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Research Article

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Optical constants of poly(vinyl chloride) doped by nano ZnO

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ABSTRACT

Films of Poly (vinyl chloride) (PVC) doped with different concentration of nanosize zinc oxide (ZnO) (1-20) what% have been prepared using the casting method at room temperature. Optical properties were investigated by spectrophotometric measurement of absorption, reflection and transmission in the wavelength range (200-800) nm from computerized UV-visible spectrophotometer (Shimadzu UV-1601 PC). Both the absorption coefficient and energy gap were determined for the films. It has been found that the optical properties of PVC are affected by the doping of ZnO. The Reflection and absorption coefficient has increased as ZnO concentration increased, but the energy gap was decreasing with these increments from 3.9 to 3.8 eV.

Key words: PVC polymer, ZnO nanosize, Optical properties.

INTRODUCTION

In recent years, nanotechnology has been used in the synthesis of various types of polymer-nanocomposite and understanding their physical and chemical properties [1-3]. Nanoparticles have initiated unique properties in materials. The presence of nanoparticles in polymer improves the mechanical, electrical and optical properties of the materials, the polymer doped with metal oxide nanoparticles have been studied as alternative materials for optical applications, including planar waveguide devices and microoptical elements [5]. Many polymers have been proved suitable matrices in the development of composite structures due to their ease production and processing, good adhesion with reinforcing elements, resistance to corrosive environment, light weight, and in some cases ductile mechanical performance [6,7].

ZnO has been one of the most promising materials for electrical devices, including transparent conductive films, light emitting diodes, photocatalyst and solar cells [4,8-14]. Moreover, because it has been chemically and optically stable and has a low toxicity, its use as a fluorescent label for bioimaging has been anticipated when using nanoparticles for biomedical purposes(4). Recently, ZnO has attracted attention as one of the materials for the antireflection coating of solar cells because it showed good transparency and an appropriate refractive index [15-17]. In the present work, PVC doped with nano-metal-oxide (ZnO) by using casting method, the objective of this work is to measure the optical properties of PVC doped with ZnO.

EXPERIMENTAL SECTION

Poly (Vinyl Chloride) (PVC) is powder supplied by BDH doped with nanosize zinc oxide (ZnO) at room temperature by using casting technique. The PVC was dissolved in THF and heated gently in water bath to prevent thermal decomposition of polymer. The polymer was stirred by using a magnetic stirrer for completely dissolution. Nano ZnO material with different weights (1, 5, 10, 15 and 20) wt% was added to the polymer solution, heated for a while for completely dissolution. The solution was poured in to a clean glass plate and left to dry for (24 hr) to remove any residual solvent. The thickness of the produced films was (20 µm) measured by using electronic digital caliper.

Optical absorbance, Reflectance and Transmittance spectrums were recorded in the wavelength range (200-800nm) using computerized UV-visible spectrophotometer (Shimadzu UV-1601 PC). The light sources are halogen lamp and socket-deuterium lamp.

RESULTS AND DISCUSSION

The optical reflectance R spectra of the PVC thin films with different concentrations of nano ZnO are shown in Figure 1, The measurements was performed in the wavelength λ range of 200-800nm. This Figure indicates that for all compositions, the reflectance decreases with increasing wavelength for samples (1, 5) % dope. However, the samples with (10, 20) % dope showed an increase in Reflectance with increasing wavelength. The figure revealed that the reflectance increases with the concentration as shown in Table (1). This is due to the increasing optical absorption and the increasing attenuation of incident beam [18].

Table (1): Properties of PVA thin films for different concentrations at wavelength (600nm)

Films type	*R*	*α (cm)$^{-1}$*
PVC+ 1% ZnO	14.74	182.89
PVC+ 5% ZnO	18.46	276.76
PVC+10% ZnO	20.33	429.26
PVC+20% ZnO	19.82	496.99

