Int. J. Chem. Sci.: 9(4), 2011, 1725-1730
ISSN 0972-768X
www.sadgurupublications.com

ORIENTATION STUDIES IN MWNT / PMMA NANOCOMPOSITES

GHANSHYAM TRIPATHI[*], BALRAM TRIPATHI[a], Y. K. VIJAY[a], AMREESH CHANDRA[b] and M. K. SHARMA

Department of Chemistry, MSJ (P.G.) College, BHARATPUR – 3 10005 (Raj.) INDIA
[a]Department of Physics, University of Rajasthan, JAIPUR – 302004 (Raj.) INDIA
[b]Department of Applied Physics and Metrology, IIT, KHARAGPUR – 721302 (W.B.) INDIA

ABSTRACT

Orientation behavior of MWNTs (0.01-0.05%) in PMMA matrix has been studied using scanning electron microscopy, FT-IR spectroscopy and Raman spectroscopy. MWNT/PMMA nanocomposites have been synthesized by solution cast method. Dispersion of MWNT in PMMA matrix has been performed by ultrasonication. SEM images show surface morphology of MWNTs oriented in PMMA matrix. FT-IR spectra show interaction nature of MWNT with PMMA matrix. Shifted wavenumber shows the orientation characteristics and bonding nature. Increased Raman intensity for 0.01% MWNT in PMMA matrix shows orientation nature of MWNTs in PMMA matrix.

Keywords: PMMA, MWNT, SEM, FT-IR, Raman spectroscopy.

INTRODUCTION

Carbon nanotubes have attracted considerable attention and generated intense research activities on nanotubes and their composites with polymers. Carbon nanotubes have extra ordinary properties like electrical, mechanical and thermal properties[1-4]. These properties, combined with very high aspect ratio, make nanotubes an excellent candidate for novel composite materials. Several previous studies focus on fabrication and characterization of carbon nanotube-polymer nanocomposites[5-12]. Industrial applications of MWNT/PMMA composites have also been diversified to various fields including electronic devices and field emission display. Because of electrical properties of MWNTs and MWNT/PMMA composites can be applied as an electromagnetic shielding material. The

[*]Author for correspondence; Mo.: +91-9461300426; Fax: +91-141-2711049;
E-mail: tripathi.ghanshyam@gmail.com

diameter of MWNT at nanoscale enables these nanocomposites to be transparent as far as the MWNTs are well dispersed. MWNTs are very difficult to disperse in a polymer matrix as they have large surface areas and posses large Van der waals force among themselves. This can lead to the formation of strongly bound aggregates[13]. A need to obtain well dispersed and oriented CNTs in polymer matrix has been the subject of several reports as this condition is anticipated to give rise the best composite performance. Sonication of solutions of polymers with dispersed nanotubes followed by solvent evaporation has been used successfully to achieve homogeneous nanocomposites[14]. The orientation of nanotubes in the composite is a critical issue regarding the electrical, thermal and mechanical properties of the composites.

EXPERIMENTAL

Dispersion of MWNTs in PMMA matrix has been performed by using ultrasonication. MWNT/PMMA composites of 40 μm thickness have been synthesized by solution cast method. Orientation of MWNTs in PMMA matrix has been performed by applying 1200 Gauss magnetic field. SEM measurements have been taken at 10μm scale to study the dispersion of MWNTs in the PMMA matrix. FT-IR measurements have been performed by using Simadzu-330 model. Raman measurements have been performed by using R-3000, model at 532 nm excitation. Magnetic field of 1200 G has been used for proper orientation of MWNTs in the PMMA matrix.

RESULTS AND DISCUSSION

Scanning Electron Microscopy (SEM) has been used to study the dispersion of MWNTs in the PMMA matrix. Fig. 1, Fig. 2 and Fig. 3 show the SEM images of PMMA matrix, 0.01 MWNT/PMMA matrix and 0.05 MWNT/PMMA naocomposites, respectively. It is found that MWNTs at low loadings in PMMA matrix oriented well while MWNTs at higher loadings in PMMA matrix agglomerates.

FT-IR spectroscopy has been used for characterizing bonding nature of MWNTs with PMMA matrix. From Fig. 4, it is clear that peak at 1696 cm^{-1} is attributed to the ester bond (O-C=O) in PMMA matrix and peak at 1705 cm^{-1} originates from C-C bond between MWNTs and PMMA which may be formed during the composite growth. The peak at 1758 cm^{-1} is attributed to CH_2 stretch. The types of interactions between PMMA and MWNTs demonstrates here, that these could improve the interfacial bonding between nanotubes and the polymer.

