental Part

A polymeric material with a molecular weight of 691.9 g/mol from B.D.H. was used and added to prepare (PVA) films. (0.1 g) of (PVA) is dissolved in (5 ml) of pure water to obtain a (PVA) solution. Eosin solution is prepared by dissolving it in pure water. Then (2%, 4%, 6%) of the concentrated eosin was mixed with (PVA). The solution was added to the dishes. Homogeneous films were obtained after drying in an electric oven for (24 h) at (313 K).

A numerical micrometer (China Hunan E&K Tools) was used, and The thicknesses of the films were obtained to be between 25 and 1 µm, and their average area was (2.5 × 2.5 cm^2). A Shimadzu (UV/VIS-160A) dual-beam spectrophotometer (Shimadzu Japan) was used to Analyze transmittance and absorbance within the given wavelength. (200–900 nm).

Results and Discussion

Infrared spectroscopy was performed to detect vibrational energy levels, and Figure (1) shows the FTIR system for pure PVA impregnated with different concentrations of Eosin-Y, From the FTIR screening spectrum, the O-H extended band in the infrared spectrum is the most characteristic feature of alcohols and phenols. Through this, we find that the hydroxyl group at (3300 cm^{-1}) acts as a stretching vibration with a strong hydrogen bond [11,12] , The results show that the two characteristic bands of asymmetric and symmetric (C–H) spanning at (2990 and 2818 cm^{-1}), respectively, and the pitting at (1650 and 1560 cm^{-1}) vibration bands of (CO and C-C), respectively. The high absorption at (1714 cm^{-1}) corresponds to the vibrational stretching to (C=C). While the state at 1622 cm^{-1} corresponds to the acetyl group (C=O), which can be explained based on intra/intermolecular hydrogen bonding with the nearby (OH) group [13,14]. The band around (1000 cm^{-1}) is the (C-O) stretching of acetyl groups on the (PVA) in all samples [15].

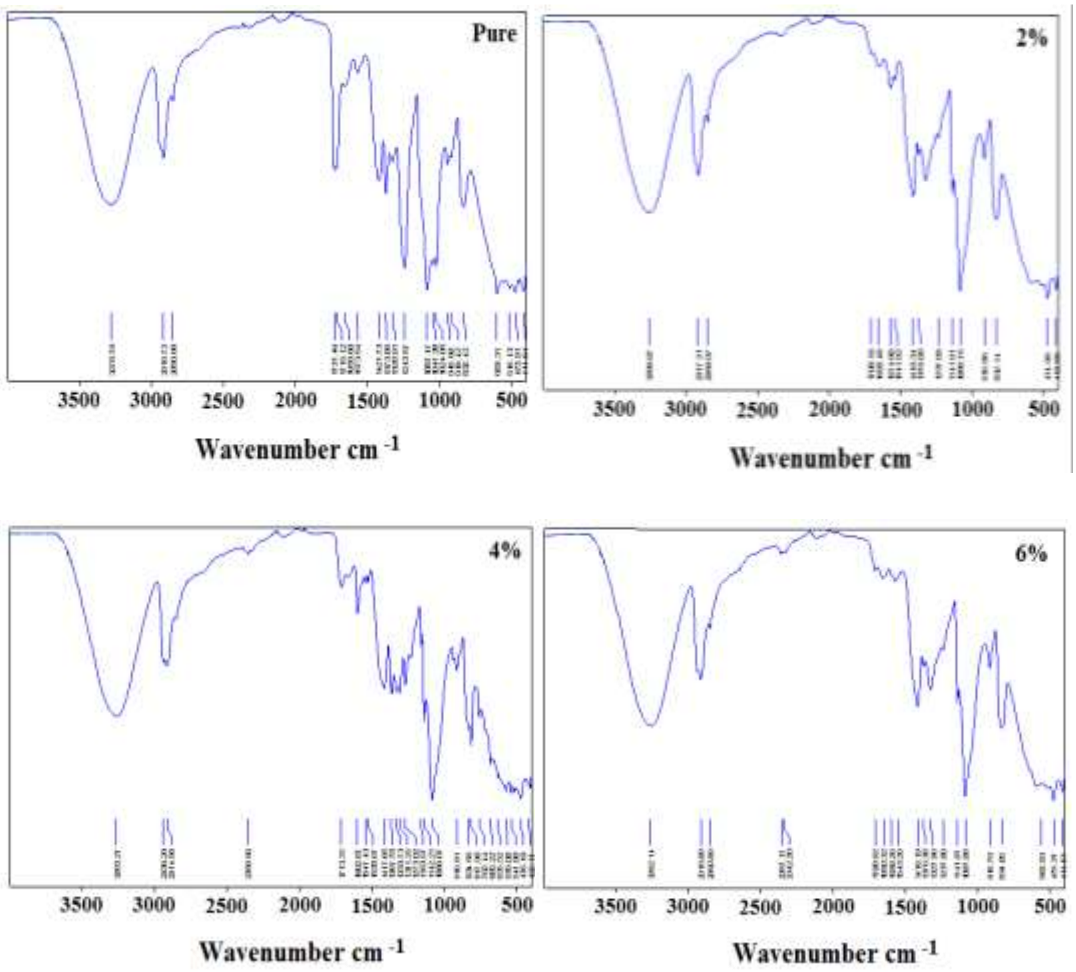

Figure 2: FTIR spectra analysis of pure PVA polymer doped with different concentrations of Eosin-Y

