

UV-Visible Spectroscopic Investigation of Short Jute Fiber Reinforced Polypropylene Composites

Md. Nazrul Islam¹, M.A.Gafur² and Amir Hossain Khan³

Abstract: The composite of polypropylene (pp) reinforced with short fiber (jute) were prepared by hot press molding system. The effects of fiber addition were evaluated through ultraviolet–visible spectroscopic (UV-Vis) investigation. From the UV-Vis absorption spectra, allowed direction transition (Eqd) energy gaps are found to be 2.27 –2.46 eV. Eqd decreases a little with the increasing of percentage of fiber in the matrix. The ageing effects also reveal that the absorbances are almost same for all the polypropylene-Jute (PP-J) composites.

Key words: Polypropylene (pp), ultraviolet–visible spectroscopic (UV-Vis), Polypropylene-Jute (PP-J) composites.

Introduction

The use of bio-fibers derived from annually renewable resources, as reinforcing fibers in both thermoplastic and thermosetting polymer matrix composites provides positive environment benefits with respect to ultimate disposability and raw material utilization [1]. In the past few years the hot–press molding process has emerged as a very promising technique for synthesis of composites PP-J with enhanced non-linear optical property. The study of the structural and other physical properties of polymer composites reinforced with natural fiber is useful as an analytical technique due to their promising electronic and photonic properties. In fact the UV- visible optical absorption spectroscopic study determines the presence, nature and extent of conjugation present in the composite. The molecular structure of the PP-J composites are different from that of matrix because they are formed with polymerization of propylene using the famous Ziegler-Natta catalysis [2]. The binding forces holding the monomers together are usually covalent or ionic nature and consequently strong. In adding two neighboring macromolecules held together by lateral weak fabrication of PP-J composites give rise to its functional properties suitable for a wide range of modern applications.

Using UV–Vis spectroscopy, plasma polymerized thiophene thin films were studied by kim et al [3]. UV–Vis spectra showed an energy band gap shift from 3.78 to 4.02 eV with increasing radio frequency power and quite high optical transmittance up to 95%. The plasma polymerized N, N, 3,5 – tetramethylaniline thin films were studied by H. Akter et al [4], using infrared and UV – Vis spectra of plasma. It was observed that E_{qd} and E_{qi} are found to be 2.80 and 1.56 eV respectively. PPTMA thin film with conjugate can be produced

1 Department of Physics, Dhaka College, Dhaka 1205, Bangladesh

2 PP&PDC, BCSIR, Dhaka – 1205, Bangladesh

3 Department of Physics, Jahangirnagar University, savar, Bangladesh

* Corresponding Author ¹

by Plasma polymerized and the structure order can be improved by heat treatment. The UV-Vis spectra of PVC co-polymer at different weight percentage ratios were studied by Momanul et.al [5]. It was observed that E_{gd} and E_{gi} values varied from 1.9-2.7 eV and 1.3-1.95 eV respectively. They also reported that in both the cases the optical absorption co-efficient did not drop to zero. Polyaniline prepared from aniline, an amine aromatic shows interesting combination of properties that make them very attractive. It seems to be a promising material which exhibits good electrical behavior and good environment stability [6-8].

This paper describes the preparation of PP-J composites by hot press molding technique and the optical properties of PP-J composites studied by UV-Vis spectroscopy. The ageing effects of the composites are also included in this investigation.

Experimental

Sample preparation

PP and jute fibers were collected from local market. Fibers were chopped and kept at 110° C for 24 hours to remove moisture. The length of the fibers was approximately 2-3 mm. Same procedure was applied to remove moisture from PP granules. Chopped fibers and polypropylene were thoroughly mixed together with a blender. The mixing time and blade speeds were 2 minutes and 400 rpm respectively. The mixture of fiber and matrix is cast by simply pouring the mixture into the mold and leveling it to the desired thickness only slight stamping or force on the mold is required for sufficient compaction. This process is valid for both treated and untreated fibers. The mixed fibers and polymer were taken in a mold. An initial of 50 KN load was given to top of the mold area then the mold (6"×6") was kept in a Paul-Otto-Weber Press machine. The total heating system was controlled by microprocessor. Heating was done electrically and the temperature was set at 180°C. Only 25 – 30 minutes were required to reach the temperature at 180°C. The temperature was kept at 180°C for 20 minutes. After reaching the temperature the final load of 50 KN over the sample area was set to avoid the kind of voids and to have a required thickness. The additional pressure was kept for one hour. Cooling was done by water flow through the outer area of the heading plates. After cooling the specimens were separated from the mold. From this specimens, the samples of size (5x3) cm² was cut as per requirement for this test.

UV-Vis Spectroscopy

For UV-Vis measurements, the samples were made in a rectangular shape of area (8x5)cm² and of thickness 0.60 cm. PP-J composites were obtained in absorption mode with a Shimadzu UV-160A Spectrometer (Shimadzu) in the wavelength 200-1100 nm at room temperature. The optical absorption was measured in the above wavelength region for 0%, 10%, 20% and 25% PP-J samples for 0,8,12 months ageing period on substrate against a blank cover glass side as the reference. The band gaps values for the composites have been established using the optical spectra.

