Study the Optical Properties of (PVA-PVAC-Ti) Nanocomposites

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***Abstract*—**In the present work, the effect oftitanium nanoparticles on optical properties of (PVA-PVAC) has been studied. For this purpose , many samples were prepared with different weight percentages of titanium nanoparticles, the samples were prepared by casting method. The absorption spectrum has been recorded in the wavelength range (200 - 1100) nm , the optical energy gap of the indirect allowed and forbidden transition, absorption coefficient and optical constants such as (extinction coefficient, refractive index and real ,imaginary dielectric constants) have been determined.
The optical constants are increase with increasing of titanium nanoparticles concentration ,also the energy gap decreased with increasing the weight percentages of titanium nanoparticle.

***Keywords*—**Nanocomposite , Optical properties , poly(vinyl alcohol) , Poly(vinyl acetate) , titanium nanoparticles.

I. INTRODUCTION

The study of composite materials, i.e., mixtures consisting of at least two phases of different chemicalcompositions, has been of great interest from both fundamental and practical standpoints [1].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 equipment's. 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 [2]. In the recent years conjugated conducting polymers have been main focus of research throughout the world. Since the discovery led by 2000 chemistry Nobel winners, Shirakawa, Macdiarmid and Heeger, the perception that plastic could not conduct electricity has changed Nowadays, conducting polymers also known as conductive plastics are being developed for many uses such as corrosion inhibitors, compact capacitors, antistatic coating, electromagnetic shielding and smart windows; which capable to vary the amount of light to pass [3].

Composites are used in making solar cells, optoelectronic device elements, laser , diodes and light emitting diodes (LED), industrial applications in aircraft, military and car industry[4]. PVA is one of the earliest and best known polymers, it was seen to use in a variety of applications and is currently used extensively in semiconductors applications[3]. The transmission for visible light is very high. Polymeric composites of PVA are known for their importance in technical applications[5]. Further, polymers, on doping with noble metal nanoparticles, show novel and distinctive properties obtained from unique combination of the inherent characteristics of polymers and properties of metal nanoparticles [6]. The advantage of poly vinyl alcohol that has the ability to blend into the water which is resistant to do solvents, oils, and has the ability exceptional adhesion materials cellulosic so uses his wide is used in making paper and textile industries in the manufacture of membranes resistance to oxygen in the coating photographic film [7].Poly (vinyl acetate) polymer is a thermoplastic, which we got from the polymerization of vinyl acetate using an appropriate beginning, in a solvent or with water Installation of polymer (PVAC), which is white color, and thermoplastic [8]. The polyvinyl acetate (PVAC) discovered in 1912 by Dr. Fritz Klatte in Germany. It is one of the most commonly used resins water on a large scale since 1945 has used water-based emulsions of polyvinyl acetate and paints in homes, and adhesives [9].

Enjoy minutes titanium nanoparticles qualities make them useful in the uses of visual and electrical insulators, anti-bacterial and chemical stability as well as high catalytic properties useful in industrial applications Kalobbag , chock materials ,auxiliary materials and stimulation of photosynthesis, titanium strong and light weight, but also high resistance to corrosion. Thus, it can be used in military and space applications,it is the main applications of the particles of titanium nanoparticles are anti-microbial, antibiotics , antifungal medications, space materials, used in aluminum alloys, optical filters, paint, nanofibers, bandages, wires and textiles[9].

I. EXPERIMENTAL PART

The materials used in this paper are polyvinyl alcohol , Poly (vinyl acetate) and titanium nanoparticles . The solution of (PVA,PVAC) was prepared by solved (0.7,0.3 gm) in (40 ml) of distilled water respectively .The (Magnitic Stirrer) is used to maxid and the solution more homogeneous at (70C). The weight percentages of nanotitanium are (0, 4, 8 and 12) wt.%. These are mixed for (120-180) minutes. the samples were prepared using casting technique. The absorbance spectrum was recorded of the wavelength range (200 - 1100)nm by using the double-beam spectrophotometer (UV-1800 shimedza).

II. RESULTS AND DISCUSSION

A. The absorbance of nano composites

Absorptance can be defined as the ratio between absorbed light intensity (I_A) by material and the incident intensity of light (I_o)[10].