Fig. 1: SEM image for PMMA matrix

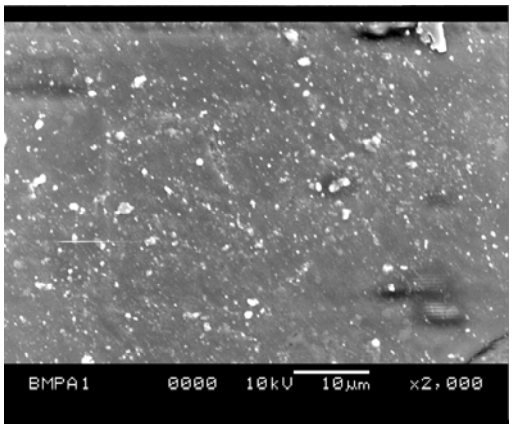

Fig. 2: SEM image for (0.01) MWNT/PMMA nanocomposite

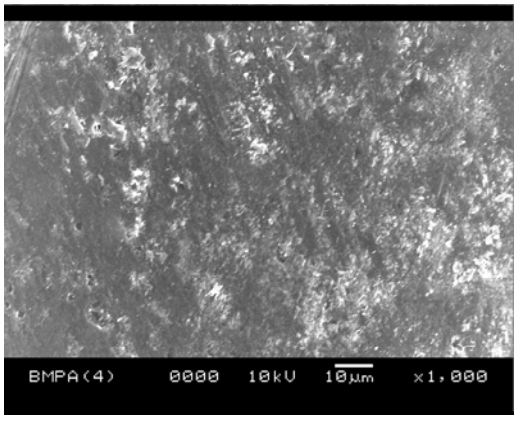

Fig. 3: SEM image for (0.05) MWNT/PMMA nanocomposite

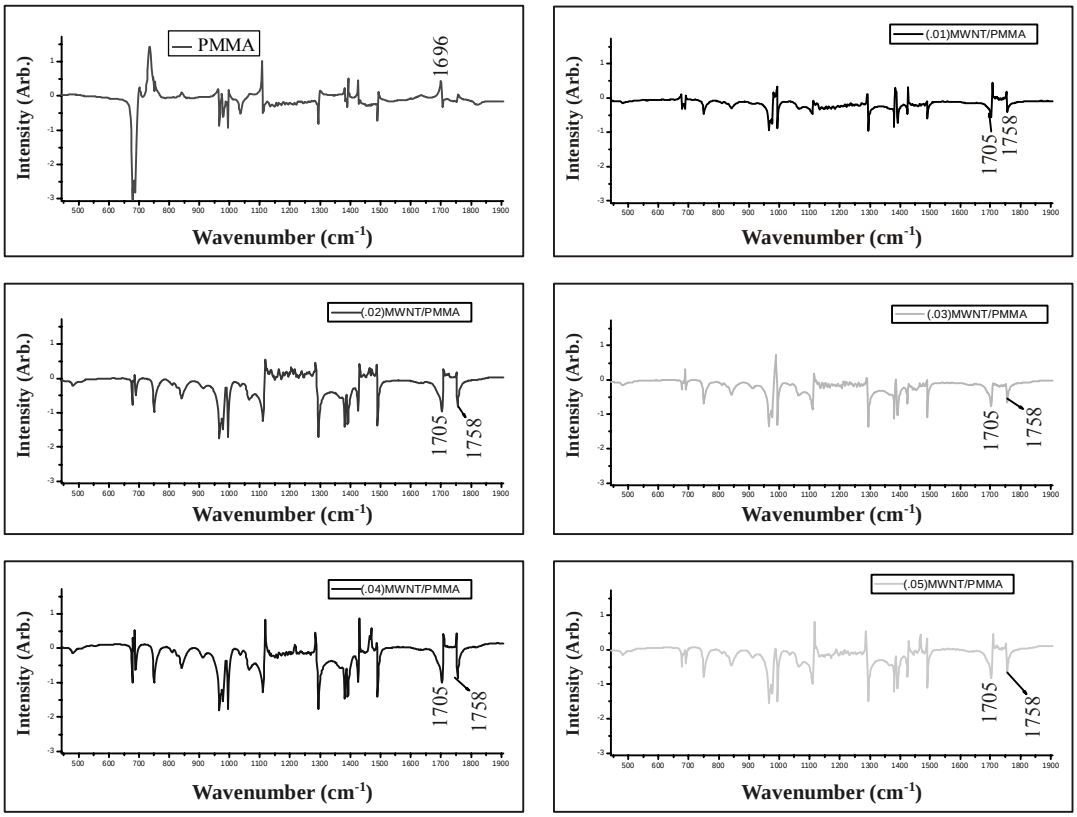

Fig. 4: FT-IR spectra for MWNT/PMMA nanocomposites

Raman spectroscopy is surface sensitive, since the penetration depth is generally no more than several micrometers, depending upon MWNTs loading. Although it is possible that the orientation of MWNTs inside the matrix could be different from that of the matrix surface. We believe that the intensity ratio measured on the surface is reasonable representation of the overall orientation. For the present study, orientation of MWNTs within the PMMA matrix was assessed with a R-3000, Raman spectrometer with 1 μm beam spot and 532 nm excitation. Raman spectra were recorded for (0.01-0.05%) MWNT/PMMA composites of thickness 40 μm.

