The Effect of Sodium Fluoride on Optical Properties of Polyvinyl pyrrolidone

Hamad Rahman Jappor   Majeed Ali Habeeb   Ahmad Hashim

University of Babylon, College of Education for Pure Science, Department of Physics, Hilla, Iraq

Abstract

The composites materials are important in many applications and industries. For the importance of these materials, this paper is aimed to study optical properties of sodium fluoride polyvinyl pyrrolidone (PVP-NaF) composites. The effect of sodium fluoride on optical properties of polyvinyl pyrrolidone has been investigated. The samples of (PVP-NaF) composites are prepared by using casting technique. The optical properties of (PVP-NaF) composites were measured in the wavelength range (200-800) nm. Results showed that the absorbance, absorption coefficient, extinction coefficient, refractive index and real and imaginary dielectric constants of polyvinyl pyrrolidone are increase with increasing the sodium fluoride concentrations. The energy band gap of polymer is decrease with increasing the sodium fluoride concentrations.

Keywords: sodium fluoride, polyvinyl pyrrolidone, optical properties, polymer.

1. Introduction

Polymers have relatively poor mechanical, thermal, and electrical properties as compared to metals and ceramics. Many types of polymers such as homopolymers, co-polymers, blended polymers and modified polymers are not sufficient enough to compensate various properties, which we have demanded. Alternative approaches to improve their properties are to reinforce polymers with inclusion of fiber, whisker, platelets, or particles. The choice of the polymers is usually guided mainly by their mechanical, thermal, electrical, optical and magnetic behaviors. However, other properties such as hydrophobic/hydrophilic balance, chemical stability, bio-compatibility, optoelectronic properties and chemical functionalities (i.e., solvation, wettability, template effect, etc.) have to be considered in the choice of the polymers.

The polymers in many cases can also allow easier shaping and better processing of the composite materials (Jeon and Baek, 2010). The doped polymers may present useful applications in integrated optics or in real time holography. In order to tailor materials with improved properties within the doped polymer class, it is necessary to understand and control the electronic mechanisms involved in the optical behavior (Bulinski *et al*., 2003). The studies on optical properties of polymers have attracted much attention in view of their application in electronic and optical devices (Ahmad *et al*., 2012). PVP is a potential material having a good charge storage capacity and dopant dependent electrical and optical properties. Chemically PVP has been found to be inert, non-toxic and interestingly, it displays a strong tendency for complex formation with a wide variety of smaller molecules (Rawat *et al.*, 2012). This paper deals with effect of sodium fluoride on polyvinyl pyrrolidone.

2. Materials and Methods

The materials which used in this paper are polymer and sodium fluoride. The polymer was dissolved in distill water by using magnetic stirrer in mixing process to get homogeneous solution. The concentrations of sodium fluoride are (0, 5, 10 and 15) wt.% were added and mixed for 20 minute to get more homogenous solution, after which solution was transferred to clean glass. The optical properties of composites are measured by using UV/1800/Shimadzu spectrophotometer.

The absorption coefficient (α) is defined by (Ahmad *et al.,* 2007):

$$\alpha = 2.303 A/t \qquad \text{...............… (1)}$$

Where A is the absorbance of the material and t is the sample thickness.

The energy band gap given by (Ahmad *et al*., 2012):

$$\alpha h\upsilon = B(h\upsilon - E_g)^r \text{……………..…….…(2)}$$

1

Where hυ is the photon energy, B is a constant, E_g is the optical energy band gap, and r=2, or 3 for indirect allowed and indirect forbidden transition, respectively.

The extinction coefficient (k) calculates by using the following equation (Ahmad *et al.,* 2007):

$$k=\alpha\lambda/4\pi \qquad \ldots\ldots\ldots\ldots (4)$$

The refractive index (n) of the specimens is defined (Alwan, 2010):

$$n= (1+R^{1/2})/(1-R^{1/2}) \qquad \ldots\ldots\ldots\ldots (3)$$

The real and imaginary parts of dielectric constants (ε_1 and ε_2) were calculated by using equations (Alwan, 2010):

$$\varepsilon_1=n^2-k^2 \quad \text{(real part)} \qquad \ldots\ldots\ldots (5)$$

$$\varepsilon_2=2nk \quad \text{(imaginary part)} \qquad \ldots\ldots\ldots (6)$$

