http://jgu.garmian.edu.krd https://doi.org/10.24271/garmian.218

Optical properties of Polyvinyl Alcohol Films doped with Fe

Mahmood M. Kareem[1*] Sami Salman Chiad[2] Nadir Fadhil Habubi[2] Khalid HaneenAbass[3] Nidhal Nissan Jandow[2] Ismaeel A. Al-Baidhany[2] Khudheir Abbas Mishjil[2]

[1] Department of Physics, College of Education, University of Garmian, Kalar, Kurdistan Region, Iraq
[2] Department of Physics, College of Education, Al_Mustansiriyah University, Baghdad, Iraq
[3] Department of Physics, College of Education for Pure Sciences, University of Babylon, Babel, Iraq
[*]Corresponding author. Email: mahmood.mohammed@garmian.edu.krd

Abstract
$FeCl_3$ was used as a source of Fe that added to the PVA films. PVA-Fe films were prepared by casting method. The UV-Visible spectrophotometer used to record the absorbance spectrum in the range of 300-900 nm. The absorbance decreased with the increasing of Fe in the PVA films. The absorption coefficient increased with the increasing of Fe content, while the extinction coefficient, refractive index and optical conductivity are decreased. The optical conductivity decreased from 4 eV for PVA film to 3.3 eV for PVA-3% Fe films.

Keywords: PVA, PVA-Fe, Optical parameters, optical energy gap

Introduction
In recent year's great progress in understanding polymer surface phenomena and development in their theoretical aspects have been done. Forces occurring on polymer surfaces depend on the interaction between macromolecules, which are different inside the material and on the phase boundary [1]. 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 [2]. The incorporation of the dopants into polar organic polymers can induce pronounced changes in various properties of polymers in order to modify and improve its properties [3].
The final properties of reinforced polymers (composites) are influenced by the nature, properties and content of components, dimensions of components and microstructure of composite and interfacial interactions between matrix and dispersed phase. The aspect ratio of the filler is very important and crucial for many properties in composite such as

electrical [4]. Some optical properties are evaluated as a function of Fe additive in the PVA matrix prepared by casting solution method.

Experimental part

Poly (vinyl alcohol) with molecular weight 10000 g/mol was used as a host polymeric material in this work, supplied by (BDH Chemicals England) . $FeCl_3$ supplied from (Merck Chemicals Germany) volumetric percentageof (1% and 3%) was used as a doping agent embedded in the polymer matrix , the solution were deposited using casting method at room temperature.

Absorbance and transmittance measurements were carried out using double beam UV-VIS spectrometer (Shimadzu Japan) in the wavelength range (300-900) nm.

Results and Discussion

The optical absorbance spectra as a function of wavelength was presented in the wavelength range 300-900 nm. The absorbance spectra of PVA films with various content of Fe were shown in Fig.1. From the figure, it can be seen that the absorbance was decreased sharply with increasing of wavelength in the UV region, where its decreased gradually in the visible region. Also, it can notice the decreasing of absorbance with increasing of Fe content in PVA films.

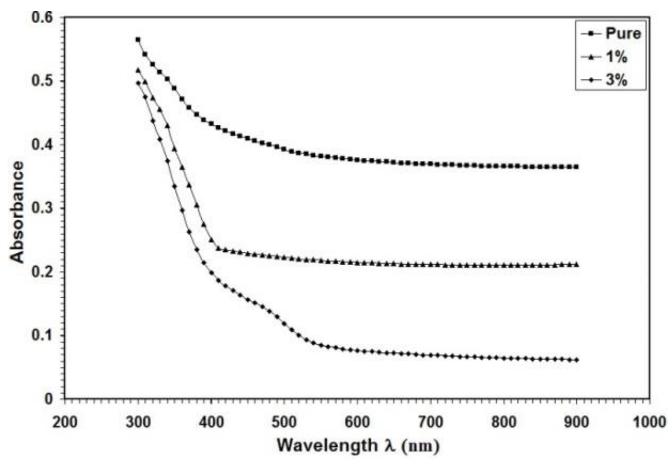

Fig.1: Absorbance spectra of PVA-Fe composites.

