Preparation and evaluation of optical properties of Ag: PANI nanocomposite

Aman Deep Acharya[1,] Bhawna Sarwan[2,*], Manpreet Kaur[1], Akashdeep kaur[1], Sakshi Sharma [1], Sandeep Singh Manhas[1] and Sagar Bisoyi[1]

[1]*Lovely Professional University Phagwara, Punjab (India)*
[2]*Vikram University, Ujjain (M.P.), India*

Abstract:

Solution cast technique is employed to prepare Ag:PANI composites with different concentrations (1 and 3 wt%). The prepared samples were characterized by UV-VIS spectroscopy in order to study the effect of silver (Ag) doping on the optical properties of PANI such as, refractive index, absorption coefficient, extinction coefficient, real part, imaginary part and dissipation factor. The obtained result reveals that optical properties are affected by doping concentrations. Absorption coefficient confirms the interaction of silver nanoparticles in the polymer matrix.

Keywords: *Silver, Polymer, Nanocomposite, Doping*

1. Introduction

The presence of amazing physical and chemical properties especially of transition metal oxides nanoparticles has made them as the center of research in the recent years. Transformation from the bulk scale to nanoscale considerably enhances the several properties such as the high surface area, quantum size effects, and lower sintering temperature [1] Fabrication of the nanocomposites by inclusion of the metal nanoparticles in the polymer matrix has become important aspects as it lead to improve the various properties of the nanocomposites and make them available for different applications such as biological, optical, sensors, plasmonic materials, microelectronic devices, etc [2-5]. Among the class of the conducting polymers following has attracted much attention, polypyrrole, polythiophene, polyaniline, etc. [6]. The unique physical properties of polyaniline especially high absorption coefficients, high stability, tuneable optical properties and controllable electrical properties made it the topic of interest [7]. Unique optical as well as electrical properties and easy preparation process of silver nanoparticles does make them of current importance. As it is well evident that, surface plasmon resonance has good impact on optical properties of the metal nanoparticle [6]. Therefore it will be more interesting to investigate the distinctive change in the optical properties by embedding silver nanoparticle in the polyaniline matrix which acts as a dielectric medium.

2. Experimental Details

Silver doped Polyaniline (PANI) nanocomposites were prepared using Solution casting method. Toluene was used as a solvent in order to make homogenous solution of desired amount of PANI and silver nanoparticles. To obtain the uniform distribution, the solution was heated on magnetic stirrer for 1 hour and then ultrasonicated for around 4 hours. At last the obtained Ag:PANI solution was poured into petri dish and allow to dry nearly up to 48 hours at room temperature. Weight percentage of dopant was varies as: 1% and 3% respectively.

3. Results and Discussion:

Refractive index (n) and extinction coefficient (k) has been calculated by using relations [8-12]

$$n = \frac{1+R}{1-R} + \sqrt{\frac{4R}{(1-R)^2} - k^2} \qquad\qquad k = \frac{\alpha\lambda}{4\pi}$$

The decreasing trend of the extinction coefficient (see figure 1a) with increase in wavelength might be due to scattering which causes light loss [13]. However the extinction coefficient is found to be increased with increase in dopant amount can be ascribed to the rise in surface roughness [14]. On the other hand the increase in refractive index (see figure 1b) with doping concentrations points towards the densification of the films.

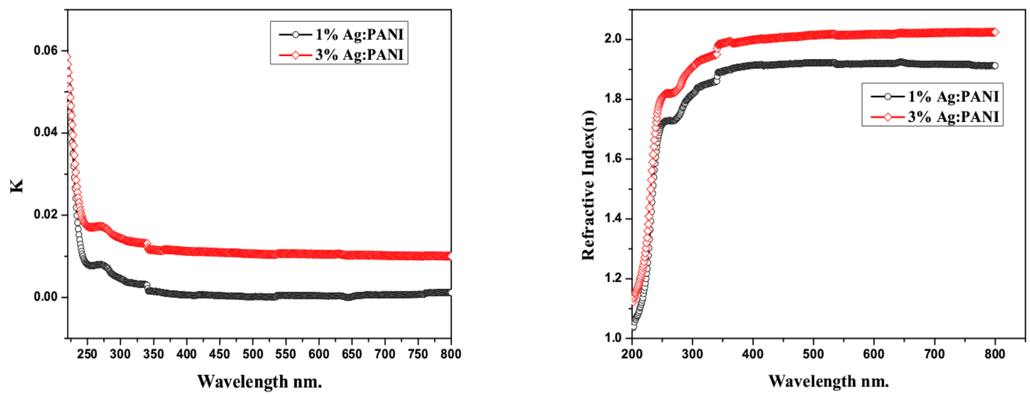

FIGURE 1: a) Extinction coefficient for Ag:PANI films and b) Refractive index of Ag:PANI thin films as a function of wavelength .