3. Results and Discussion

Figure (1) shows the absorbance spectra with wavelength for (PVP-NaF) composites of different concentration of filler. From figure (1), the absorbance is decrease with the increasing the wavelength; this can be simply attributed to the absorbance of polymer which lies in UV- region. Also, the absorbance of (PVP-NaF) composites increases with the increase of the weight percentages of sodium fluoride, this behavior due to high absorbance of sodium fluoride compared with the absorbance of polymer (Sunitha *et al.*, 2012).
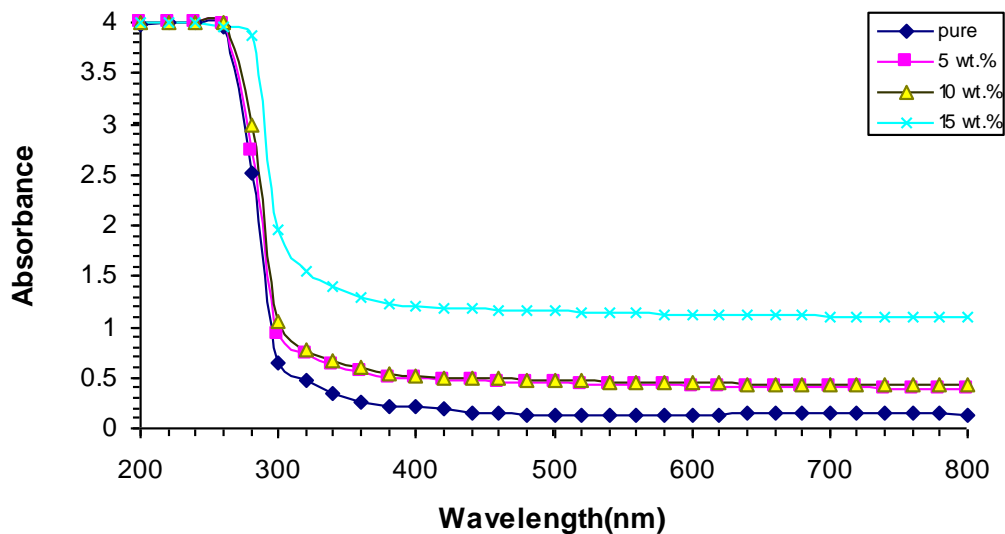

FIG.1

The variation of optical absorbance for composite with wavelength

The variation of absorption coefficient with photon energy of (PVP-NaF) composites is shown in figure (2). The absorption coefficient less than 10^4 cm^{-1}, this mean that the composites have indirect energy band gap as shown in figure (3) and figure (4) for allowed and forbidden indirect energy gap, respectively. These figures show that the indirect energy gap is decrease with the increasing the sodium fluoride concentration which attributed to create local energy levels in the energy gap (Abdelrazek *et al.*, 2012).
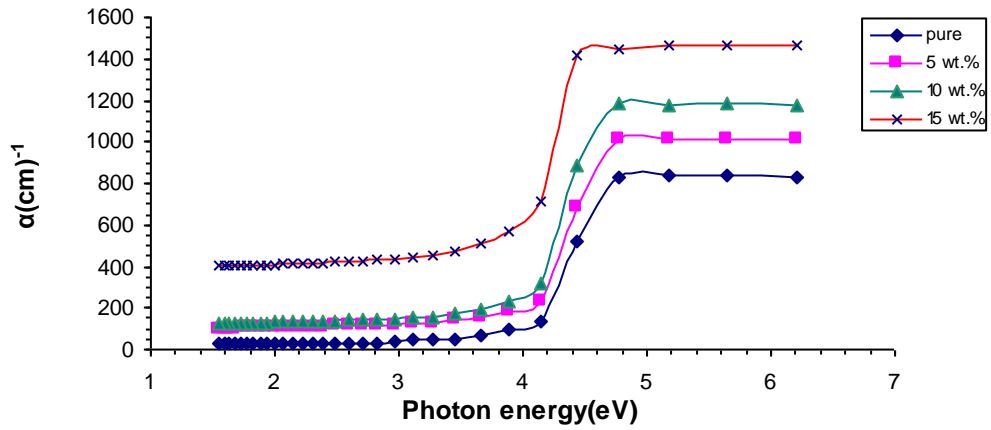
2

