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Study the Optical Properties of (PVA-PEG-Aniline Blue Dye) Composites

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Abstract: This study discovers the study effect of Aniline blue dye (ABD) addition on optical properties of polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) blend. The composites samples were prepared by adding (ABD) percentages of 0, 0.013, 0.015, 0.017 and 0.020 wt. (%) to the (PVA-PEG) blend. The films were prepared by casting method with different thicknesses. The absorption noted in range of wavelength 200-800 nm. While the optical constants such as extinction coefficient, absorption coefficient, energy gap of the forbidden transition, indirect allowed, imaginary and real dielectric constants determined. The optical constants improved with improving of (ABD) concentration. The energy gap reduced with reduction the weight percentages of (ABD).

Key words: ABD, PVA, PEG, optical properties

INTRODUCTION

The composites at latest years appeal the attention engrossed both in science and industry applications. There is the option to syndicate electric, optical and mechanical properties of basic components in the sample. From vision of optical point, several fascinating properties of these composites obtained (Kovalchuk *et al*., 2005). Polyvinyl Alcohol suggest a mixture of excellent films binder features and formation, along with insolvability in organic solvents and cold water. This mixture of features is valuable in application variety. Moreover, it covers a backbone carbon with hydroxyl groups close to carbons methane. The hydroxyl groups could be a source of bonding hydrogen (Tawansi *et al*., 2005). The steadiness of thin films polymer on solid-substrates is on excessive technological significance in the applications were extending from protective coats to painting, optical-electronic and semiconductor devices (Bhattacharya and Ray, 2004; Reiter, 1994). There are extensive studies on optical properties and applications of polymer like electronic and optical devices, solar cells, solid-state batteries, fuel cells. Also exhibitions applications of medical technology. The high dielectric strength, capacity of good charging storages like the conductivity of highly flexibility make an excellent (PVA) as polymer for industrial micro-electronic. Polymers electrical conductivity have calculated widely in last years to know the charge transport nature in the materials. Many mechanisms of conductivity like the Pool-frenkel effect, hopping conduction, Schottky effect and space charge limited conduction advised for the charges transportion (Abdullah and Saeed, 2013). This study comprised the (ABD) addition effect on the properties of optical of (PVA-PEG) blend.

MATERIALS AND METHODS

The raw materials used in this paper were 75% g of Polyvinyl Alcohol (PVA) dissolved in 60 mL of distilled water at temperature 70°C, mixed by a magnetic stirrer in 1 h. 25% g of Polyethylene Glycol (PEG) added to the PVA at a temperature 50°C mixed by a magnetic stirrer for 30 minutes to obtain more homogeneous solution. Using the casting method to prepare the (PVA-PEG-Aniline-Blue Dye) with different concentrations of Aniline-Blue Dye (ABD) added to the blend as (0, 0.013, 0.015, 0.017, 0.020) wt. (%) mixed for 30 min at temperature 50°C, the thickness of prepared thin films were 0.015 mm.

RESULTS AND DISCUSSIONS

Optical microscope measurement: Figure 1 show the images of (PVA-PEG-ABD) composites with different concentrations of (ABD) at magnification power (10X). This figure display the aggregation of dye as clusters at concentrations with low values. With growing, the dye concentration creating network paths inside the (PVA-PEG) blend (Abdullah *et al*., 2015).

Absorbance of (PVA-PEG-ABD) composites: Figure 2 shows the absorbance of (PVA-PEG-ABD) composite vs wave length, the figure indicate that the absorption rises with dye addition and reduction with wavelength rises because of free electron number rising that absorbed the light incident (Hegazy *et al*., 2014). The high absorption of composites in the UV-region attributed to the energy of photon sufficient to cooperate with the atom, the excitation of electrons from a lower to a level with higher energy with absorbing a photon energy (Indolia and Gaur, 2013).

