

Evaluation of Optical Properties of Polypyrrole: Polystyrene Nanocomposites

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Abstract. In the present work the nanocomposite containing polypyrrole and polystyrene were synthesized by solution cast technique. The effect of different (especially small) concentrations of polypyrrole on structural and optical properties was studied. The results reveals that properties can be tuned significantly even with inclusion of small filler concentration in polymer matrix. Drastic decrease in the transmittance (up to 35%) has been observed even with small amount of filler concentration (i.e. 3%).

INTRODUCTION

Conducting polymers have attracted much attention due to their wide range of potential applications [1-5]. Researchers demonstrated that not all the polymers have insulating behavior. There are the conjugated polymers which in the neutral state show insulating or semiconducting characteristics and find the applications in the various field like solar cells sensors, organic light emitting diodes and optoelectronic devices [6-8]. Polypyrrole (PPy) is found to be most studied polymer because of its easily oxidizable nature, water solubility, commercial availability, high conductivity, best environmental stability and redox properties [9]. Polystyrene (PS) is found to be more suitable in terms of optical properties like color, high refractive index, chemically inert. It serve as resistant to oxidizing and reducing agents. Therefore blending PS with PPy opens new area of application e.g., as electromagnetic shielding and chemical sensing properties [10-13]. In the present study PPy-PS composites were prepared by solution casting method. The films were characterized for structural and optical studies.

EXPERIMENTAL

The Polypyrrole was prepared by chemical polymerization method. In the synthesis of Polypyrrole (PPy) FeCl₃ is used as an oxidant and ethanol as solvent. Desired amount of pyrrole is added in ethanol and stirred continuously. In the prepared solution FeCl₃ added drop wise. After 24 hours suspension it is filtered and washed with distilled water and acetone. The precipitate was dried about 1 hour at 60-70°C. Prepared Polypyrrole (PPy) is doped in a doping percentage of 1 and 3 wt% in polystyrene (PS). Prepared solution was ultrasonicated and after constant stirring it was casted on Petri dish over the mercury and left to dry at room temperature.

X-RAY DIFFRACTION

Fig. 1 shows the XRD spectra of PPy:PSnanocomposite. Intensity of the peaks is found to be increased with increase in doping concentration. The broad peak at 2θ between 20 to 35° corresponds to the PPy and has been reported previously [14]. Also a sharp growth in the peak intensity is quite visible with higher doping. On the other hand the peak observed at 2θ between 10 to 25° is ascribed to PS[15]

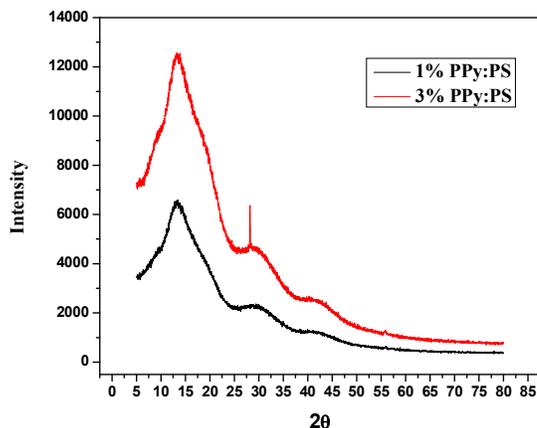


FIGURE 1: XRD spectra of PPy:PS films

FTIR SPECTROSCOPY

The spectrum is as shown in Fig.2. A slight shift in the peak positions towards higher wave number with increase in filler concentrations is observed, which suggests the active electronic interactions[16]. Strong absorption is clearly visible in the range 600 to 1600 cm^{-1} . The doping state of the composite has been confirmed by the presence of the peak at 1141 cm^{-1} . The bands at 1544 cm^{-1} and 1459 cm^{-1} are assigned to the C-C/C=C stretching and the C-N stretching vibrations in the ring, respectively[17].The peak position observed at about 1174 cm^{-1} is attributed to the Pyrrole ring vibration [18].

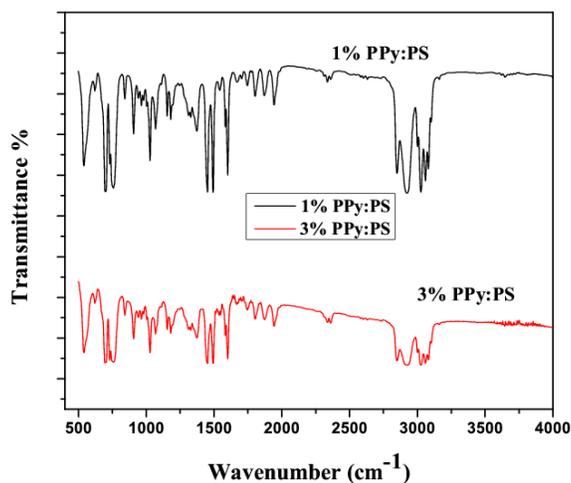


FIGURE 2: FTIR spectra of PPy:PS films

OPTICAL PROPERTIES

Optical measurements were done in transmittance mode. The spectra (see Fig. 3a) show that films are more absorptive in UV range. However the transmittance is found to be decrease with increase in filler concentrations. An abrupt decrease in transmittance has been observed even with 3 wt% of filler content. This decrease in the transparency suggests that optical scattering increased due to