Figure 3 shows the UV-VI-NIR absorption spectra of pure as well as eosin-doped PVA polymer. This study showed the effect of doping with different concentrations of Eosin-Y on the optical properties of poly (vinyl alcohol). It was found that the absorption spectra increase with increasing dose in the ultraviolet region, where the photon whose energy is higher than the band gap energy is absorbed. Electromagnetic waves interact with an electron within the valence bands, which then rises through the energy gap in the conduction bands, through two possible types of electronic transfers, the first is a direct transfer and the second is an indirect transfer. In direct transfer, the electron wave vector remains unchanged, and indirect transfer, phonons or lattice vibration helps the transfer so that the bottom of CB is located in the different part of k-space from the top of VB, showing the strong dependence on the donor-acceptor mechanism between the matrix Polymer and ionic materials [16,17]. It was found that the doping process leads to a shift of the absorption edge towards lower energies. Furthermore, Salman et al. [18] Films prepared from poly (vinyl alcohol) with different concentrations of (methyl red).

The films showed indirect transitions between the permissible ranges, which were affected by the doping and the energy gap (4.49-3.19) MeV of the films. Abbas et al. [19]. Thin films of nickel-doped poly (vinyl alcohol) were prepared. Absorption spectroscopy showed that the energy gap ranged between (6 eV and 5.2 eV) for the films. The transmission was found to decrease with doping *by* Eosin- y. Figure (4) Shows transmission as a function of wavelength. Such results are like those obtained by Salman et al. [18].

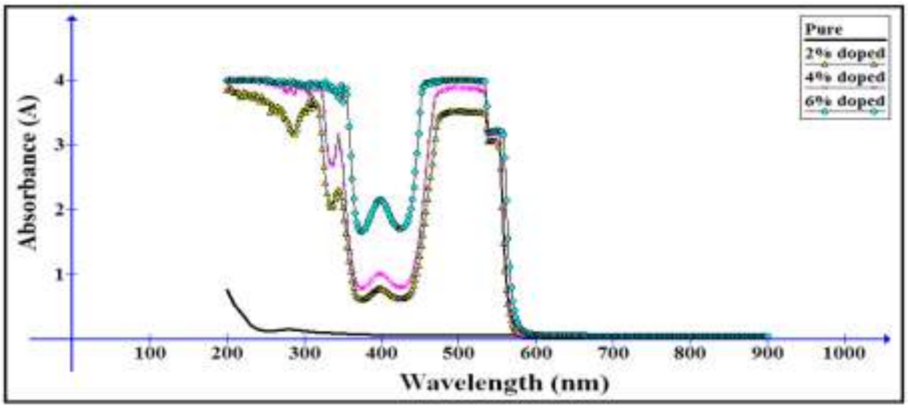

Figure 3: Absorbance of (PVA: Eosin- y).

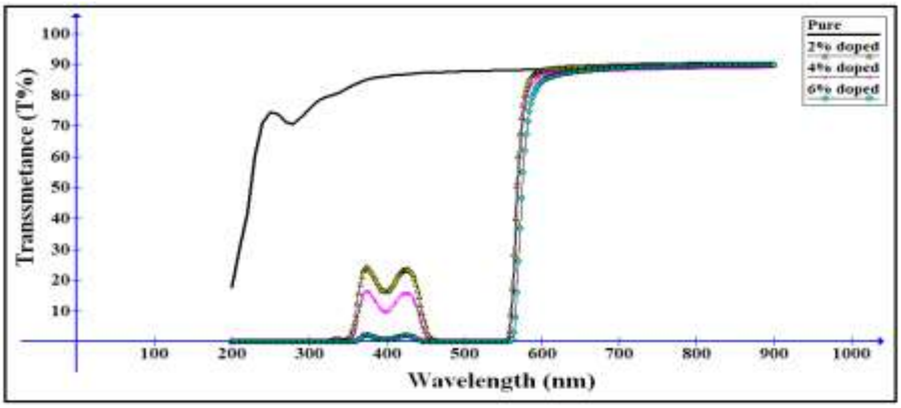

Figure 4: Transmission spectra of (PVA: Eosin- y).

Figure (5). shows reflectance as a function of wavelength.