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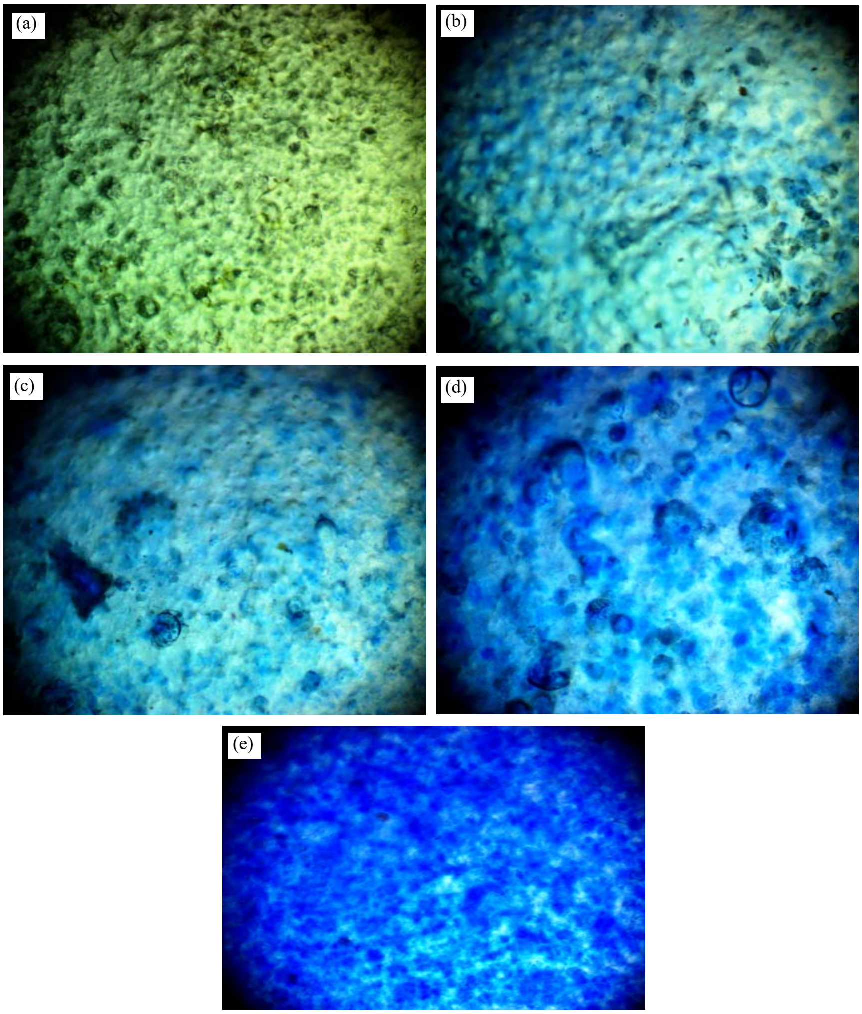

Fig. 1(a-e): Photomicrographs (10X) for (PVA-PEG-ABD) composites: (a) for (PVA-PEG) blend, (b) for 0.013 wt. (%) (ABD), (c) for 0.015 wt. (%) (ABD), (d) for 0.017 wt. (%) (ABD) and (e) for 0.020 wt. (%) (ABD)

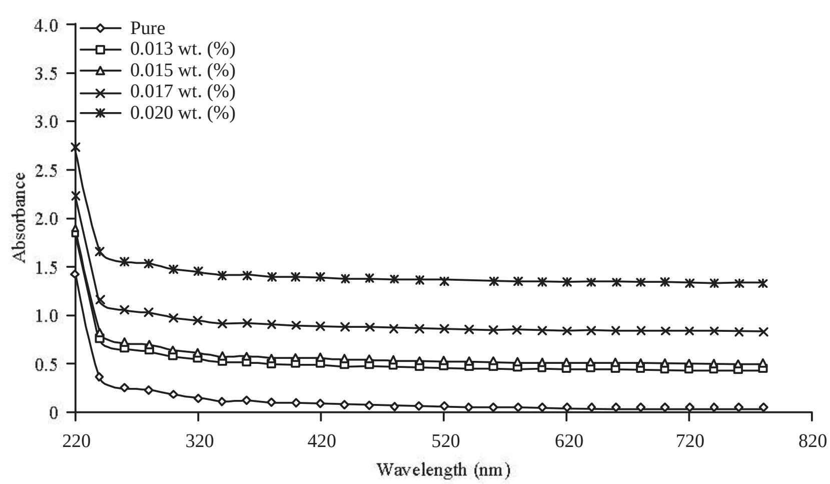

Fig. 2: The absorbance as a function of wavelength for (PVA-PEF-ABD) composites

Absorption coefficient and energy band gap of composites: Figure 3 shows the coefficient of optical absorption as a function of photon energy for (PVA-PEG-ABD) composite, it was institute that the composite consume a little absorption coefficient at a minor photon energy after that growth with rising photon energy depending on the structure of composite. The study of spectra of absorption coefficient might expose the energy gap Eg between the valence band and the conduction band due to transitions of direct and indirect for both amorphous and crystalline materials. The absorption coefficient rises with growing in (ABD) concentration. The absorption coefficient (α) calculated from the following equation (Kurt, 2010):

$$\alpha = 2.303\, A/t \qquad (1)$$

where, A is absorbance and (t) is the thickness of sample.