The orientation of MWNTs in PMMA matrix has been characterized with the measurement of Raman intensity which is mentioned in Fig. 5. It is found that MWNTs in low concentration (0.01%) with in the PMMA matrix have higher Raman intensity (1707/cm, 180). It may be attributed to low loading of MWNTs in composites having more freedom to flow during shear, which results in better alignment, while higher concentration (0.05%) of MWNTs have low Raman intensity (1707/cm, 81) as well as decreased FWHM. It may be

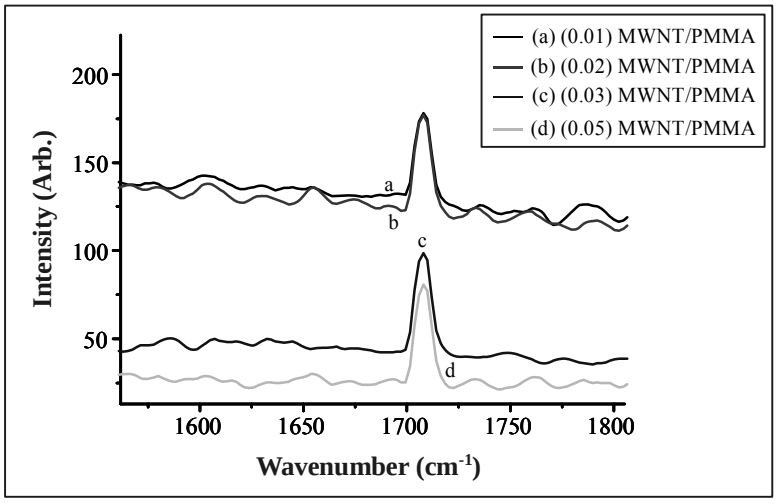

Fig. 5: Raman spectra for MWNT/PMMA nanocomposites

attributed to restricted motion by neighboring nanotubes and thus, can not align as well. Furthermore, the MWNTs could tend to agglomerate at higher loading, which prevents good alignment. The variation in Raman intensity is mentioned in Table 1.

Table 1: Variation in Raman intensity with MWNTs concentration in the PMMA matrix

Samples	Wave number (cm^{-1})	Intensity
0.01 MWNT/PMMA	1707	180
0.02 MWNT/PMMA	1707	177
0.03 MWNT/PMMA	1707	100
0.05 MWNT/PMMA	1707	81

CONCLUSION

(i). The successful fabrication of MWNT/PMMA nanocomposites has been demonstrated upto 0.05 wt % MWNTs.

(ii). The fabrication method is by solution cast and dispersion of MWNT through ultrasonicator is appreciable to a wide range of matrix polymers.

(iii). The orientation decreases for higher nanotube loading but it is still good at lower loading as confirmed by Raman spectroscopy.

(iv). Improvement of dispersion and interface properties of the nanotubes is necessary to further improve the composite properties.

REFERENCES

1. M. F. Yu, B. S. Files, S. Arepalli and R. S. Ruoff, Phys. Rev. Lett., **84**, 5552 (2000).
2. F. Li, H. M. Cheng, S. Bai, G. Su and M. S. Dresselhaus, Appl. Phys. Lett., **77**, 3161 (2000).
3. E. W. Wong, P. E. Sheehan and C. M. Lieber, Sci., **277**, 1971 (1997).
4. P. Kim, L. Shi, A. Majumdar and P. L. McEuen, Phys. Rev. Lett., **87**, 215502 (2001).
5. M. J. Biercuk, M. C. Liaguno, M. Radosavljuvic, J. K. Hyun, A. T. Johnson and J. E. Fischer, Appl. Phys. Lett., **80**, 2767 (2002).
6. M. S. Shaffer and A. H. Windle, Adv. Mater., **11**, 937 (1999).
7. D. Qian, E. C. Dickey, R. Andrews and T. Rantell, Appl. Phys. Lett., **76**, 2868 (2000).
8. P. M. Ajayan, L. S. Schadler, C. Giannaris and A. Rubio, Adv. Mater., **12**, 750 (2000).
9. V. G. Hadjiev, M. N. Hiev, S. Arepalli, P. Nikolaev and B. S. Files, Appl. Phys. Lett., **78**, 3193 (2001).
10. R. Haggenmueller, H. H. Gommans, A. G. Rinzler, J. E. Fischer and K. I. Winey, Chem. Phys. Lett., **330**, 219 (2000).
11. L. Jin, C. Bower and O. Zhou, Appl. Phys. Lett., **73**, 1197 (1998).
12. J. R. Wood, Q. Zhao and H. D. Wagner, Comp., A **32**, 391 (2001).
13. S. J. Park, S. T. Lim, M. S. Cho, H. M. Kim and H. J. Choi, Curr. Appl. Phys., **5**, 302 (2005).
14. D. Gian, E. C. Dicky, R. Andrews and T. Rantell, Appl. Phys. Lett., **76**, 2868 (2000).

Accepted : 15.09.2011