SYNTHESIS OF POLYANILINE-COATED MULTI-WALLED CARBON NANOTUBES/MAGHEMITE NANOCOMPOSITES AND THEIR ELECTROMAGNETIC SHIELDING PROPERTIES

*Jumi Yun, Yeon Ee Kim, Ji Sun Im, Young-Seak Lee, and Hyung-Il Kim**

Department of Industrial Chemistry, BK21-E^{2}M,
Chungnam National University, Daejeon 305-764, Korea

Introduction

In recent years, the electromagnetic interference (EMI) has been a serious problem because of the proliferation of electronic devices and instruments. EMI can cause the operational malfunction of electric devices leading to loss of valuable time, energy, and resources. It can also cause the human diseases such as leukemia, miscarriages, and breast cancer. So the investigation on the attenuation of EMI has been carried out more deeply by many researchers [1-6]. The metal-based materials have been widely used to reduce EMI. But they have been suffered by the disadvantages of heavy weight and easy corrosion which restrict the wide use of these materials [7].

Carbon nanotubes (CNTs) have been a focus of considerable research since their first observation by Iijima. Their remarkable properties include their interesting mechanical, electrical, thermal, and conductive behavior, and they offer tremendous opportunities for the development of fundamentally new material systems for application in nano scale devices and materials particularly. Similarly, composites based on polymers and CNTs have the potential to make an impact on various applications ranging from general low-cost circuits and displays to power devices, microelectromechanical systems, super capacitors, solar cell sensors, and displays. Despite their appealing properties, the low solubility of CNTs in most organic solvents and their poor compatibility within a polymer matrix make the uniform dispersion of CNTs in the polymer matrix very difficult, limiting their applications.

Recent study shows that modifications with the conducting polymers can enhance the sensing properties and dispersion of CNTs. Polyaniline (PANi) has great potential for use in commercial applications because it is cheap to produce, environmentally stable, exhibits enhanced conductivity, and changes its color depending on the redox states.

In this study, highly conducting PANi and multi-walled carbon nanotube (MWCNT) nanocomposites were prepared by in situ polymerization for electromagnetic interference shielding. To improve the ferromagnetic properties of the nanocomposite, ferromagnetic materials like γ-Fe_2O_3 magnetic particles were used together.

Experimental

The PANi/MWCNT/γ-Fe_2O_3 composites were synthesized using in situ chemical oxidative polymerization. In typical synthesis process, equal volumes of HCl solutions containing 5 wt% oxyfluorinated MWNTs, γ-Fe_2O_3, and aniline monomer were sonicated for 2 h to form uniform suspensions. Then the required amounts of APS were dissolved in HCl solutions separatively, and added slowly into the above suspensions to initiate the polymerization. The resulting reaction mixtures were allowed to react for 6 h at 4 ◦C with stirring in order that aniline could be fully polymerized. The synthesized PANi/MWCNT/γ-Fe_2O_3 composites was filtered and rinsed several times with distilled water and methanol. The various kinds of samples are classified as shown in Table 1.

Table 1. Classification of PANi/MWCNT/γ-Fe_2O_3 composites

Abbreviation	Compositions		
	Aniline	Fe_2O_3	MWCNT
PANI	O	-	-
PF	O	O	-
PC	O	-	O
PFC	O	O	O

Morphology was studied with field emission scanning electron microscopy (FE-SEM, FEI, Sirion-200). Thermogravimetric analysis (TGA) was performed in air flow (25cm3/min) at a heating rate 10 ◦C/min.

Results and Discussion

The surface morphology of samples was presented by FE-SEM images in Fig. 1. The in-situ polymerized polyanilne showed the cylinder shape indicating the polymerization with direction of y-axis as shown in Fig. 1 (a). This surface morphology was changed by MWCNT additive showing the enlarged scale about 5 times as shown in Fig. 1 (b). This was attributed to the polyanilne polymerization on the surface of MWCNTs. In case of using Fe_2O_3 additive only, the regular shape was not observed showing the random polymerization without specific polymerization direction as shown in Fig. 1 (c). The PFC sample showed the combined surface morphology of PF and PC. Even though the regular shape was not shown like a PC, the PANI polymerization direction was observed more clearly when comparing with that of PF sample.

The oxidative degradation properties of samples were studied by TGA analysis in Fig. 2. The strikingly improved resistance to oxidation was observed in PFC sample based on effects of Fe_2O_3 and CNT additives.

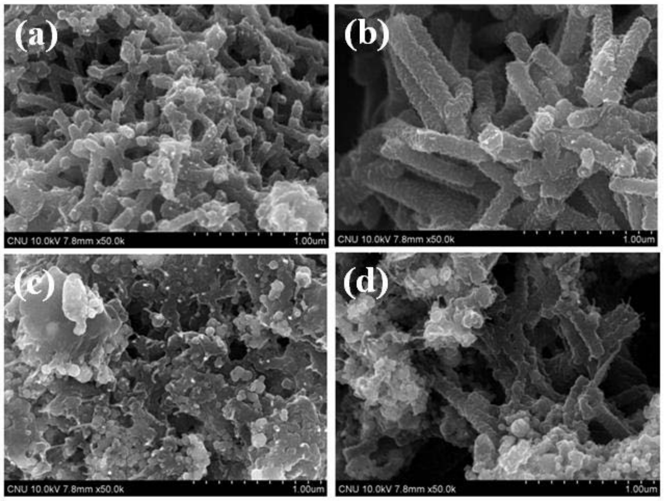

Fig. 1. SEM microphotographs of (a) PANI, (b) PC, (c) PF, and (d) PFC.