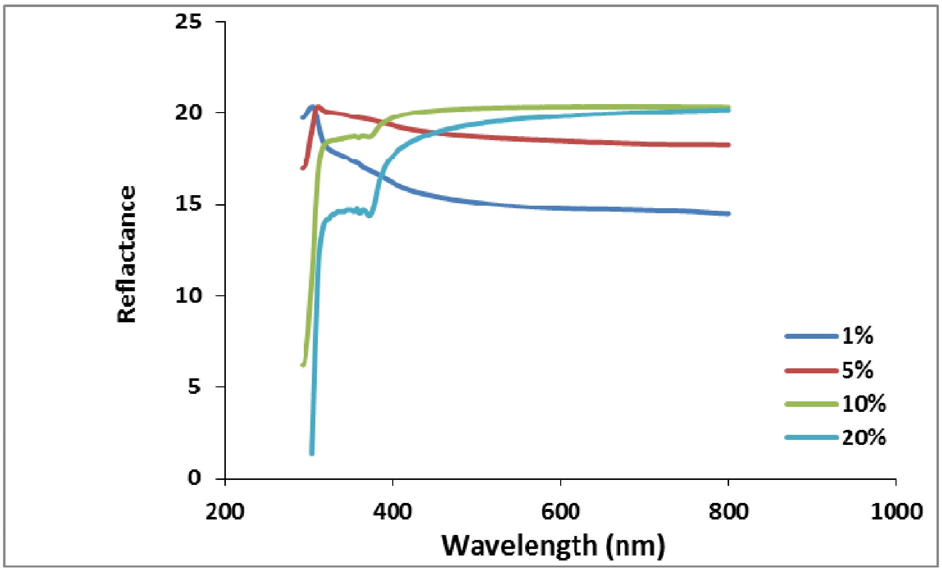

Fig (1) Reflectance spectra of samples

The variation of the optical bulk absorption coefficient α with wavelength is a unique parameter of the medium; it provides the most valuable optical information available for material identification. The absorption coefficient was calculated using the following equation:

$$\alpha(\nu) = \frac{1}{d}\ln\frac{1}{T} = \frac{A}{d} \qquad \text{……………..(1)}$$

Where d is the sample thickness, T is the transmittance and A is the absorbance. Figure (2) shows the dependence of the absorption coefficient on the wavelength for the all samples with different concentrations of nano ZnO. The absorption coefficient was decreasing with the increasing wavelength but increasing with increasing impurity concentration as mentioned in Table (1). This increment may be attributed to the difference in carrier concentration or could be related to the existence of more transmissions from higher vibration levels of the ground state to higher sublevels of the first excited singlet state [19].

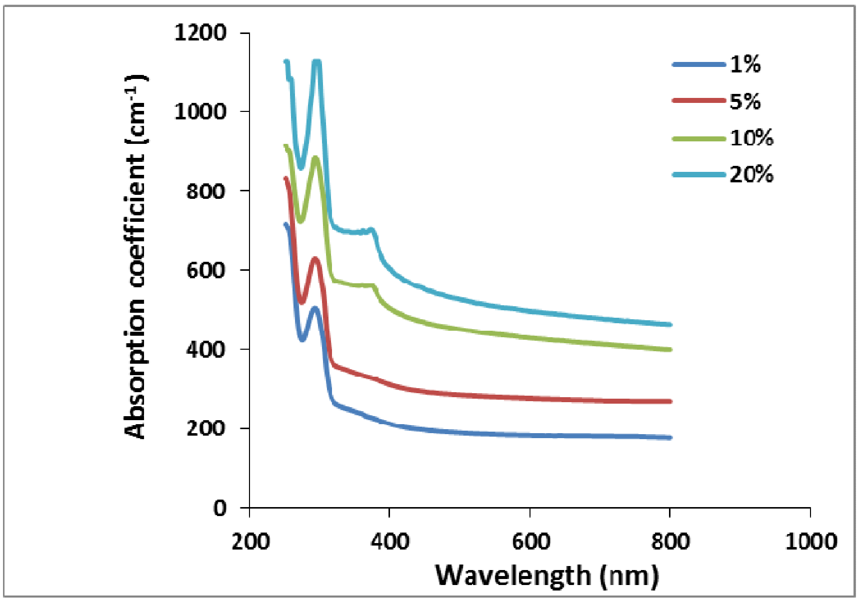

Fig (2) Absorption coefficient spectra of samples

The direct optical band gap for allowed direct transition can be evaluated from extrapolating of linear region of the curve to a point of $(\alpha h\nu)^2$ versus hv for PVC doped with different concentrations of ZnO as shown in Figures. (3 to 6).