FIG.2

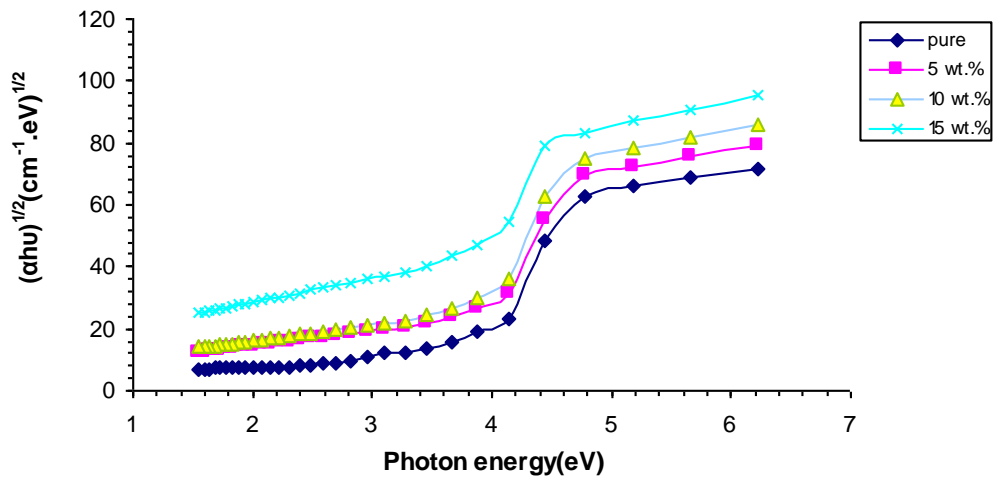The absorption coefficient for (PVP-NaF) composite with various photon energy

FIG.3

The relationship between $(\alpha h\upsilon)^{1/2}(cm-1.eV)^{1/2}$ and photon energy of PVP-NaF composites.
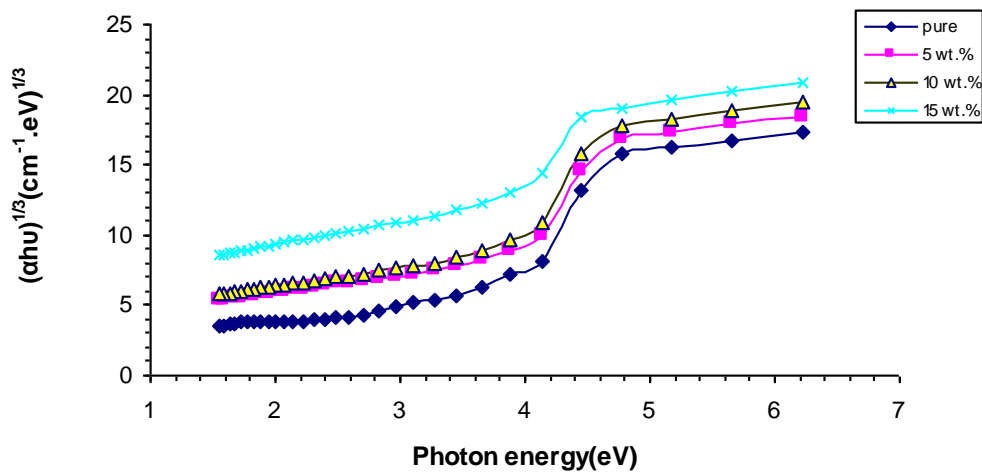

FIG.4

the relationship between $(\alpha h\upsilon)^{1/3}(cm^{-1}.eV)^{1/3}$ and photon energy of PVP-NaF composites.

3

Figure (5) shows the variation of extinction coefficient of (PVP-NaF) composites with photon energy. The extinction coefficient (as shown in the figure) is increased with the increase of the concentration of sodium fluoride. The increase of extinction coefficient attributed to the sodium fluoride ions which absorb the incident light (Ugwu, 2006) (as shown in figure (1))
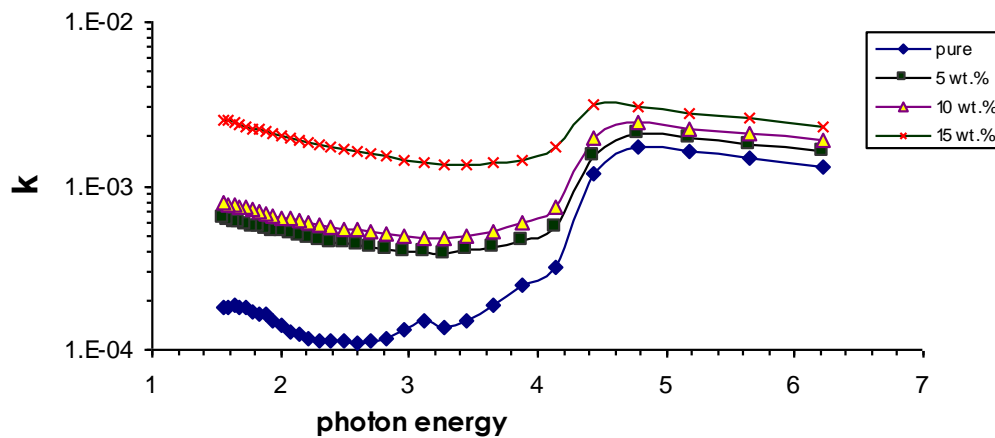