$A=I_A/I_o$ (1)

Figure1show the variation of the optical absorbance with wavelength of the incident light for (PVA-PVAC-Ti**)** nanocomposites, it is noticed that the absorbability increases with increasing concentration of titanium nanoparticles. The absorption at any wavelength depends on the number of particles along the route of the incident light (based on concentration) and also depends on the length of the optical path passing through the form in addition to the temperature.[13]

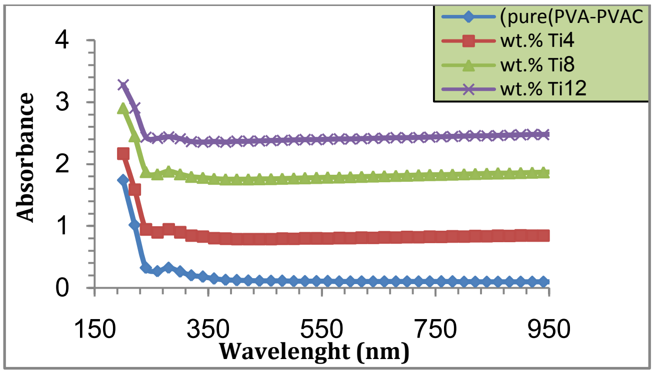

Fig.1:The variation of optical absorbance for (PVA-PVAC-Ti) nanocomposites with wavelength .

B. The absorption coefficient and energy gap of nanocompsites.

Absorption coefficient is defined as a ratio decrement in flux of incident rays energy relative to the distance unit in the direction of incident wave length. The absorption coefficient (α) depends on incident photon energy (hυ)[12].

$\alpha = 2.303\frac{A}{d}$(2)

Where: A is absorbance and d is the thickness of sample.

Figure2shows the relation between the absorption coefficient versus the photon energy of the(PVA-PVAC-Ti) nanocomposite ,we can be see noticed that the change in the absorption coefficient is small at low energies , at high energy the change of absorption coefficient is large this is indicates to the large probability of electronic transitions[14].

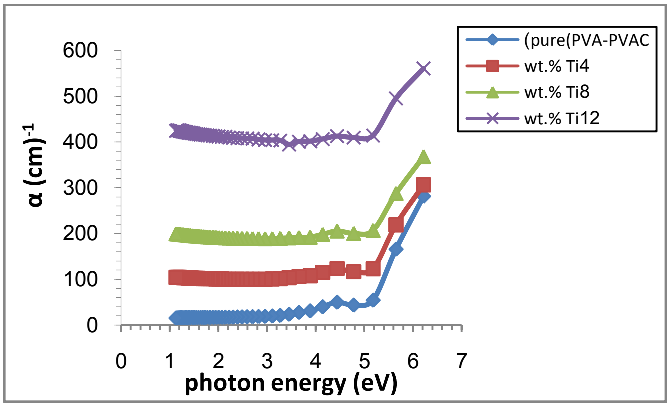

Fig. 2:The variation of Absorption coefficient for (PVA-PVAC-Ti) nanocompsiteswith photon energy.

The absorption coefficient helps to conclude the nature of electronic transitions, when the high absorption coefficient values ($\alpha > 10^4 cm^{-1}$) at the high energies indicate to direct electronic transitions, and the energy and momentum preserve of the electron and photon, when the values of absorption coefficient is low ($\alpha < 10^4 cm^{-1}$) at low energies indicate to indirect electronic transitions, the momentum of the electron and photon preserves by phonon helps, the optical energy gap can be calculated from this formula [15].

$(\alpha h\nu) = B(h\nu - Eg)^r$ (3)

Where(B) is constant depending on the transition probability and(r) is index that characterizes the optical absorption process and is theoretically equal to 1/2,2, 1/3 or 2/3 for indirect allowed, direct allowed, indirect forbidden and direct forbidden transition, respectively[17]. The usual method to calculate the band gap energy is to plot a graph between $(\alpha h\nu)^r$ and photon energy (hν), and find the value of then which gives the best linear graph[10]. This value of (r) decides the nature of the energy gap or transition involved. If an appropriate value of (r) is used to obtain linear plot, the value of *Eg*will be given by intercept on the hν-axis[11] .

The relation between $(\alpha h\upsilon)^{1/2}$ $(eV/cm)^{1/2}$and photon energy of nanocomposites shown in figure 3 from this figure we note that the value of optical energy gap decrease by increasing of weight percentage of titanium nanoparticles, this is due to the creation of localized levels in the allowed energy gap and have a go at this case through two steps include transmission electron from the valence band to the localized levels and from the localized levels to the conduction band as a result of increasing weight percentage of titanium nanoparticles[13] ,also the transition which occurs in the samples is allowed indirect transition as shown in table (1).