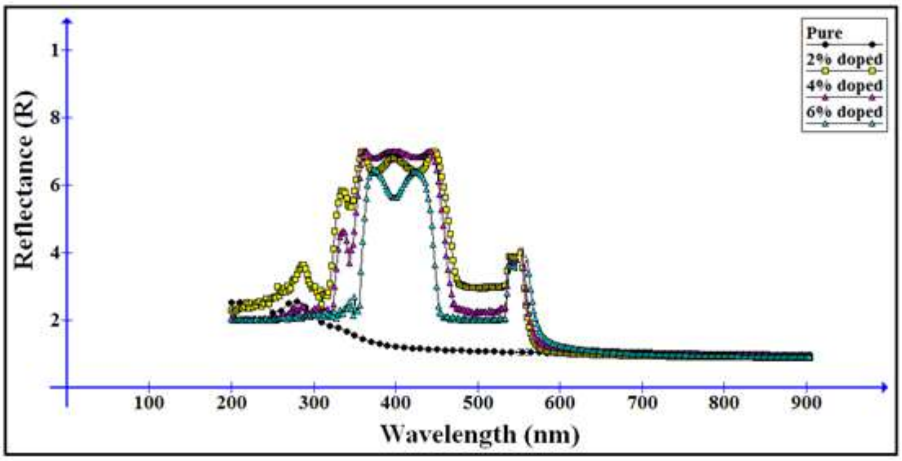

Figure 5: Reflectance of (PVA: Eosin- y).

Through the following equation we can calculate the absorption coefficient (α) [20] :

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

From Figure (6), we find that the absorption coefficient (α) depends on the wavelength of the samples. We find that at shorter wavelengths , the absorption coefficient shows high values, which means that there is a high probability of direct transmission allowed [21,22], then (α) decreases with increasing wavelength.

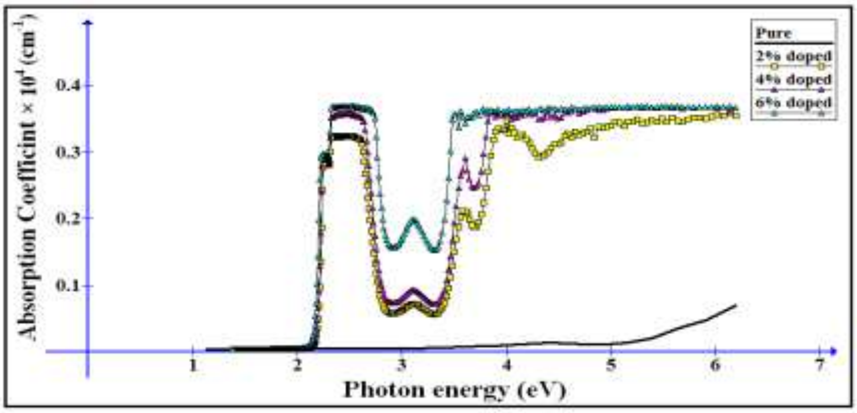

Figure 6: Absorption coefficient of (PVA: Eosin- y).

Figure (7) The linear behavior shown by the plot (αhf)1/2 with (hf) is that which shows the indirect transition allowed. Extrapolating the linear part of this curve to the point (αhf)1/2 = 0 gives the energy gap (for example) for the films. The doping ratios decrease as the optical energy gap decreases. This result is similar to that obtained by Mohammed et al. [23]. The presence and variation of the optical energy band gap (for example) with the photon energy, as the Eosin increased (0%, 2%, 4%, 6%) we obtained a band gap of (3.89, 2.20, 2.17, 2.13) eV, respectively, The occurrence of cross-linking in the amorphous phase of the polymer can be explained in this way to increase the degree of organization in these parts [24].

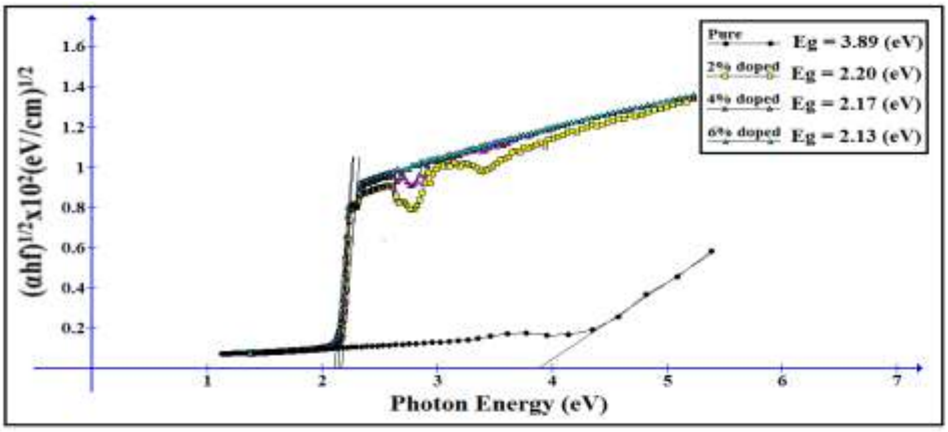

Figure 7: Band gap energy of (PVA: Eosin- y).

