The Effect of bismuth oxide Bi_2O_3 on Some Optical Properties of poly-vinyl alcohol

[1]Ghaleb Abdul Wahab AL-Dahash , [2]Hussein Neama Najeeb ,[3]Ahmed Baqer ,[4]Rafia Tiama
Babylon University –Collage of Science for Women, Laser physics Dept.

Abstract

In the present work ,the effect of addition bismuth oxide Bi_2O_3 on some optical properties of poly-vinyl alcohol has been studied . For that purpose , many samples has been prepared by adding bismuth oxide on the poly-vinyl alcohol with different weight percentages from bismuth oxide with polymer and by different thickness .The absorption and transmission spectra has been recorded in the wavelength range (190-890)nm . The absorption coefficient, extinction coefficient ,energy gap of the indirect allowed transition, real and imaginary dielectric constants and refractive index have been determined

Key word : Composites, optical properties

Introduction

Composites made of polymer with a conducting filler phase allow the combination of the mechanical properties of polymers and its ease of processing with electrical applications requiring significant conductivity, polymer-based electrically conducting materials have several advantages over their pure metal counterparts, which include cost, flexibility, reduced weight, ability to absorb mechanical shock, corrosion resistance, ability to form complex parts, and conductivity control. Filled conducting polymer composites are used for electromagnetic shielding of computers and electronic equipments. In addition, they are used as conducting adhesives in electronics packaging flip-chips, cold solders, switching devices, static charge dissipating materials, and devices for surge protection [1].

primarily because it is an efficient and cost effective process for mass production, there is currently great interest in the technological properties of particle filled polymers. Filled polymer composites have a wide range of industrial applications-they are used in anti-static materials, self regulating heaters, over current and over temperature protection devices, and materials for electromagnetic radiation shielding[2].The electrical insulating behavior of most polymeric materials is well known. However, conductive fillers can be incorporated as a second phase in to these matrices, leading to an increase in the conductivity of the resulting composites. the properties of these composites are mainly varied with the filler content. Polymeric composites are traditionally used as electrically insulating materials and generally known to have many structural applications, but their use in electronics has been relatively limited. In order to make the polymeric materials have electrical conduction, continuous pathways by electrical fillers must be established [3]. The advantage of PVA such as high mechanical strength and water-soluble selection as compared to other polymer matrices[4]. This paper deals with results of the effect of Bi_2O_3 on the some optical properties of poly-vinyl alcohol .

Experimental Part

The materials used in this paper is poly-vinyl alcohol as matrix and Bismuth Oxide as a filler. The electronic balanced of accuracy 10^{-4} have been used to obtain a weight amount of Bi_2O_3 powder and polymer powder .. The weight percentages of Bi_2O_3 are (0 ,1and 2) wt%.. The transmittance & absorbance spectra of (PVA-Bi_2O_3)composites have been record in the wavelength range (190-890) nm using double-beam spectrophotometer .

The extinction coefficient (k)is calculated by using the following equation [5]:

$$k = \alpha\lambda/4\pi \qquad \text{……………….(1)}$$

where α is absorption coefficient and λ is wave length.

The absorption coefficient (α) is calculated by using the following equation:

$$\alpha = 2.303(A/t) \qquad \text{……………….(2)}$$

where A is absorption and t is the thickness of films

The refractive index (n) is calculated by using the following equation:

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

Real (ε_1) and imaginary (ε_2) dielectric constant is calculated by using the following equations:

$$\varepsilon_1 = n^2 - k^2 \qquad \text{……………….(4)}$$

$$\varepsilon_2 = 2nk \qquad \text{…..……………(5)}$$

The allowed indirect transition energy gap is calculated by using the following equation [J . Tauce ,1972]:

$$\alpha h\upsilon = A(h\upsilon - E_g)^m \qquad \text{…………………(6)}$$

Results and Discussion

Figure (1) shows the absorbance spectrum as function of the wavelength of the incident light .It is shown that the adding of the filler to the polymer lead to increase the intensity of the peak . There is no shift in the position of the peak for all amounts of filler adding to the polymer.