Figure 4 and 5 characterized the variation of indirect for allowed and forbidden transition as a function of photon energy of (PVA-PEG-ABD) composite. According to the "model of indirect transition" for amorphous semiconductors planned by Taue (Wolfe *et al*., 1989).

$$\alpha\, h\upsilon = B(h\upsilon - E_g)^n \qquad (2)$$

where, B is a constant associated to the valance and conduction band properties, hυ is the photon energy, Eg is the optical energy band gap, n = 2, or 3 for transition of both of indirect (allowed and forbidden). From the direct plots of $(\alpha h\nu)^{1/n}$ vs (hν) for these samples as shown in Fig. 4 and listed in Table 1, Eg calculated from the extrapolations intercepts to zero with the photon energy axis $(\alpha h\nu)^{1/n} \rightarrow 0$. It is seen that the concentration of (ABD) rising in the system leads to reduction in Eg. This

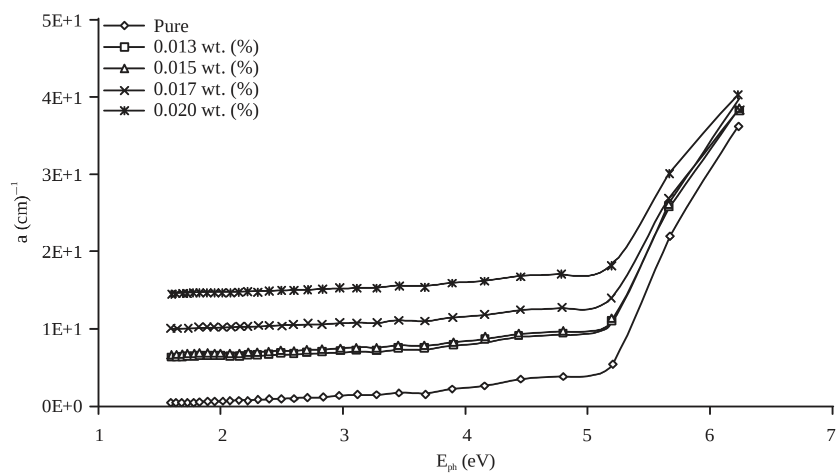

Fig. 3: The absorbance coefficient as a function of photon energy for (PVA-PEF-ABD) composite

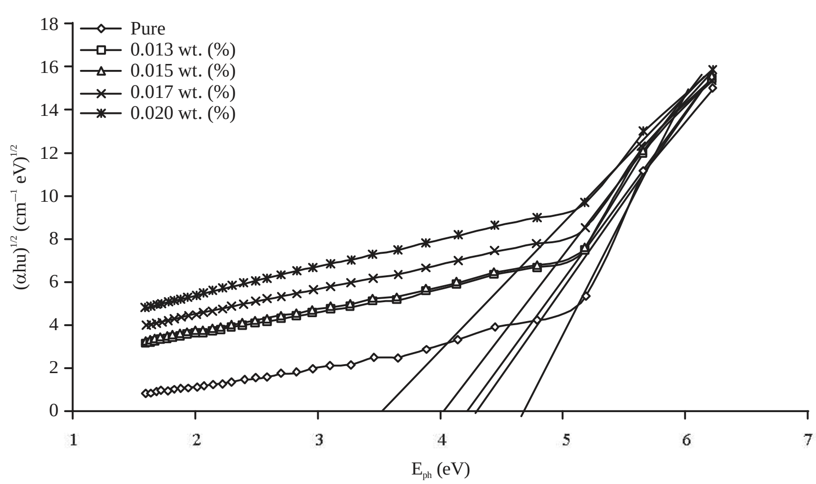

Fig. 4: The variation of $(\alpha h\nu)^{1/2}$ as a function of photon energy for (PVA-PEG-ABD) composites

might be recognized to structural disorder growth of the composites with growing (ABD) concentrations.