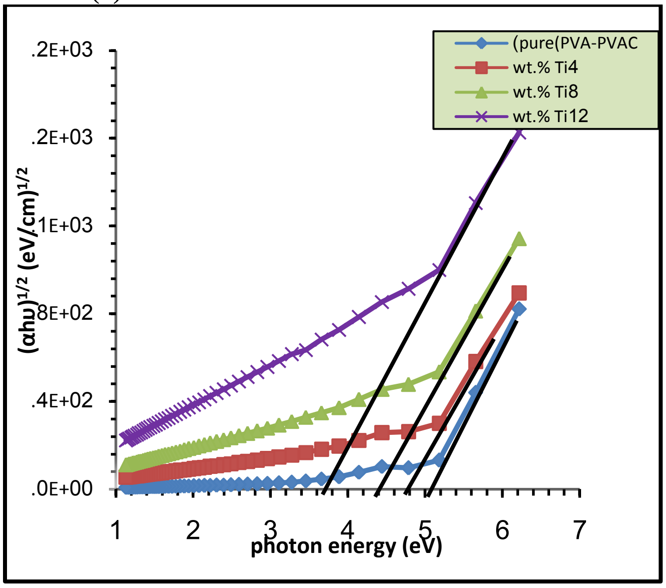

Fig. 3: The relationship between $(\alpha h\upsilon)^{1/2}$ $(eV/cm)^{1/2}$ and photon energy of (PVA-PVAC-Ti) nanocompsites.

When the value (r=3) indicates to forbidden indirect transition as shows the relationship between $(\alpha h\upsilon)^{1/3}$ ($eV/cm)^{1/3}$ and photon energy of nanocomposites in figure 4 ,we can see from this figure the value of forbidden energy gap decreases by increasing weight percentage of titanium nanoparticles, this is due to the creation of localized levels in the forbidden energy gap and have a go at this case through two steps include transmission electron from the valence band to the localized levels and from the localized levels to the conduction band as a result of increasing weight percentage of titanium nanoparticles[14], as well as this value of forbidden indirect transition is less than the one value which is represent allowed indirect transition as shown in table (1).

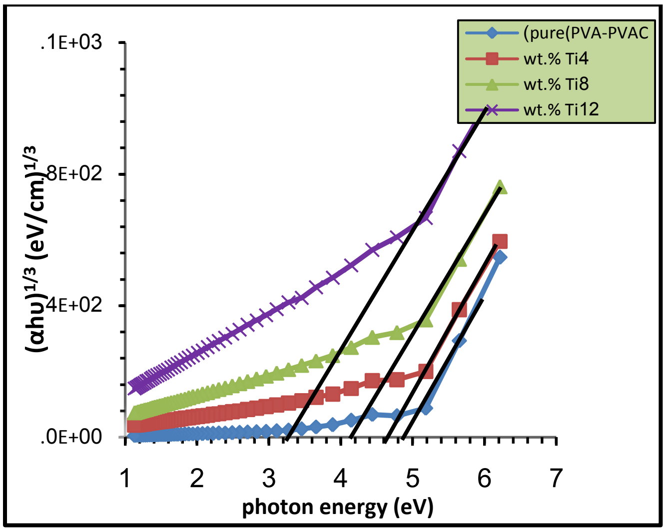

Fig. 4: The relationship between $(\alpha h\upsilon)^{1/3}$ $(eV/cm)^{1/3}$ and photon energy of (PVA-PVAC-Ti) nanocompsites.

Table (1) Show values of energy gap for indirect transition (allowed, forbidden) of (PVA-PVAC-Ti) nanocomposites

Sample	The values of energy gap for the indirect transition (eV)	
	allowed	forbidden
pure	5.1	4.9
4.wt%	4.8	4.6
8.wt%	4.4	4.1
12.wt%	3.7	3.2

C. *Optical constants*

Figure 5shows the variations of extinction coefficient with photon energy for (PVA-PVAC-Ti)nanocomposites. The extinction coefficient (k) is directly proportional to the absorption coefficient(α)[16]:

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

Where λ is wavelength of light.

This figure shows that, extinction coefficient(k) value increases with increasing of titanium nanoparticles concentration, this behavior can be described according to high absorption coefficient.

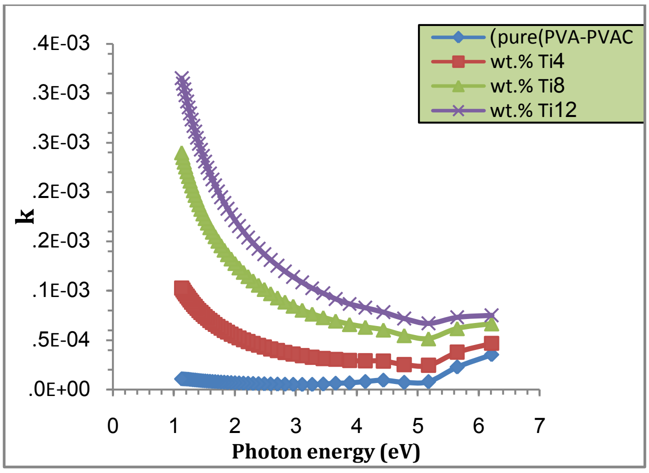

Fig. 5: The relationship between extinction coefficient (PVA-PVAC-Ti) nanocomposites with photon energy .