Chemically that means this addition do not change the structure of the ($PVA\text{-}Bi_2O_3$)composites .The increase of absorbance with the increase of weight percentage of the added Bismuth Oxide can be explained by the fact Bismuth Oxide ions absorbed the light incident on them [6, 7].

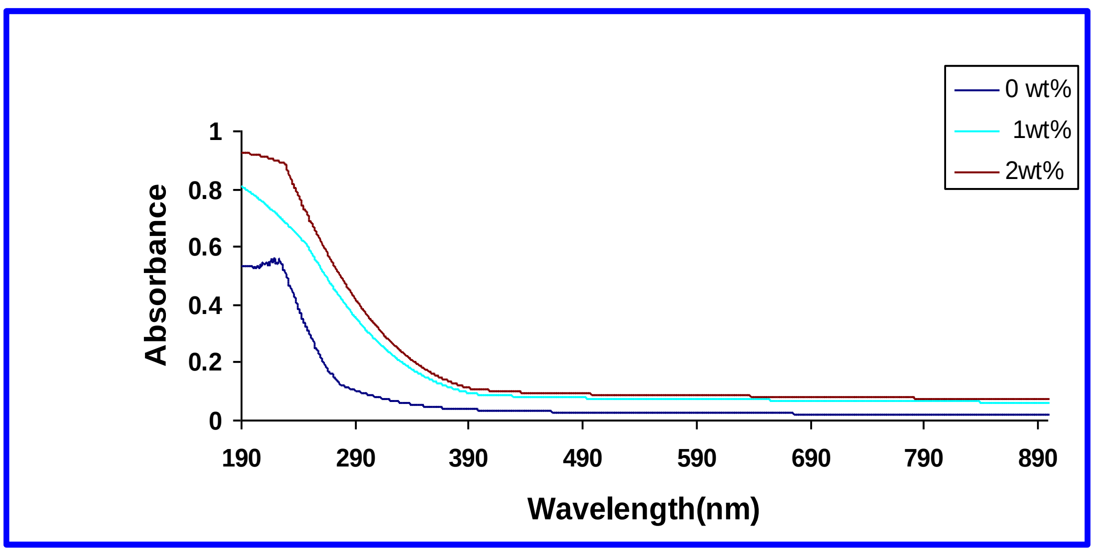


Figure (1) : the absorbance spectrum for ($PVA\text{-}Bi_2O_3$) composites as function of incident wavelength

Figure(2)shows the optical transmittance spectrum as function of wavelength of incident light by adding different rate of the added ions ,the figure shows that the transmittance decrease with the increase of the added ions concentration ,this is due to the added Bismuth Oxide Bi_2O_3 that contains in it is outer orbits, these electrons absorb the electromagnetic energy of the incident light ,resulting in the transition of electrons to higher energy levels, this process is not accompanied by emission of radiation because the electron that moved to higher levels have occupied vacant positions of energy bands ,thus part of the incident light is absorbed by the substance and dose not penetrate through it ,on the other hand the pure poly-vinyl alcohol has high transmittance because there are no free electron (i.e .electrons are linked to atoms by covalent bonds) ,this is because the breaking of electron linkage and moving it to the conduction band need photon with high energy [6].