The refractive index (n°) is a parameter directly related to the density of the material and its value increases with increasing film thickness. Measurements of electrical properties can be linked with the refractive index (n°) of the prepared films [25]. The calculation of reflectance (R) is done using the relationship [26].

$$n_0 = \left(\frac{1+\sqrt{R}}{1-\sqrt{R}}\right) \qquad \text{-------------} \ (2)$$

where (R) is the reflectance.

Figure (8) The index of refraction is a behavior similar to reflection, and by interpreting the values of the reflection coefficient (n°) as a function of the photon energy, the value of (n°)

shows the occurrence of some interactions between electrons and photons in the frequency range through which they were examined, and because of these interactions The index of refraction changes with the wavelength of the incident light beam [27].

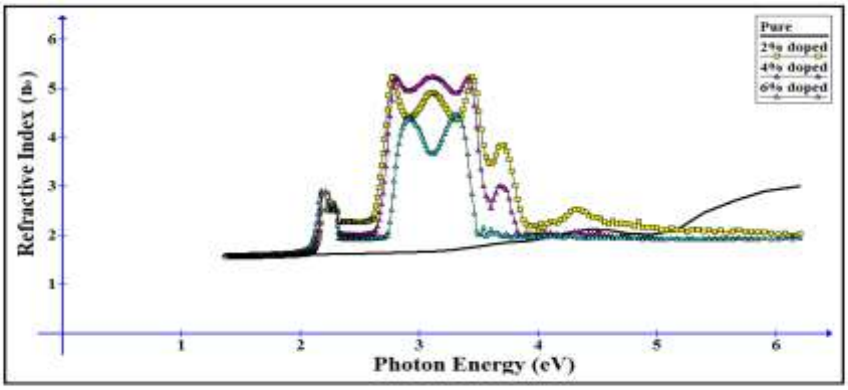

Figure 8: Refractive Index of (PVA: Eosin- y).

The extinction coefficient is defined as the amount of energy loss in the interaction that occurred between the charge of the medium and the light It is considered the imaginary part of the complex refractive index and is represented by the symbol (k°) [28]. The behavior of (ko) is a smaller absorption coefficient. As you can see regarding [29]:

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

(α) the absorption coefficient, (λ) the wavelength of the incident photon.

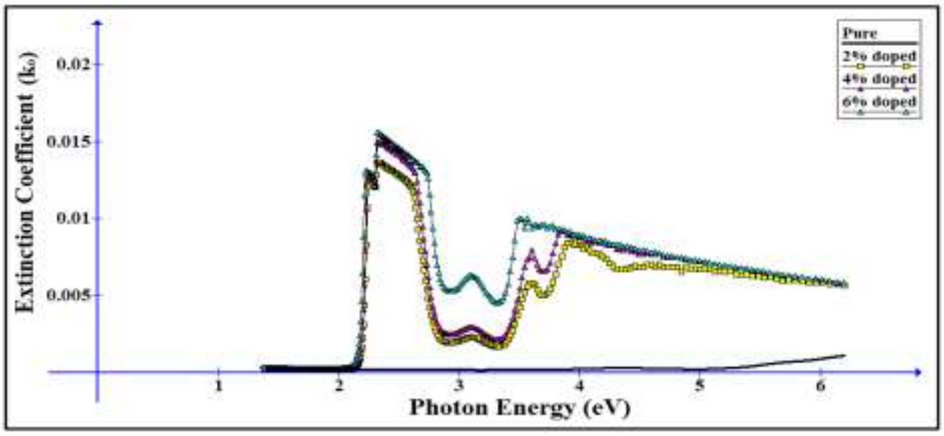

Figure 9: Extinction Coefficient of (PVA: Eosin- y).

Conclusions

Polymeric films were formed by mixing PVA with eosin by casting method at different concentrations (2%, 4%, 6%). Then, the structural and optical properties of (PVA:Eosin-y) were studied, and FTIR test and transmittance spectra showed that eosin-y has a significant effect on the structural and optical properties of (PVA) films. Adding eosin to (PVA) films leads to the formation of new acetyl groups (C-O), which play an important role in the oxidation of (PVA), and adding eosin to (PVA) leads to a change in the optical properties of (PVA).

The values studied above, which relate to optical variables, showed the presence of a redshift in the optical absorption edge, and this indicates a decrease in the energy gap (Eg) with increasing doping ratios. The results also showed the possibility of using (PVA) (Eosin-y) films in optical applications.

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