FIG.5

The extinction coefficient for (PVP-NaF) composite with various photon energy

The relationship between the refractive index and photon energy of (PVP-NaF) composites of different concentration of sodium fluoride is shown in figure (6). The figure shows that refractive index of (PVP-NaF) composites increases with the increasing the sodium fluoride concentration, this behavior due to the increase the density of polymer with increasing the sodium fluoride concentration (Ugwu, 2006).
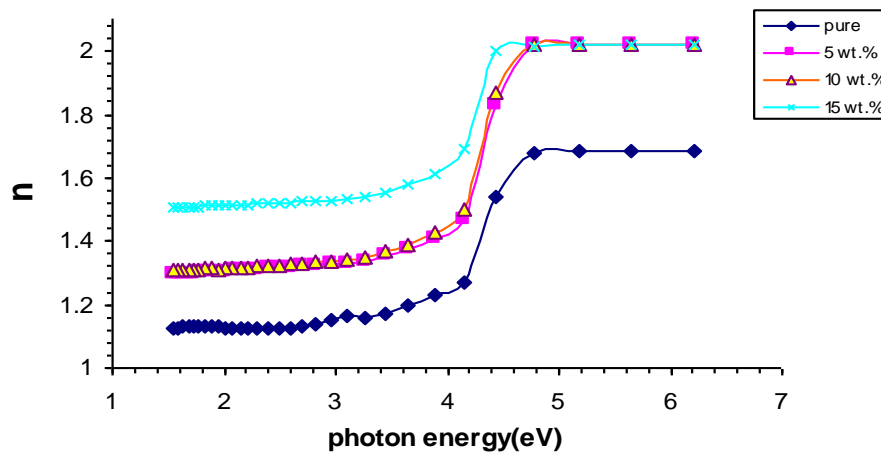

FIG.6

The relationship between refractive index for (PVP-NaF) composite with photon energy

Figures (7 and 8) show the effect of sodium fluoride concentration and photon energy on real and imaginary parts of dielectric constant. The real and imaginary parts of dielectric constant are increasing with the increase of the weight percentages of sodium fluoride which attributed to the increase the reflective index and absorption coefficient as result for the increase the density and absorbance of (PVP-NaF) composites (Nahida and Marwa, 2011).
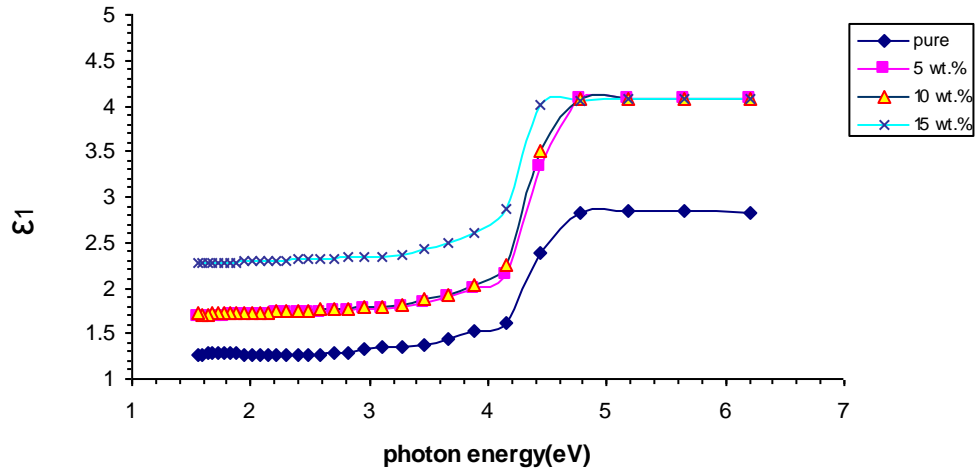
4