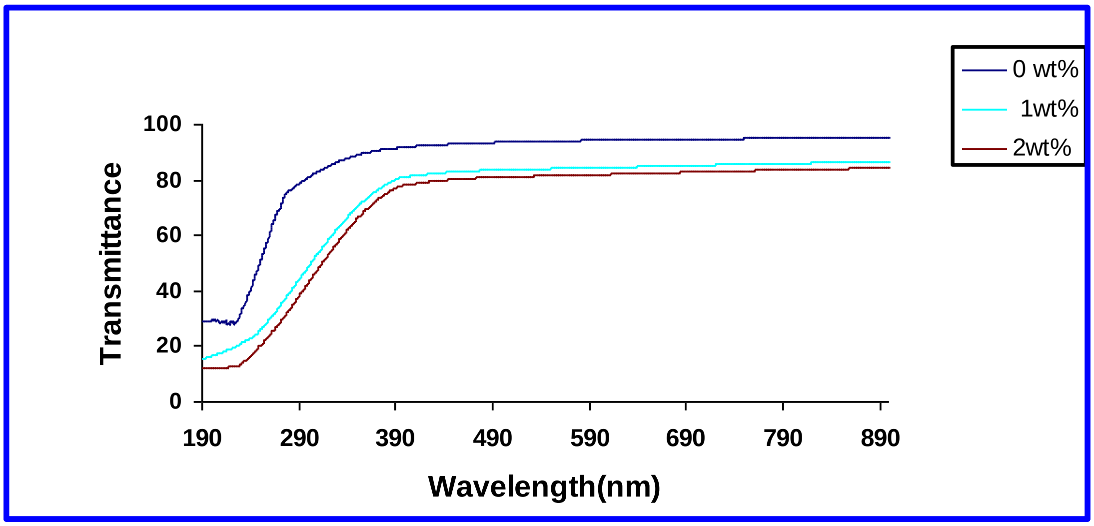
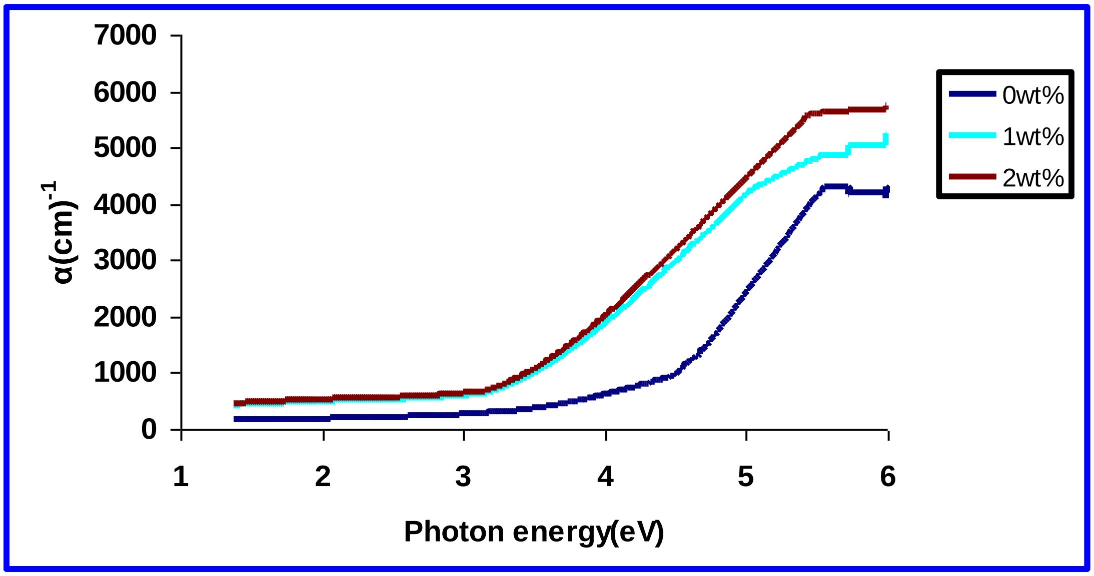


Figure (2) : the Transmittance spectrum for (PVA-Bi_2O_3) composites as function of incident wavelength

The absorption coefficient (α) is calculated by using the equation (2) .Figure (3) shows that the absorption coefficient (α) as a function of the photon energy ,it can be noted that absorption is little at low energy. This means that the possibility of electron transition are little because the energy of the incident photon is not sufficient to move the electron from the valence band to the conduction band $(h\upsilon < E_g)$.