Result and Discussion

The UV-Vis absorption spectra for PP-J composites have been recorded at room temperature and are presented in figure 1. In the spectra, it is observed that there is a sharp rise in absorption in the low wavelength side, which rapidly decreases up to about 720 nm with a peak at around 460 nm, above 700 nm absorption decreases slowly. It can be noted that a small peak appears at around 440 nm for 10% PP-J, 460 nm for 20% PP-J and 460 for 25 % PP-J composite. In the spectra it is observed that the peak value shifted to the higher wavelength compared to the peak wavelength value 380 nm of pure PP sample. Thus there is a red shift of about 80 nm in λ_{max} as compared to Pure PP. These red shifts in PP-J composites represent an increased degree of conjugation present in the composites. It is well known that increasing conjugation generally moves the absorption to longer wavelength [9]. The Appearance of the absorption peak around 480 nm in the PP-J

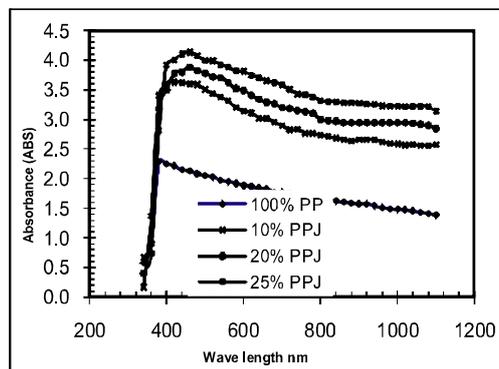


Fig. 1: Variation of absorption (ABS) with wavelength for PP, PP-J composite

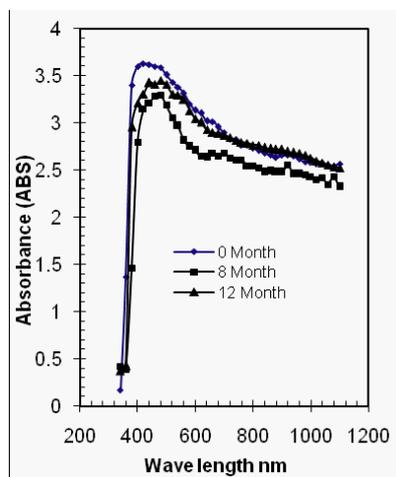


Fig. 2 (a): Ageing effect of 10% PP-J composite for the variation of absorbance with wavelength

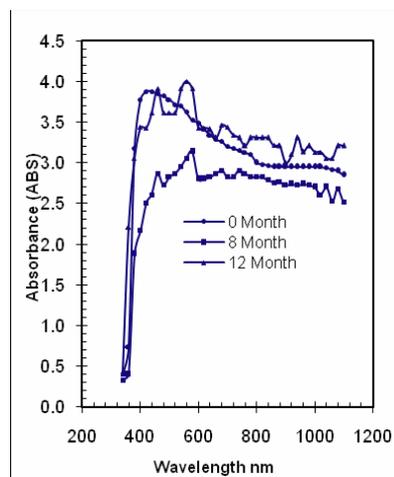


Fig. 2 (a): Ageing effect of 20% PP-J composite for the variation of absorbance with wavelength

composite may be due to π - π^* transition because of the probable development of conjugates in the structure on fiber loading in the composite.

The ageing effect for the time duration of 0-12 months is also observed for 10% and 20% PP-J samples and presented in figure 2(a) and 2(b). In these spectra, absorption of PP-J composites do not change much on ageing up to 0-12 months. There is an overall increase on absorption up to 440 nm.

The absorption coefficient α is calculated from the Beer-Lambert's law of absorption data (Fig.-1) for all the PP-J samples and plotted in figure. 3.

This law states that

$$I = I_0 e^{-\alpha d} \quad (1)$$

Where is I_0 the intensity of the incident radiation, I is the intensity of the transmitted radiation, d is the path length of the absorbing species and α is the absorption coefficient. It is found that in the high energy region follows a sharp fall of α at the photon energy about 3 eV for all the samples. This sharp falling may be due

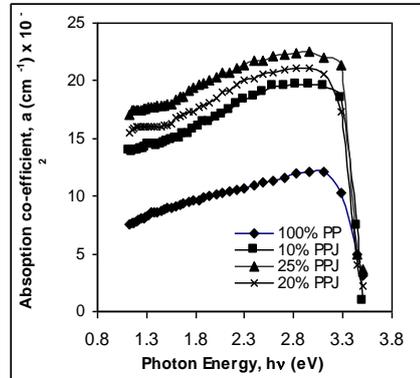


Fig. 3: Photon Energy vs Absorption co-efficient curve for the sample of PP and PP-J composite

to the presence of defect in the composites ^[10]. In all the cases optical absorption coefficient does not drop to zero, because of the setting is not free carrier absorption before the band to band transition disappear.