FIG.7

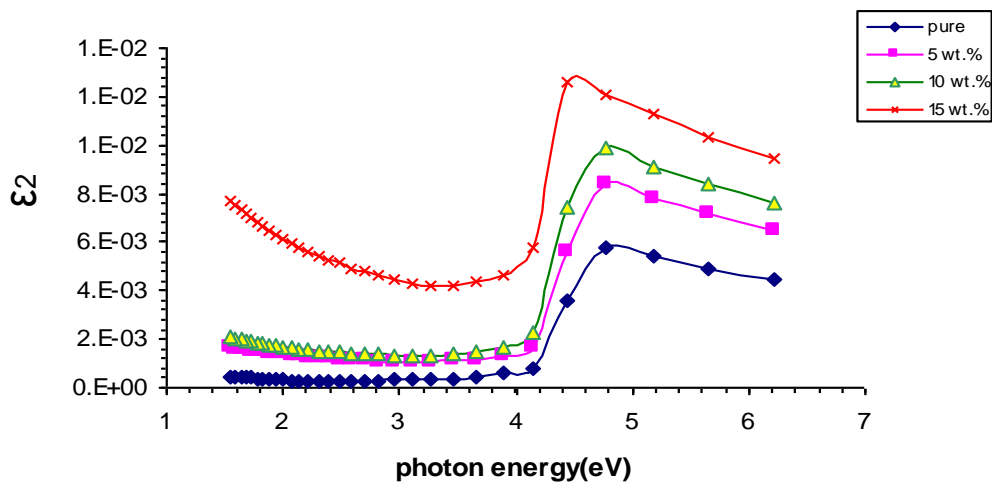The variation of real part of dielectric constant (PVP-NaF) composite with photon energy

FIG.8

The variation of imaginary part of dielectric constant(PVP-NaF) composite with photon energy

4. Conclusions

1- The absorbance of polymer increases with the increasing the weight percentages of sodium fluoride

2- The optical constants (absorption coefficient, extinction coefficient, refractive index and real and imaginary dielectric constants) are increase with the increasing of the weight percentages of sodium fluoride.

3- The energy band gap of polymer decreases with increasing the weight percentages of sodium fluoride.

5

References

Jeon I. and Baek, J. (2010), "Nanocomposites Derived from Polymers and Inorganic Nanoparticles", J. of Materials, Vol. **3**, pp. 3654-3674.

Bulinski, M. Kuncser, V., Cristea, D., Plapcianu, C. Krautwald, S., Franke, H., Wagner, F. E., Filoti, G. (2003), "Optical and electronic properties of metal doped polymers for integrated optics", J. of Optoelectronics and Advanced Materials Vol. **5**, No. 1, pp. 331-335.

Ahmad, H. Sabeeh, S. and Hussen, S. (2012), "Electrical and Optical Properties of PVA/LiI Polymer Electrolyte Films", Asian Transactions on Science and Technology, Vol. **1**, No.6, pp.16-20.

Rawat, A., Mahavar,H., Chauhan,S., Tanwarand, A. and Singh, P. (2012), "Optical band gap of polyvinyl pyrrolidone/ polyacrilamide bland thin films", Indian journal of pure applied physics, Vol. **50**, pp. 100- 104.

Ahmad, A.H., Awatif, A.M. and Abdul-Majied, Z. N. (2007), "Doping Effect on Optical Constants of Polymethylmethacrylate (PMMA)", J. of Eng. & Technology, Vol. **25**, No.4, pp.558-568.

Alwan, T. J. (2010), "Refractive Index Dispersion and Optical Properties of Dye Doped Polystyrene Films", Malaysian Polymer Journal, Vol. **5**, No.2, pp.204-213.

Sunitha M. S., Adhikari A. V., and Vishnumurthy K. A., (2012), "Nonlinear Optical Studies of a D-A Type Conjugated Polymer Containing Heterocyclic Moieties", International Journal of Applied Physics and Mathematics, Vol. **2**, No. 6, pp.436-438.

Abdelrazek, E.M., Abdelghany, A.M. Oraby A.H. and Asnag, G.M. (2012), "Investigation of Mixed Filler Effect on Optical and Structural Properties of PEMA Films", International Journal of Engineering & Technology IJET-IJENS Vol. **12** No.4, pp. 98-102.

Ugwu, E.I. (2006), "Optical Properties of Iron Halide (FeCl$_2$) Thin Film Deposited Using Solution Growth Technique (SGT)", The Pacific Journal of Science and Technology, Vol. **7**, No., 2, pp. 97-102.

Nahida. J. H, and Marwa. R. F. (2011), "Study of the Optical Constants of the PMMA/PC Blends", Eng. & Tech. Journal, Vol. **29**, No.4, pp. 698-708.