At high energies, absorption is greater ,this shows that there is great possibility for electron transitions consequently, the energy of incident photon is enough to move the electron from the valence band to conduction band ,this means that the energy of the incident photon is greater than the forbidden energy gap[6] .This shows that the absorption coefficient assists in figuring out the nature of electron transition ,when the values of the absorption coefficient is high $(\alpha>10^4)$ cm^{-1} at high energies, it is expected that direct transition of electron occur ,the energy and moment are maintained by the electrons and photons ,on the other hand when the values of the absorption coefficient is low $(\alpha<10^4)cm^{-1}$ at low energies ,it is expected that indirect transition of electron occur ,and the electronic momentum is maintained with the assistance of the photon[8] .Among other results is that the coefficient of absorption for the PVA-Bi_2O_3composites is less than 10^4 cm^{-1} ,this explains that the electron transition is indirect.



Figure(3):the absorption coefficient for PVA-Bi_2O_3composites as a function of photon energy .

The allowed indirect transition energy gap has been calculated by using equation(6). Figure (4) shows the relationship between $(\alpha h\nu)^{1/2}$ and the photon energy of pure polymer PVA , will get the value of energy gap of the allowed indirect transition , which is equal to 3.7eV.

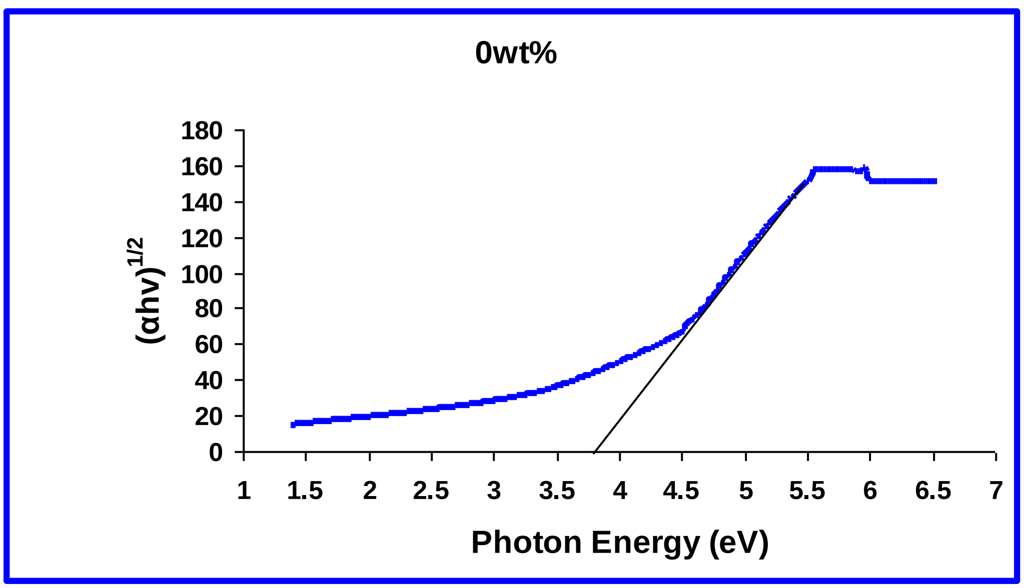


Figure (4): the Variation $(\alpha h\nu)^{1/2}$ with photon energy of pure polymer (PVA).