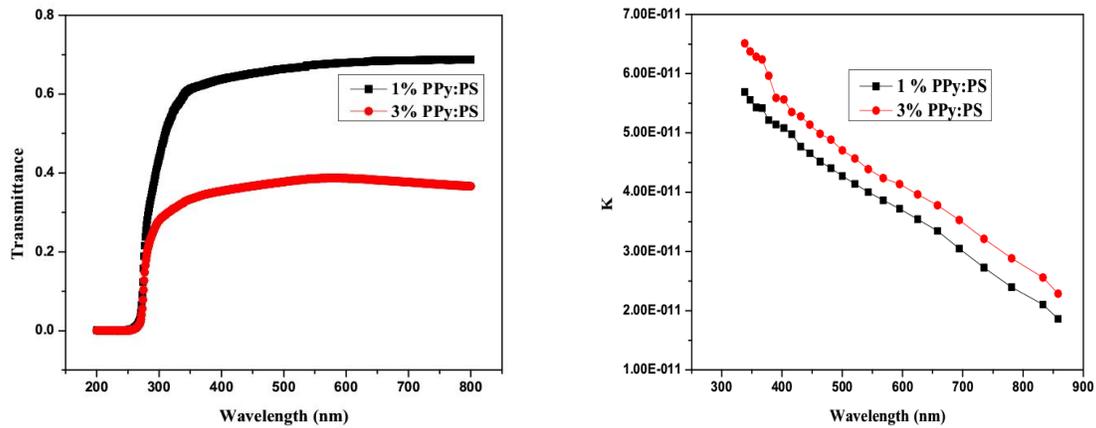


FIGURE 3: a) Transmittance spectra and b) Plot of extinction coefficient of PPy:PS films.

increase in roughness, which can also be confirmed through the spectra of extinction coefficient (see Fig. 3b) which also shows an increment in the results with filler concentrations. This confirms that roughness is responsible behind the decrease transparency. On the other hand plot of refractive index (Fig. 4) reflect that beyond 400 nm the values gets saturated. However a peak is observed near the band edge, which might be due to fundamental bandgap absorption. The increase in refractive index with increase in filler concentration indicates that films get denser.

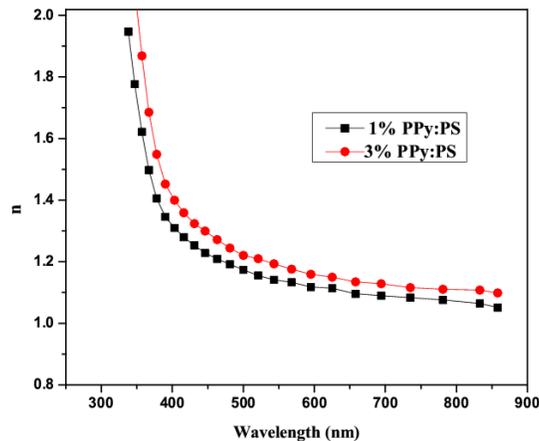


FIGURE 4: Spectral variation of refractive index of PPy:PS films.

CONCLUSION

Free standing films have been successfully prepared by casting technique and studied for structural as well as optical properties. FTIR confirms the presence of PPy nanoparticles in the blend. The uniform dispersion and the structure have been confirmed by XRD. The increase in refractive index confirms the densification of the films with concentrations. Accountable decrease in the transmittance with small filler concentration has been observed.

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REFERENCES

1. N.Vijayakumar,E.Subramanian,D.P.Padiyan, *Int. J. Polym. Mater.* 61 (11),847–863 (2012).
2. Z.Pourhashemi, H. Eisazadeh, *Polym. Plast.Technol. Eng.*, 51 (5), 533–539 (2012).
3. A.Olad,Z. Ramazani, *Int. J. Polym. Mater.*, 61 (12), 949–962 (2012).
4. T.K Das, S. Prusty, *Polym. Plast.Technol. Eng.*, 51 (14), 1487–1500 (2012).
5. M. Jaymand, *Des. Monom.Polym.*, 14 (5), 433–444 (2011).
6. J.K.Lee, W.S.Kim, H.J.Lee, W.S.Shin, S.H.Jin, *Poly. ForAdvancedTechn.* 17, 709–714(2006).
7. Y.M.Chang, W.F.Su, L. Wang, *Macromoleculer Rapid Communications* 29, 1303–1308(2008).
8. H.Yoon, M.Chang, J. Jang, *Advanced Functional Materials* 17, 431–436(2007).
9. A. Kassim, Z.B.Basar, H.N.M.E.Mahmud, *Proc. Indian Acad. Sci. (Chem. Sci.)*. 162, 114: 155 (2002).
10. F.Henry, L.C.Costa, *Micro. Opt. Techn. Let.*, 45 (4), 335–337 (2005).
11. B.Adhikari,S. Majumdar,*Prog.Polym.Sci.*, 29 (7), 699–766 (2004).
12. S.H.Hosseini, A.E.Ali,J. *Appl. Polym. Sci.*, 90 (1), 49–62 (2003).
13. E.Ruckenstein,J.S. Park, *Polym.Compos.*, 12 (4), 289–292 (1991).
14. A.Kassim, H.E.Mahmud, L.M.Yee, N.Hanipah, *Pacific Journal of Science &Technology*, 7, 103–107(2006).
15. J. D. Sudha, S. Sivakal, *Colloid Polym. Sci.*, 287, 1347(2009).
16. D.K.Bandgar, S.T.Navale, S.A.Vanalkar, J.H.Kim, N.S.Harale, *Synth.Met.* 195, 350–358(2014).
17. M. Omastova, M. Trchova, Kova'rova, J. Stejskal, *J. Synth. Met.*, 138 (3), 447–455 (2003).
18. M.Omastova,M.Trchova, J. Pionteck, J. Prokes, J.Stejskal, *Synth. Met.*, 143 (2), 153–161 (2004).