The absorption coefficient (α) can be determined from the following relation [5]:

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

Where A is the absorbance and t is the film thickness. The absorption coefficient as a function of wavelength is shown in Fig.2 for PVA-Fe films. From the figure, it can be seen that the increasing of absorption coefficient with an increase of Fe content in PVA-Fe films.

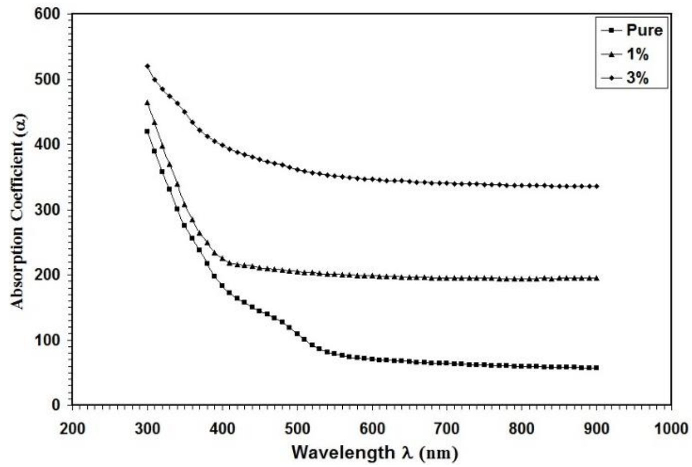

Fig.2: Absorption coefficient of PVA-Fe composites.

The extinction coefficient was related to the absorption coefficient by therelation [6]:

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

Where λ is the incident photon wavelength. The extinction coefficient has increased with the increasing of wavelength, and decrease with the increasing of Fe embedded in the PVA films as shown in Fig.3.

The refractive index (n) of PVA-Fe films have determined by using equation [7]:

$$n = \left[\left(\frac{4R}{(R-1)^2}\right) - K^2\right]^{1/2} + \frac{(R+1)}{(R-1)} \qquad (3)$$

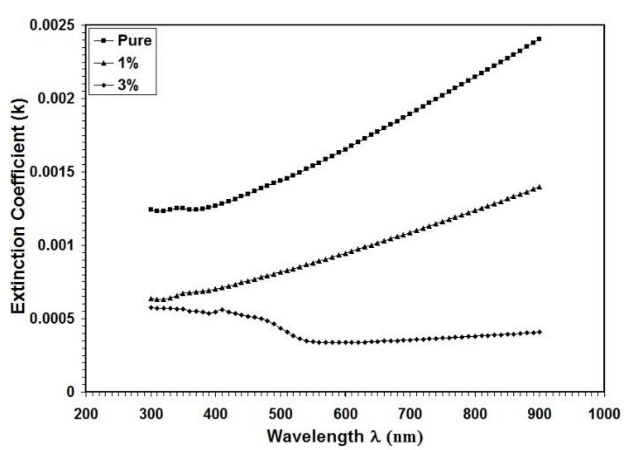

Fig.3: Extinction coefficient of PVA-Fe composites.

Where r is the reflectance. The refractive index versus wavelengthwas plotted in Fig.4. The refractive index decreased with the increasing Fe content in PVA film

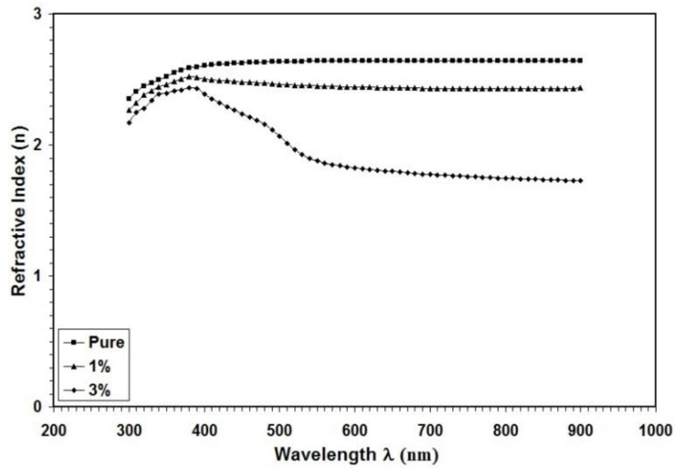

Fig.4: The refractive index of PVA-Fe composites.