Figures (5) and (6) represent the same relationship but for the polymer filled with $Bi_2O_3$with both weight percentages of 1 and 2 wt.%

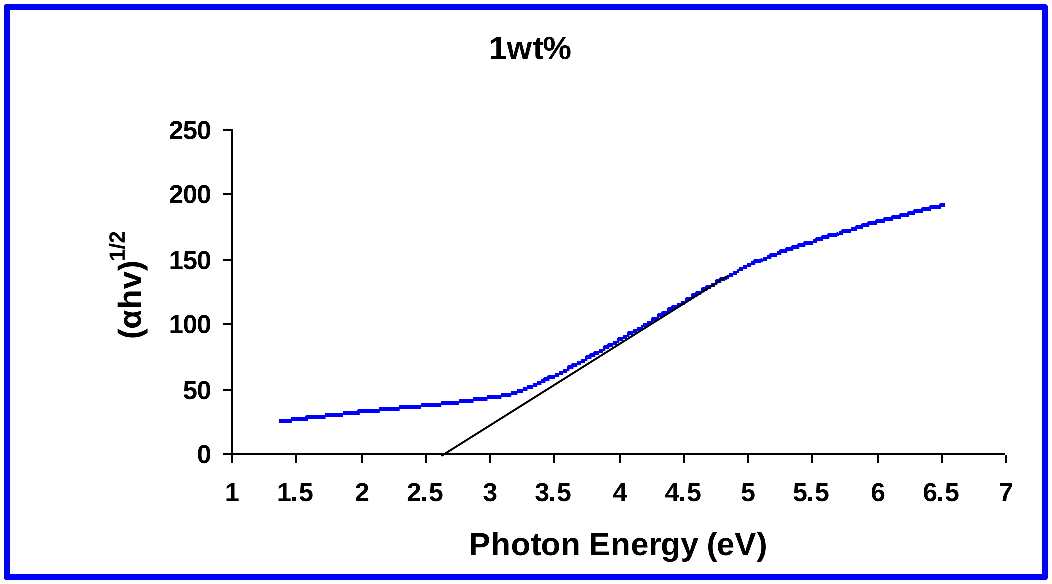


Figure (5): the Variation $(\alpha h\nu)^{1/2}$ with photon energy of (PVA-Bi_2O_3)composites.

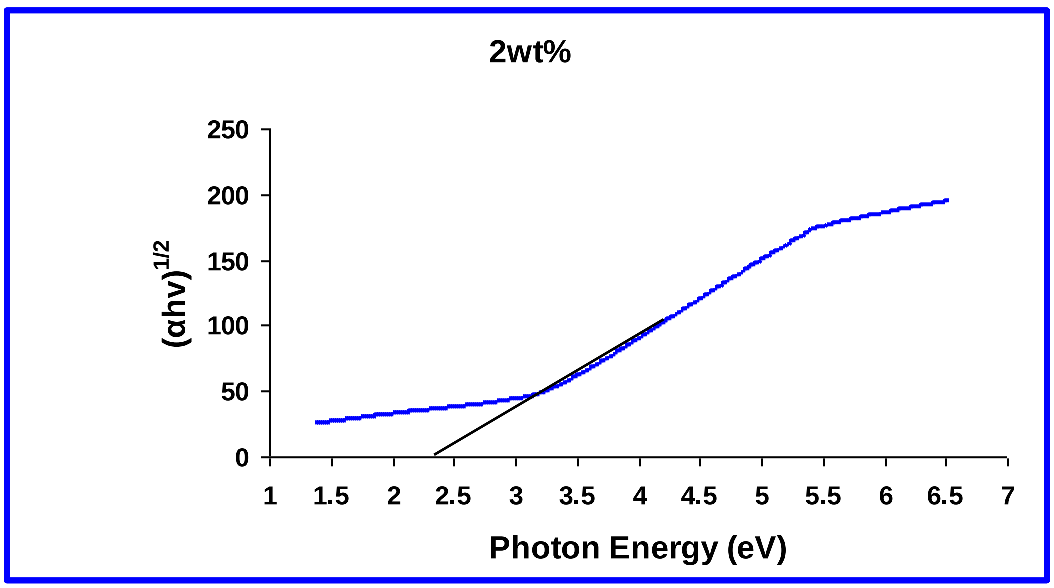


Figure (6): the Variation $(\alpha h\nu)^{1/2}$ with photon energy of (PVA-Bi_2O_3)composites.