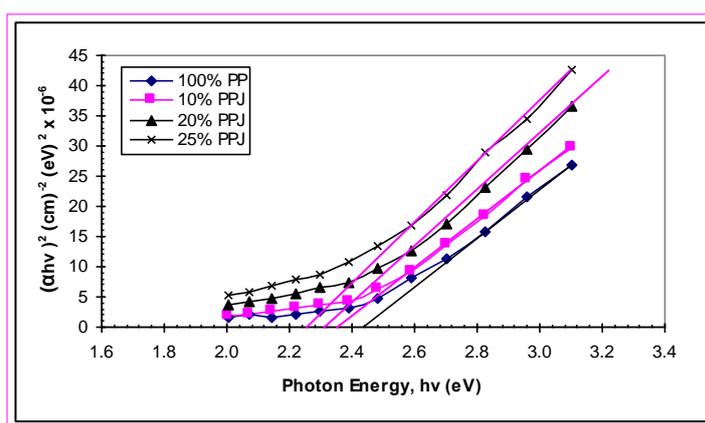
The optical band gap E_{opt} values, which is related to the electronic structure, are obtained from the Tauc relation [11]

$$\alpha hv = B (E_{opt} - hv)^n \quad (2)$$

where B is the Tauc parameter, n is the parameter connected with distribution of the density of states, h is the Planck constant, v is the frequency of radiation and E_{opt} is the optical band gap obtained from the extrapolation of the linear part of the curve (Fig.1).The E_{qd} can be evaluated from the plot of $(\alpha hv)^2$ against the corresponding value of the photon energy hv respectively are shown in Fig. 4.

Table 1: Allowed direct transition energy gaps and B values for PP and PP-J composite

| Fiber volume Wt. Percentage of PP-J composite | Direct transition energy gap (eV) | B values (cm) ^{-1/2} (eV) ^{1/2} |
|---|-----------------------------------|---|
| PP | 2.46 | 39.27 |
| 10% | 2.36 | 41.12 |
| 20% | 2.32 | 45 |
| 25% | 2.27 | 48 |

**Fig. 4:** Effect of the direct band gap corresponding to Photon Energy

Extrapolating the straight line part of the curve in this figure energy axis, where $\alpha^2 = 0$, gives the values of band gap for E_{qd} . The E_{qd} values are in the range of 2.27 – 2.46 eV for all the samples shown in Table-1. It is noticed that E_{qd} value slightly decrease with the increasing of fiber loading in the composite. Thus it can be inferred that the bands in the PP-J composites become smaller on fiber loading, which may indicate the probable increase of structural order of PP-J composite, thereby changing the energy gaps.

The Tauc parameter, B is a measure of the steepness of band tail (Urbach region) density of states. The values of B calculated from Fig.4 for different PP-J composites are found to increase with increasing fiber loading in the composite (Table-1). Higher value of B is due to effect of structural disorder [12].

Conclusions

PP-J composites are prepared by using a hot press molding. From UV-Vis investigation E_{qd} are found to be 2.27–2.46 eV. The values of B was calculated for different weight percentages of PP-J samples and is found to increases for loading of fiber in the matrix, indicating that the probable decrease of structural order of PP-J composites changing the band gap. Furthermore, we would like to investigate the structural rearrangement or modifications of pp and pp-j composites by XRD/FTIR investigation.

Acknowledgement

The authors are grateful and would like to express their appreciation for premising them to record the UV –Vis spectra in the STRC, University of Dhaka, Bangladesh.

References

1. Narayan, R., 1992, Biomass (Renewable) Resources for production of Materials, Chemicals and Fuels- A Paradigm shift Acs symp scr. 476.
2. Gowariker V. R. and N. V. Vishanathan, 1999, "Polymer Science" New age International (p) limited **99**, p-217.
3. Kim M .C., Cho S.H., Han J.G., Hong B.Y., Kim Y.J, Yang S.H. and J.H. Boo, 2003, *Surf. Coat. Technol*, **595**, 169-170.
4. Akter H. and Bhyiyan A. H., 2005, *Thin Solid Films* 474, 14-18.
5. Momanul and Obaidul Islam A. B. M., 2003, A study at the structural and electrical property of PVC Co-polymer, (Project Report).
6. Mahati C. J., Saravanan S., Jayalekshmi S, Venkitachalam S. and Anantharaman M.R., 2003, *Matter. Lett* **57**, 2253.
7. Sayed W. M. and Salim T. A., 2000, *J. Appl. Polym. Sci.* 77 165.
8. Gong X., Dai L., Mau A.W. H. and Griesser H. J., 1998, *J. Polym. Sci., A, Polym. Chem* 36,633.
9. Lambert J. H., Lighmer D. A., Shurvell H. F. and Cooks R. G., 1987, Introduction to organic spectroscopy, Macmillan publishing, New york.
10. Davis E. A. and Mott N. F., 1970, *Philos. Mag* 22, 903.
11. J. Tauc in. J. Tauc (Ed), 1974, Amorphous and Liquid Semiconductors, Plenum, London, chap. 4.
12. Matsuda A., Yamaoka T., Wolf S., Koyama M., Ymanishi Y., Kataoka H., Matsuura H. and Tanaka K., 1968, *J.Appl. phys.*60, 4025.