The optical conductivity of the PVA-Fe films with various content of Fe were calculated using the following formula [8]:

$$\sigma = \frac{\alpha n c}{4\pi} \qquad (4)$$

Where c is the speed of light, n is the refractive index, and α is the absorption coefficient. The optical conductivity as a function of wavelength of PVA-Fe films are shown in Fig.5. The figure shows a decreasein optical conductivity with increasing Fe content in the PVA films.

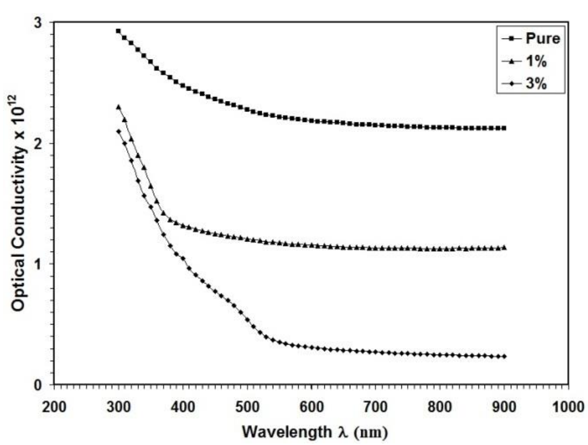

Fig.5: Optical conductivity of PVA-Fe composites.

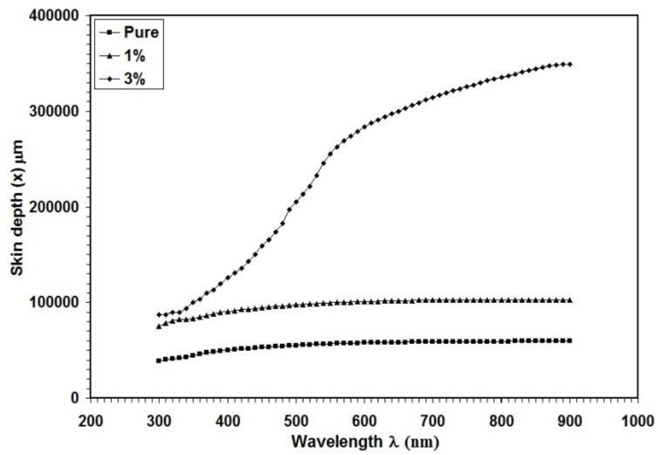

Fig.6: Skin depth of PVA-Fe composites.

The optical energy gap (E_g) can be found from the relation [9]:

$$\alpha h\upsilon = B(h\upsilon - E_g)^m \qquad (5)$$

where h is the Planck constant, hυ is energy of the incidence photon, B is constant known as the disorder parameter which is nearly independent of the photon energy. m is the power coefficient with the value that is determined by the type of possible electronic transitions, i.e., m = 1/2, 3/2, 2 or 1/3 for direct allowed, direct forbidden, indirect allowed and indirect forbidden respectively [10]. The direct band gap can be determined from the plotting $(\alpha h\upsilon)^2$ as a function of photon energy (hυ). The extrapolation of the resulted curve at $(\alpha h\upsilon)^2 = 0$ represent the value of energy gap as shown in Figs.7-9. From these figures, it can be noticed that a decrease in energy gap with increasing of Fe content in PVA films.

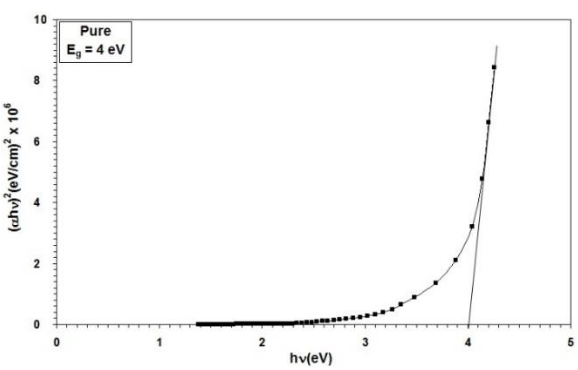

Fig.7: Optical energy gap of PVA polymer.