Figure(7) shows the variations of extinction coefficient (k) with wavelength for pure and doped PVA with Bi_2O_3 . This figure shows that k value increases with increasing of the weight percentage of Bi_2O_3 . The behavior of extinction coefficient (k) can be described according to high absorption coefficient. This result indicates that the doping atoms of Bi_2O_3 will modify the structure of the host polymer. [9].

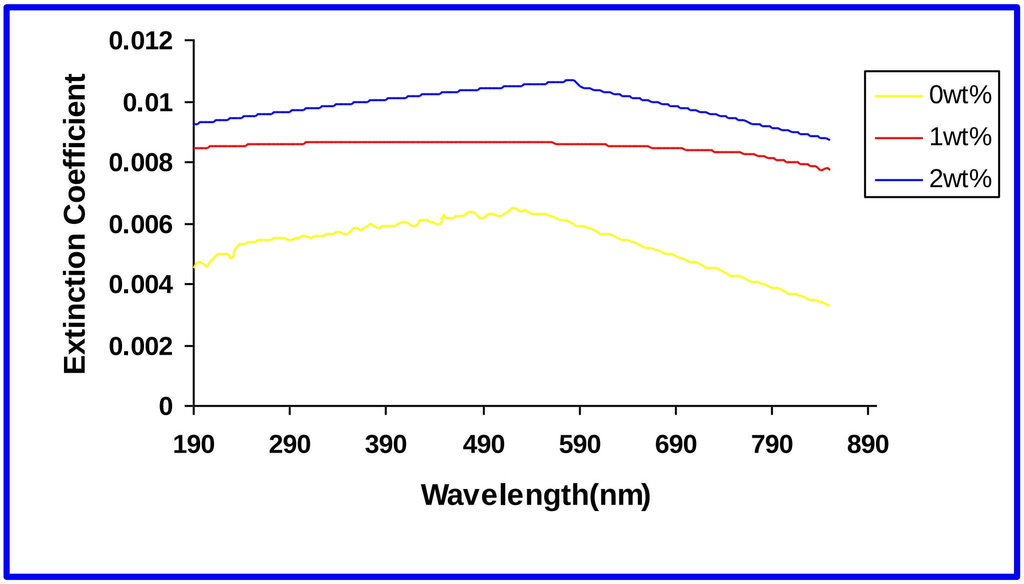


Figure (7) : the variation of the extinction coefficient (k) with wave length of the PVA-Bi_2O_3 composites.

The refractive index was found from equation (3) .Figure (8) shows the variation of refraction coefficient for PVA-Bi_2O_3 composites as a function of wavelength .From the figure we can see that the refraction index is increase with increasing the weight percentage of the added Bi_2O_3 to the polystyrene. The reason of this result is from the increased intensity of the resulting composite ,in other wards due to increase the number of free electrons .Figure (8) also shows that the pure poly-vinyl alcohol has low refraction index because poly-vinyl alcohol is amorphous crystalline substance with low density.