The effect of doping with ZnO on photon energies values is shown in Table (2) which shows that energy gap E_g decreases in the trend PVC+1% ZnO, PVC+5% ZnO, PVC+10% ZnO, and PVC+20% ZnO. The shift in the energy gap could be attributed to the formation of polarons in the doped film [7].

Table (1): Represent the Energy gap values of all films

Films type	***E_g (eV)***
PVC+ 1% ZnO	3.9
PVC+5% ZnO	3.88
PVC+10% ZnO	3.84
PVC+20% ZnO	3.8

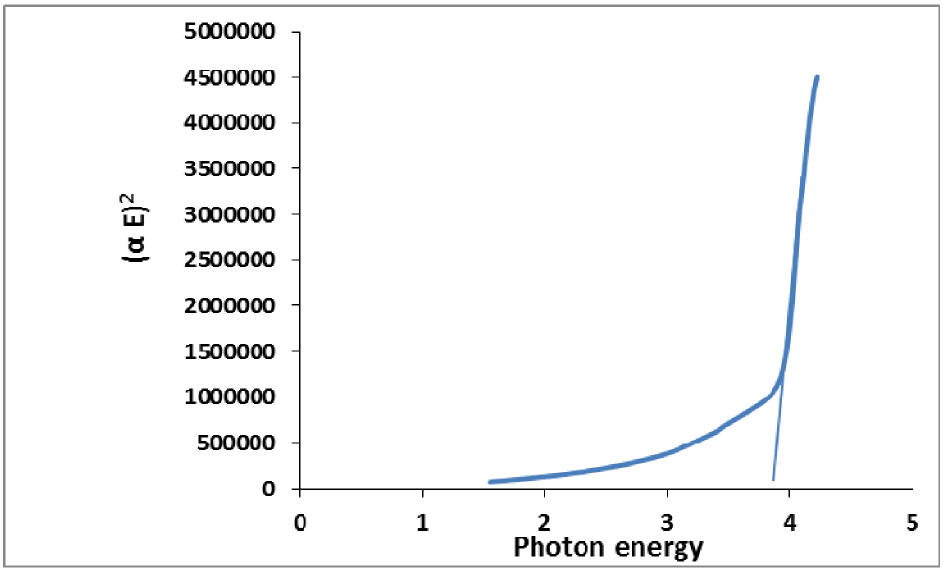

Fig.(3) The direct transition $(\alpha h\upsilon)^2$ Vs. energy for PVC+1% ZnO

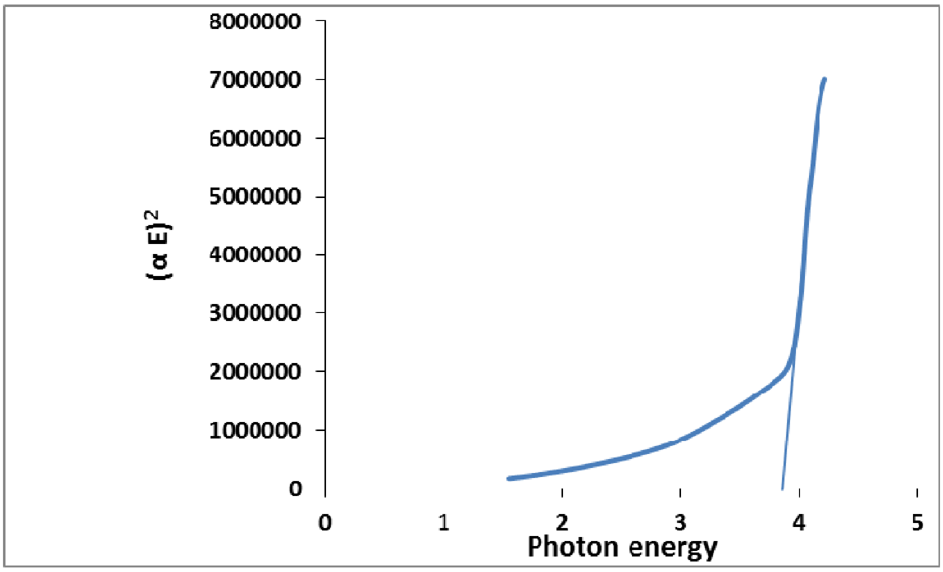

Fig.(4) The direct transition $(\alpha h\upsilon)^2$ Vs. energy for PVC+5% ZnO

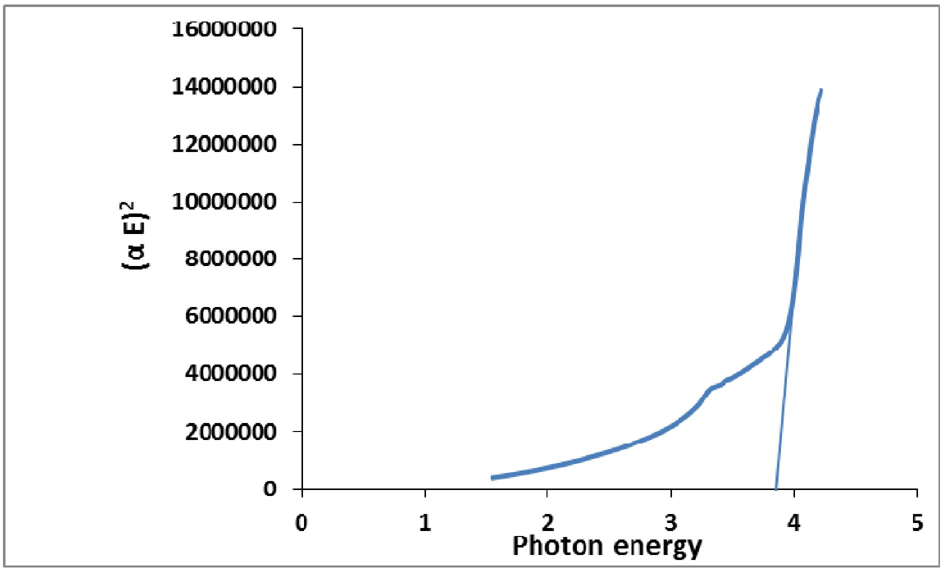