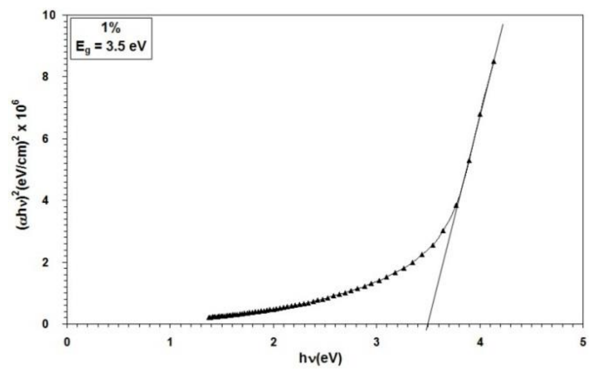

Fig.8: Optical energy gap of PVA-1%Fe composite.

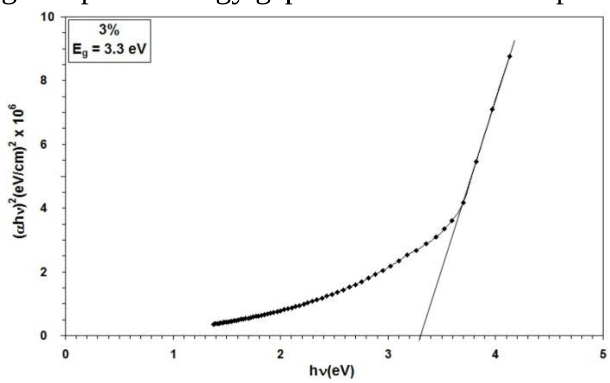

Fig.9: Optical energy gap of PVA-3%Fe composite.

Conclusion

PVA-Fe films were prepared by casting method with various content of Fe. Optical properties were studied from the data of absorbance and transmittance spectra, such as absorption coefficient, extinction coefficient, refractive index and optical conductivity. The optical energy gap was decreased from 4 eV for PVA film to 3.3 eV for PVA-3% Fe films.

References

[1] D. Dorranian, Z. Abedini, A. Hojabri, M. Ghoranneviss, J. of Non-Oxide Glasses, 1(3) (2009) 217.

[2] M. Krumova, D. Lopaz, R. Benavente, C. Mijangos and J. M. Perena, Journal of Applied Polymer, 41 (2000) 9265.

[3] Ghani, A., Young, H. Conductive polymer based on polyaniline-eggshell powder (PANI-ESP) composites. J. Phys. Sci. 21 (2010) 81–97.

[4] Groosiord. N.; Loos, J.,Laake, L.; Maugey, M.; Zakri, C.; Koning, C.E. & Hart, A.J.High-conductivity polymer nanocomposites obtained by tailoring the characteristics of carbon nanotube fillers. Adv. Func. Mater., 18(2008) 3226-3234.

[5] KhalidHaneenAbass, Effect of the Cobalt Additiveon the Optical Properties of CdO Thin Film, AttidellAFondAzioneGiorGio ronchi,120 (1) (2015) 113-120.

[6] MusaabKhudhr M. and Khalid HaneenAbass, Effect of Al-doping on the Optical Properties of ZnO Thin Film Prepared by Thermal Evaporation Technique, International Journal of Engineering and Technologies, 7(2016) 25-31.

[7] D. Bonnell, B. Huey and D. Carroll, In-Situ Measurement of Electric Fields at Individual Grain Boundaries in TiO2, Solid State Ionics, 75 (1995) 35.

[8] Sami SalmanChiad, NadirFadhil Habubi, KhalidHaneenAbass, Nidhal NissanJandow, IsmaeelA. AL-Baidhany, WasmaaAbdulsattarJabbar, HassanHadiDaroysh, MohmoodMuwafaqAbood, Optical constants of Aluminum doped Zinc oxide thin films", AttidellA“FondAzioneGiorGioronchi, 122(1) (2017) 121-126.

[9] Mott, N.F. and E.A. Davis, ElectronicProcess in Non-crystalline Materials. 2nd Edn.,Clarendom Press,(1979).

[10]Arshak, A. and O. Korostynska, Gamma radiation dosimetryusing tellurium dioxide thin film structures. Sensors, 2(2002) 347-355.