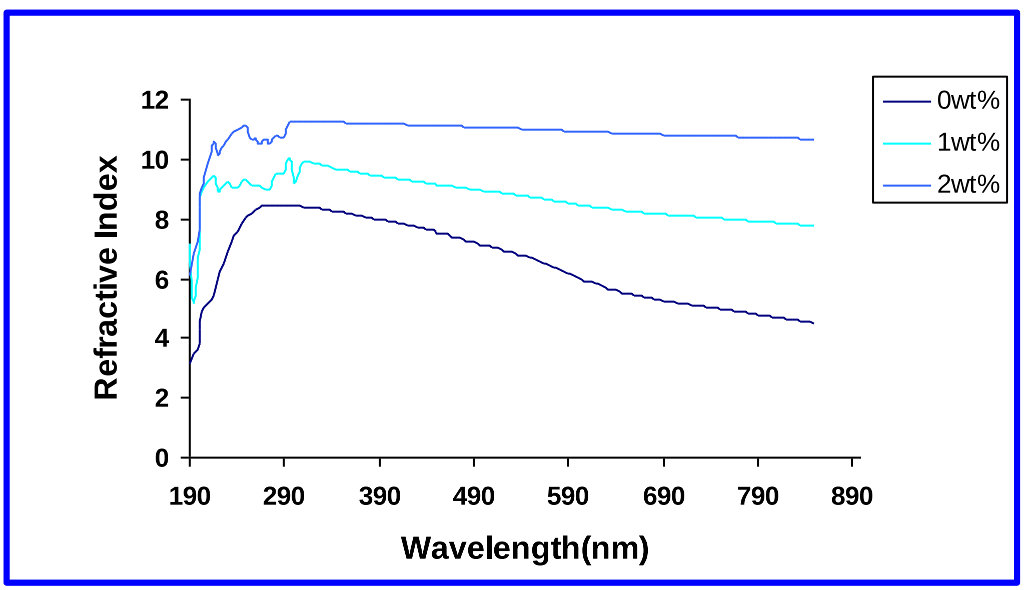


Figure (8) : the variation of refractive index for PVA-Bi_2O_3composites wavelength.

The real and imaginary dielectric constant (ε_1,ε_2) for (PVA-Bi_2O_3) composites have been calculated from equations (4)and(5), respectively .The figures (9) and (10) show the change of ε_1 and ε_2 as a function of the wavelength .It can be seen that ε_1 is considerably depends on n^2 due to low value of k^2 ,while ε_2 is dependent on k values that change with the change of the absorption coefficient due to the relation between n and k.

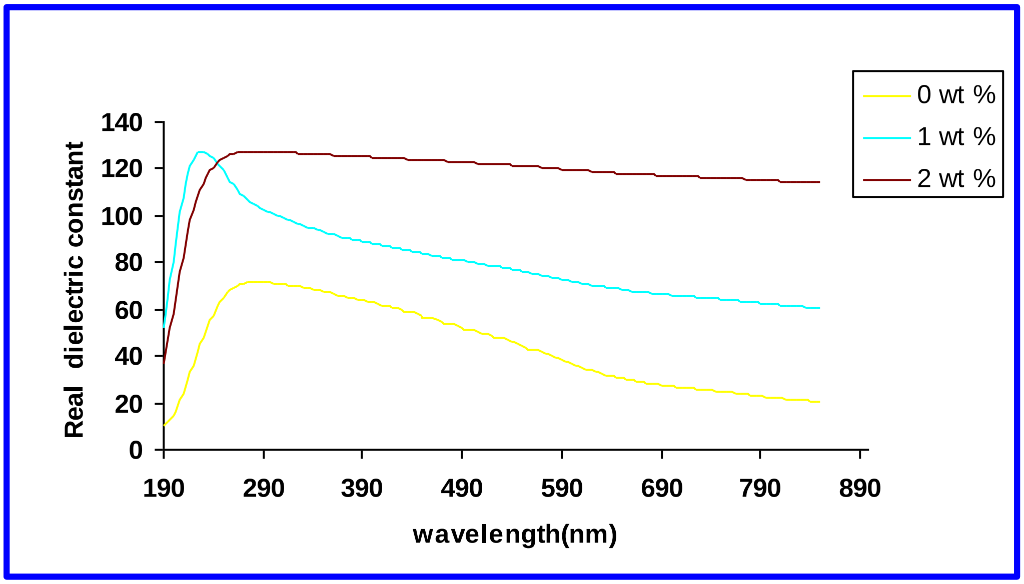


Figure (9): the real dielectric constant for PVA-Bi_2O_3composites as a function of incident wavelength.