Absorption coefficient can be estimated by following relation [15].

$$\alpha = 2.303\frac{A}{t}$$

Figure 2 shows that the plot of absorption coefficient as a function of photon energy embedded with absorption band at energy value 4.2 to 4.7 eV (~ 266 to 297 nm) might be due to π-π* transition in benzenoid rings, which slightly blue shifted for 3% Ag:PANI nanocomposite. The observed blue shift indicates the interaction of silver nanoparticles with amine and imine units of polyaniline lead to change in the electronic band [6].

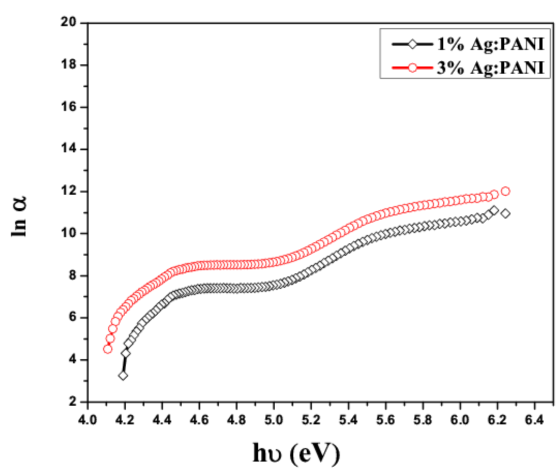

Figure 2: Plot of $\ln \alpha$ versus photon energy

Following relations were utilized for the calculation of the real part (ε_1) and imaginary (ε_2) part of dielectric constant [16].

$\varepsilon_1 = n^2 - k^2$ $\varepsilon_2 = 2nk$

Figure 3(a, b) shows the obtained trend for real and imaginary part as a function of wavelength. As it is evident from the equation that real part has the dependency on refractive index. Further according to the expression, real part suggests that up to what extent speed of light in the material will slow down. This is in good agreement with the obtained high refractive index values. Hence these composites have the importance in optical confinement and augment the optical intensities for nonlinear interactions [15]. On the other hand, as it is visible from the spectra of imaginary part that it has low values as compared to the real part. As a valuable result imaginary part displays that how a polymer matrix absorbs energy from an electric field due to dipole motion [16].

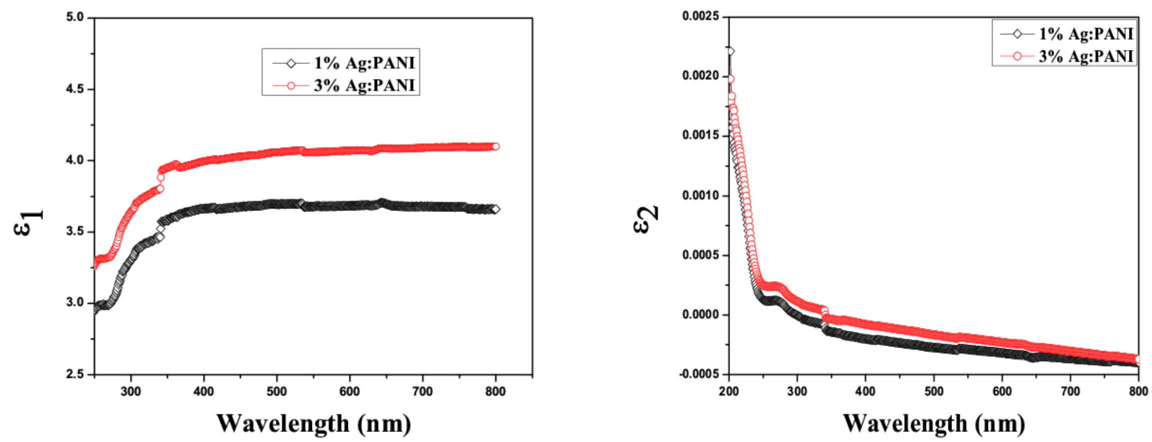

FIGURE 3: Plot of a) Real part and b) Imaginary part of dielectric constant.

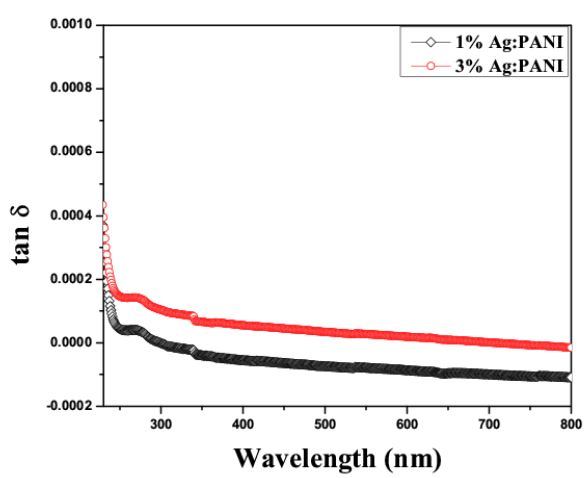

FIGURE 4. Plot of dissipation factor as a function of wavelength.