Extinction coefficient and refractive index: Figure 6 and 7 show the variation of extinction coefficient (k) and refractive index (n) as a function with the wavelength for (PVA-PEG-ABD) composite The extinction coefficient calculated by using the relation (El-Raheem, 2007):

$$k = \alpha \lambda / 4 \pi \quad (3)$$

Table 1: The values of energy band gap for the allowed and forbidden indirect transition for (PVA-PEG-ABD) composites

	Eg (eV)	
ABD wt. (%)	Allowed	Forbidden
0	4.43	4.18
0.013	4.30	3.70
0.015	4.21	3.60
0.017	4.10	3.18
0.020	3.60	2.70

where, λ is the wavelength, α is the absorption coefficient. While the refractive index of the films calculated by the following equation (Abdullah and Saeed, 2013):

$$n = [4R/(R-1)2-k2]-(R-1)/(R-1) \quad (4)$$

where, R is the reflectance and k is the extinction coefficient, the k values rise with growing (ABD) concentration. This growing shows that the through material the electromagnetic radiation is transient faster in the transient photon energy with low levels, this as the increment of photons dispersion and optical absorption in polymer matrix (Al-Ramadhan *et al.*, 2016). While the refractive index n rising with increment of (ABD) concentration and reduced with increment of wavelength. This performance can be recognized as growing of the concentration of (ABD) density (Al-Dulaimi, 2016), also

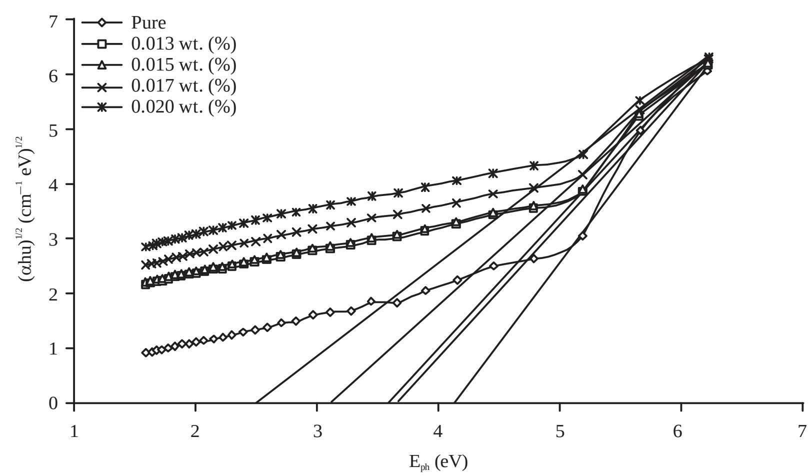

Fig. 5: The variation of $(\alpha h\nu)^{1/3}$ as a function of photon energy for (PVA-PEG-ABD) composite

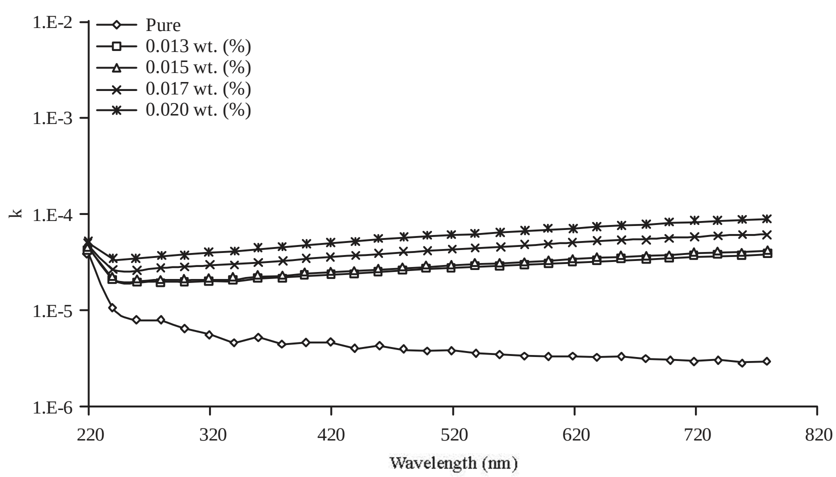

Fig. 6: The variation of extinction coefficient for (PVA-PEG-ABD) as a function of photon energy

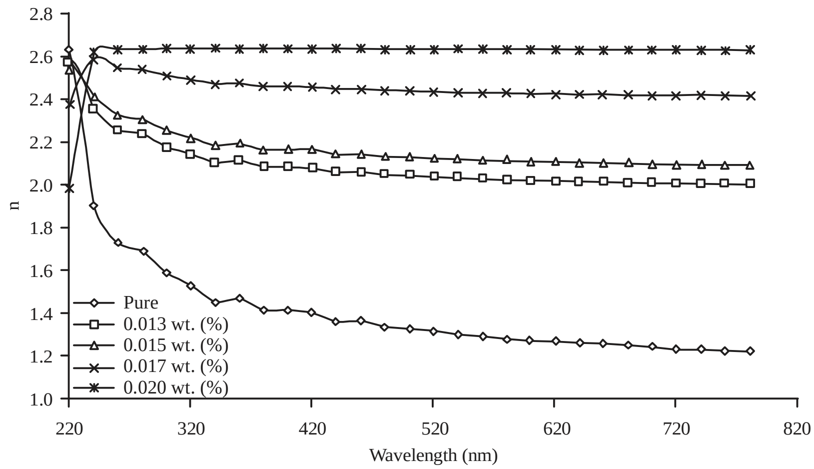

Fig. 7: The variation of refractive index for (PVA-PEG-ABD) as a function of wavelength