Figure 6 shows the variation of refractive index of nanocomposites as function of photon energy . The refractive index (*n*) has been calculated by using this equation[19] :

$$n = \sqrt{4R - \frac{K_0^2}{(R-1)^2}} - \frac{(R+1)}{(R-1)} \quad (5)$$

where, *n*refractive index, R reflectance.

We have been found that the value of refractive index increases with increasing the concentration of titanium nanoparticles which is a result of increasing the number of atomic refractions due to the increase of the linear polarizability in agreement with Lorentz - Lorentz formula [16].

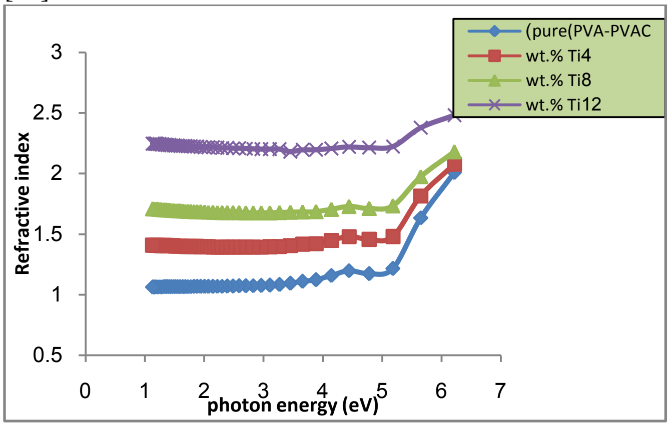

Fig. 6: The relationship between refractive index (PVA-PVAC-Ti) nanocomposite with photon energy.

Figures (7and 8) show the variation of real and imaginary parts of dielectric constants(ε_1, ε_2) of (PVA-PVAC-Ti) nanocomposites . The real and imaginary parts of dielectric constants have been calculated by using this equations[12] :

$\varepsilon_1=n^2-k^2$ (6)

$\varepsilon_2=2nk$ (7)

the variation of ε_1 mainly depends on(n^2) because of small values of the (k^2), while the ε_2 mainly depends on the (k) values which are related to the variation of absorption coefficients[18].

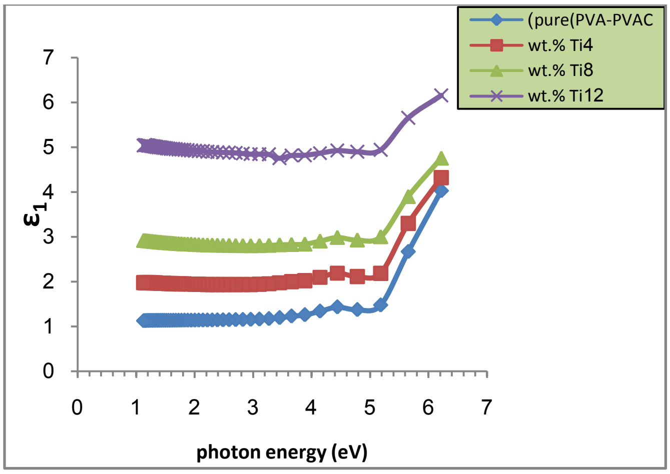

Fig. 7: The relationship between realparts of dielectric constant (PVA-PVAC-Ti) nanocomposite with photon energy.

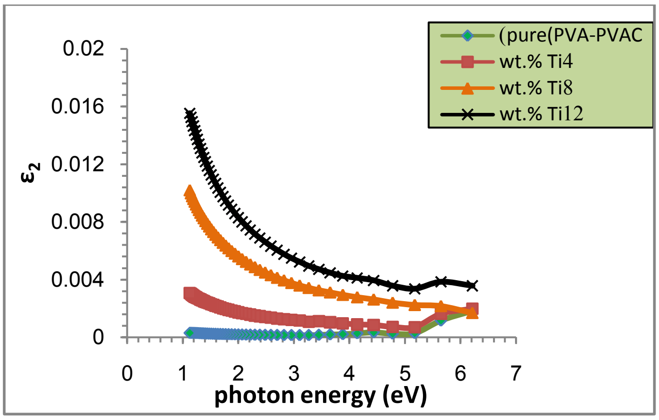

Fig. 8: The relationship between imaginaryparts of dielectric constant (PVA-PVAC-Ti) nanocomposite with photon energy.

III. CONCLUSIONS

- The absorption coefficient for all (PVA-PVAC-Ti) samples increases with increasing of Ti.wt% concentration.
- The energy gap of indirect (allowed, forbidden) transition decreases with increasing of Ti.wt% concentration.
- The Extinction coefficient, refractive index and dielectric constant (real and imaginary) increased with increasing of Ti.wt% concentration.

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