$\tan\delta$ which termed as dissipation factor used for the measurement of oscillator mechanical power lost can be calculate by using relation [16].

$$\tan\delta = \frac{\varepsilon_2}{\varepsilon_1}$$

Figure 4 shows the graph of dissipation factor as a function of wavelength and found to be increased with increase in doping concentrations.

Conclusion: Solution cast technique is employed to prepare Ag:PANI composites with different concentrations. The prepared samples have been studied for various optical constants such as extinction coefficient, refractive index, absorption coefficient, real and imaginary part and dissipation factor are found to be increased with Ag doping. Increased values of the refractive index suggest the densification of the films. The observed blue shift indicates the interaction of silver nanoparticles with polymer matrix.

References:

[1] B. H. Shambharkar and S. S. Umare, "Synthesis and Characterization of Polyaniline/NiO Nanocomposite", Journal of Applied Polymer Science, Vol. 122, **(2011),** pp. 1905–1912

[2] S. Bhadra, D. Khastgir, N.K. Singha, "Progress in preparation, processing and applications of polyaniline", Prog Polym Sci., Vol. 34, no.8, **(2009),** pp. 783–810.

[3] X. Feng, H. Huang, Q. Ye, "Ag/polypyrrole core- shell nanostructures: interface polymerization, characterization, and modification by gold nanoparticles", J Phys Chem C. Vol. 111, no.24, **(2007),** pp.8463–8468.

[4] Y.K. Mishra, S. Mohapatra, V.S.K. Chakravadhanula, "Synthesis and characterization of Ag-polymer nanocomposites", J Nanosci Nanotechnol, Vol 10, no.4,**(2010),** pp. 2833–2837.

[5] T.J. Rivers, T.W. Hudson, C.E. Schmidt, "Synthesis of a novel, biodegradable electrically conducting polymer for biomedical applications, Adv Funct Mater. Vol. 12, no.1, **(2002),** pp. 33–37.

[6] K. Gupta, P. C. Jana and A. K. Meikap, "Optical and Electri-cal Transport Properties of Polyaniline-Silver Nanocom-posite," Synthetic Metals, Vol. 160, no. 13-14, **(2010),** pp. 1566-1573

[7] S. M. Reda and S. M. Al-Ghannam, "Synthesis and Electrical Properties of Polyaniline Composite with Silver Nanoparticles," Advances in Materials Physics and Chemistry, Vol. 2, no. 2, **(2012)**, pp. 75-81.

[8]H.C. Casey Jr., D.D. Sell, K.W. Wecht., "Concentration dependence of the absorption coefficient for n− and p−type GaAs between 1.3 and 1.6 eV", J. Appl. Phys. Vol. 46, **(1975),** pp.250–257

[9] N. Benramdane, W.A. Murad, R.H. Misho, M. Ziane, Z. Kebbab, "A chemical method for the preparation of thin films of CdO and ZnO", Mater. Chem. Phys., Vol. 48, **(1997),** pp.119–123

[10] J. Tian, H. Deng, L. Sun, H. Kong, P. Yang, J.H. Chu," Effects of Co doping on structure and optical properties of TiO_2 thin films prepared by sol–gel method" Thin Solid Films, Vol. 520, **(2012),** pp.5179–5183

[11] J.I. Pankove, "Optical Processes in Semiconductors", Dover Publications, (NewYork **1971**).

[12] A. Abu EL-Fadl, G.A. Mohamad, A.B. Abd El-Moiz, M. Rashad, "Optical constants of $Zn_{1-x}Li_xO$ films prepared by chemical bath deposition technique" Physica B: Condens. Matt. Vol.366, **(2005),** pp.44–54

[13] R Tintu , Nampoori V P , Radhakrishnan P and Sheenu Thomas, "Nonlinear optical studies on nanocolloidal Ga–Sb–Ge–Se chalcogenide glass", J. Appl. Phys. Vol. 108, **(2010)**, pp.073525

[14] N. Tigau, V. Ciupina, G.I. Rusu, G. Prodan, E. Vasile, "Influence of substrate temperature on the structural and optical properties of sb_2s_3 thin films", Rom. J. Phys. Vol. 50, no. 7-8, **(2005),** 859-868

[15] H. Ahmed, H. Bahaa Rabee, H. Hakim, A. Hashim , R. Saba Salman, "Preparation and Study of Optical Properties of (Polymer-Nickel Nitrate)" Composite Advances in Physics Theories and Applications, Vol.20**, (2013)**

[16] M.I. Mohammed, " Optical properties of ZnO nanoparticles Dispersed in PMMA/PVDF Blend", Journal of Molecular Structure **(2018)**