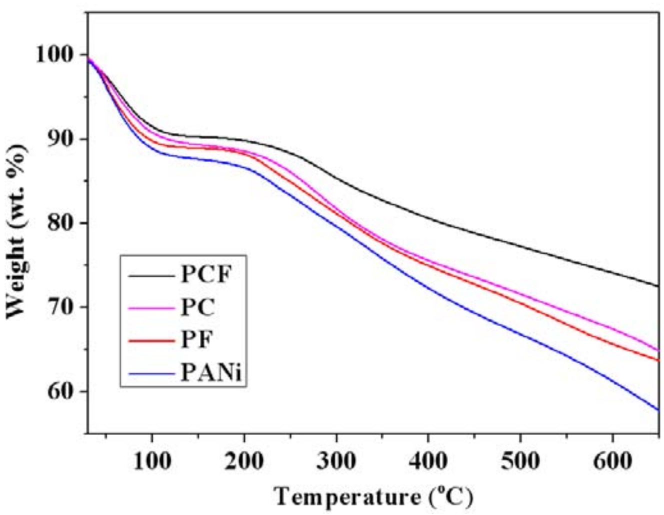

Fig. 2. TGA thermograms of various samples.

The EMI shielding efficiency (SE) was presented in Fig. 3. In case of PANI sample, the average EMI SE was around 38 dB. EMI SE increased by forming composites with additives up to 43 and 44 dB due to the effects of CNT or Fe_2O_3 additives, respectively. The highest EMI SE was observed in PFC sample showing an average EMI SE about 45 dB. Therefore, it was concluded that an use of Fe_2O_3 and CNT additives together led the synergistic effect for improving EMI SE effectively.

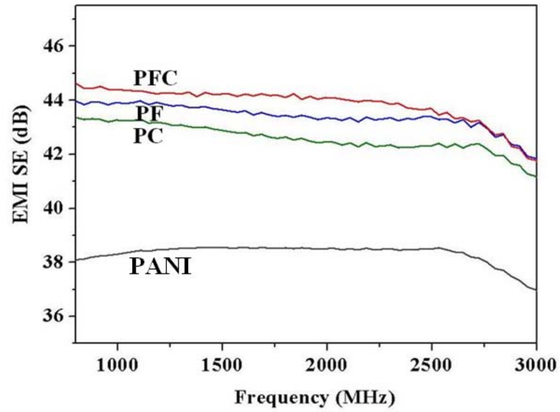

Fig. 3. EMI shielding efficiency of various samples.

Conclusions

Highly conducting PANi and MWCNT nanocomposites were prepared by in situ polymerization for electromagnetic interference shielding. To improve the ferromagnetic properties of the nanocomposite, ferromagnetic materials like γ-Fe_2O_3 magnetic particles were used together. The nanocomposites showed significant increases in permittivity, permeability, and electromagnetic interference shielding efficiency. The electromagnetic interference shielding efficiency of nanocomposites increased up to 45 dB mainly base on the absorption and reflection mechanism. These nanocomposites were proposed as hybrid conductive fillers in various thermoplastic matrices, for producing electromagnetic interference shielding materials.

References

[1] Al-Saleh MH, Sundararaj U. Electromagnetic interference shielding mechanisms of CNT/polymer composites. Carbon 2009;47(7):1738-1746.
[2] Yu X, Shen Z. The electromagnetic shielding of Ni films deposited on cenosphere particles by magnetron sputtering method. J Magn Magn Mater 2009;321(18):2890-2895.
[3]Saini P, Choudhary V, Dhawan SK. Electrical properties and EMI shielding behavior of highly thermally stable polyaniline/colloidal graphite composites. Polym Advan Technol 2009;20(4):355-361.
[4] Sudha JD, Sivakala S, Prasanth R, Reena VL, Nair PR. Development of electromagnetic shielding materials from the conductive blends of polyaniline and polyaniline-clay nanocomposite-EVA: Preparation and properties. Compos Sci Technol 2009;69(3-4):358-364.
[5] Saini P, Choudhary V, Singh BP, Mathur RB, Dhawan SK. Polyaniline–MWCNT nanocomposites for microwave absorption and EMI shielding. Mater Chem Phys 2009;113(2-3):919.
[6] Thomassin JM, Pagnoulle C, Bednarz L, Huynen I, Jerome R, Detrembleur C. Foams of polycaprolactone/MWNT nanocomposites for efficient EMI reduction. J Mater Chem 2008;18(7):792-796.
[7] Zhang Zh, Wan M. Nanostructures of polyaniline composites containing nano-magnet. Synth Met 2003;132(2):205-212.