Fig.(5) The direct transition $(\alpha h\upsilon)^2$ Vs. energy for PVC+10% ZnO

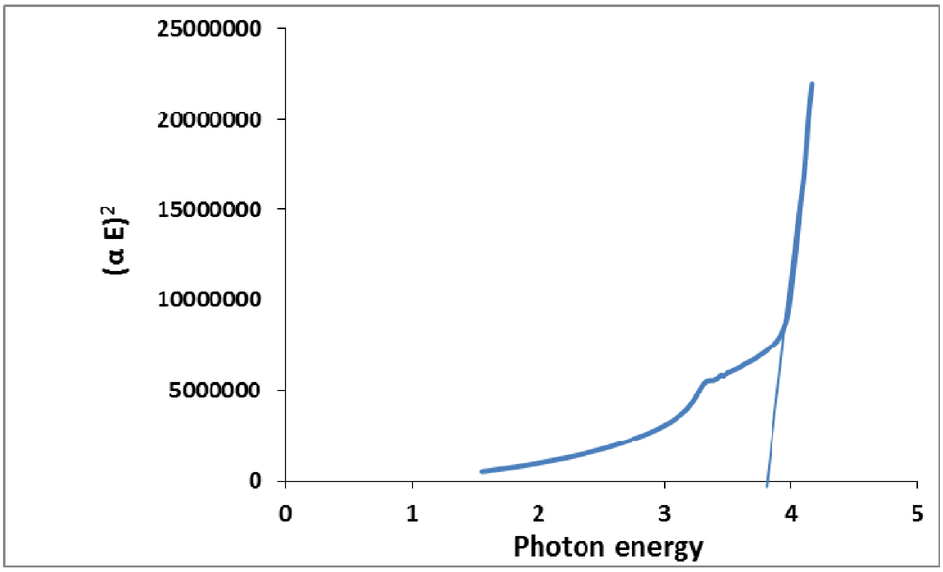

Fig.(6) The direct transition $(\alpha h\upsilon)^2$ Vs. energy for PVC+20% ZnO

CONCLUSION

The results indicate that nanosize zinc oxide ZnO can effectively dope PVC and enhance its optical properties. The presence of ZnO leads to increase the reflection as ZnO concentration increases. The values of optical properties show dependence on ZnO concentration where absorption coefficient increased after doped and with the increase of ZnO concentration. The optical band gap decreased with increasing impurity concentration from 3.9 to 3.8 eV.

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