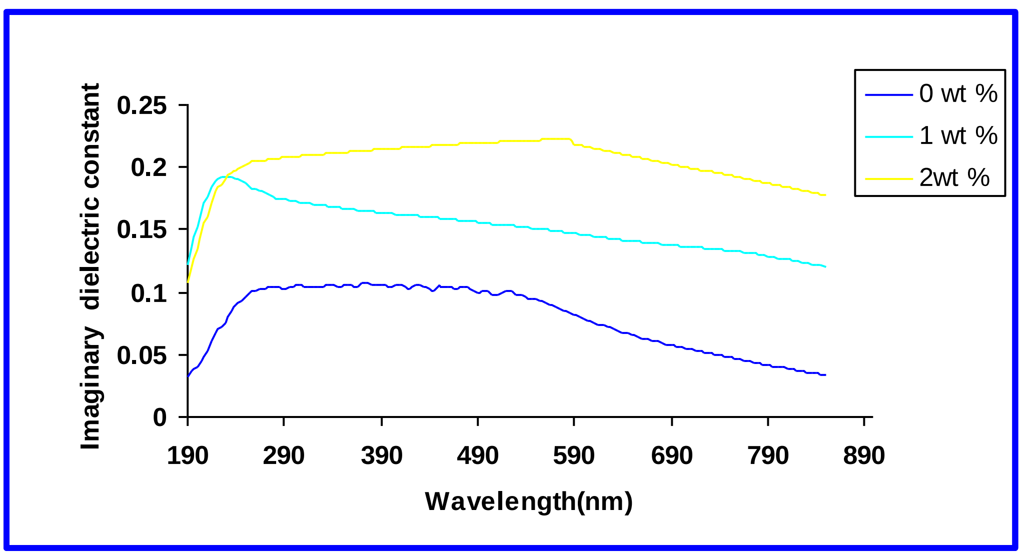


Figure (10): the imaginary dielectric constant for PVA-Bi_2O_3composites as a function of incident wavelength.

Conclusions

1. The absorption coefficient is increasing with increasing of the filler wt.% content.
2. The experimental results showed that the absorption coefficient less than $10^4 cm^{-1}$ this is indicates to allowed indirect electronic transitions.
3. The Bi_2O_3 additive not change the nature of electronic transfers of PVA samples.
4- The refractive index and extinction coefficient are increasing with increasing of the filler wt.% content.

References

[1] M. A.Muhsien, A. Hashim, K. Mahdy , (2010) "Doping Effect On Constants of poly-vinyl alcohol" Science Conference of collage of Science ,Al-Kuffa University
[2] S. Bhattacharya, V.K.Sachdev & R.P.Tandon, (2008) "Electrical properties of Graphite Filled Polymer Composites",2nd National Conference Mathematical Techniques, Dilhi University.
[3] S.M Scholz., Carrot.G and Hilborn.J ,2008, "Optical properties of Gold-Containing poly (Acrylic Acid) composites" , Lausanne, Switzerland.
[4] M. Hamzah, Elias Saion and Anuar Kassim, (2009),"Dielectric properties of PVA/PPY compsite polymer films, J. for the Advancement of science& Arts, Vol.1, No.1.
[5] J .Tauce, (1972),"States in the Gap", J. of Non – Crystalline Solids, PP . (569 – 585).
[6] M. Dahshan, (2002)," Introduction to Material Science and Engineering" ,2nd Ed.
[7] A.Abdul munaim and A.Hashim, , (2010),"Electronic Transitions For (PS –LiF) composites" Sixth Science Conference of College of Science, Al-Mustansiriyah University
[8] M.A.. Crane, Translationty, Y.M.Hassan , (1989), "Solar Cells", Collage of Education, University of Mosul
[9] R.M Ahmed, (2008),"Optical Study on Poly(methyl Methacrylate)/Poly(vinyl acetate)", Zagazig Uni., Zagazig, Egypt, E-mail-rania 8_7@hotmail. Com