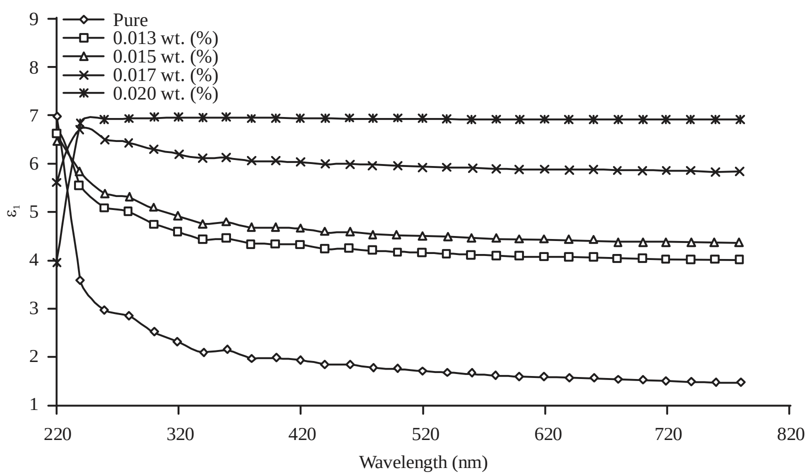

Fig. 8: The variation of the real part of dielectric constant for (PVA-PEG-Aniline blue dye) as a function of wavelength

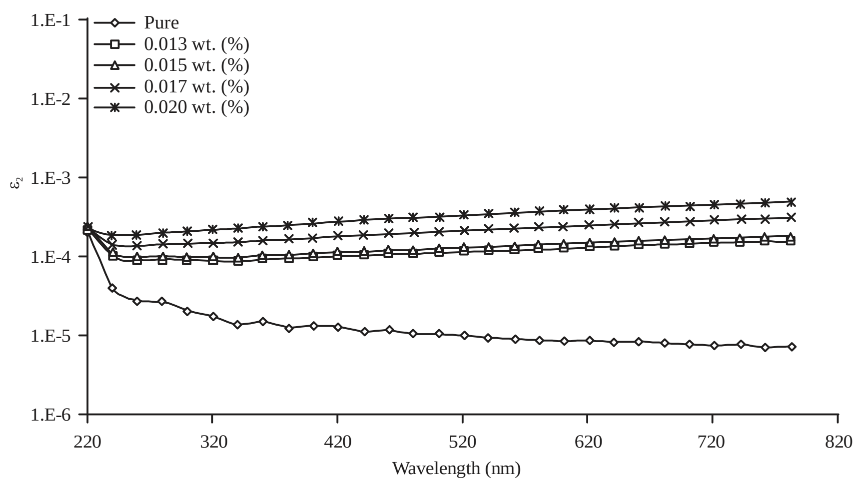

Fig. 9: The variation of imaginary part of dielectric constant for (PVA-PEG-Aniline blue dye) as a function of wavelength

may the variation of the absorption coefficient which principals to deviation of spectrum in the charge polarization location.

Dielectric constants: The real and imaginary of dielectric (ε_1 and ε_2) can be calculated by using equations (Tintu *et al*. 2010):

$$\varepsilon = \varepsilon_1 \text{-i } \varepsilon_2 \tag{5}$$

$$\varepsilon_1 = n_2\text{-}k_2 \tag{6}$$

$$\varepsilon_2 = 2nk \tag{7}$$

Figure 8 and 9 represented the real and imaginary part of the dielectric constant vs the incident wavelength, it's clear that the real and imaginary part of the dielectric constant were improved with (ABD) concentration growing, this because of extinction coefficient and refractive index amassed (Abdullah, 2014).

CONCLUSION

Studying the optical properties of (PVA-PEG-ABD) composites in the spectral region 200-800 nm. The composites have high absorbance in the ultraviolet and visible region and poor absorbance in the IR region making it suitable for using in solar thermal devices. The inter band transitions were found to be indirect type. The optical energy gap has been found to reduction with the growing the concentration of ABD. The extinction coefficient, refractive index and real and imaginary dielectric constant are increasing with the increasing of the concentration of ABD.

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