Synthesis and Electrical Characterization of PMMA/MWCNT Nanocomposites

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Abstract

Multiwall carbon nanotubes (MWCNT)/poly(methyl methacrylate) (PMMA) nanocomposites were prepared via "in situ" solution polymerization assisted by probe sonication. A Factorial Experimental Design was used to study compounding and processing variables: amount of MWCNT and ultrasound amplitude. Thin polymeric films were obtained by solvent casting and asperion for electrical characterization using the four-probe method to measure the electrical sheet resistivity of the nanocomposites.

Key words:

PMMA Nanocomposites, Carbon Nanotubes, Electrical Properties

Introduction

The potential of carbon nanotubes in nanoelectronics technology has long been researched since their discovery in 1991 by Iijima¹. It's known that the incorporation of CNTs into polymers blends offer a new perspective of conductive and transparent materials, which introduce an alternative way not only for reinforcing the mechanical qualities in polymer films but also new electronic properties based on morphological modifications or electronic interactions between the two components².

Results and Discussion

Solution polymerization of PMMA composites containing 1, 1.5 and 2 wt% CNTs were performed in chloroform using the initiator 2,2'- Azo-bis-isobutyronitrile AIBN. CNTs were dispersed and sonicated using an ultrasonic processor QSONICA, model SONICATOR Q700 with a titanium microtip 6 mm in diameter. The reaction temperature was set to 60°C, due to the boiling point of the solvent.

The electrical surface resistivity of the samples prepared by solvent casting was measured, first, with the four-probe method (*Thin Film Devices*, mod. FPP-2000). Further analyses were repeated on the same samples by using the Van der Pauw method (Fig. 1).

surface resistivity decreases from 10.3 kΩ/sq., for test 1 with asperion, to 7.8 kΩ/sq., using casting. Thus, the results indicated a significant effect of the preparation methods on the electrical properties of the PMMA/MWCNT composites. Both methods showed good homogeneity, but dispersion of the MWCNT in the PMMA matrix prepared by solution casting could be better and likely a percolation network behavior was achieved.

Fig.1. Rectangular sample with four electrical contacts placed onto glass substrate (right). A Van der Pauw scheme (left) of an irregular shaped sample showing probes locations.

Conclusions

The methods of synthesis of PMMA/NWCNT nanocomposites via *in situ* polymerization (sonication assisted), dispersion and film preparation greatly affect the ability of CNTs to form a dense and homogeneous network. It was showed that the addition of the CNTs improved the sheet conductance of the nanocomposites produced by solvent casting comparable with semiconductors materials.

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¹ Z. Jia et al, Study on poly(methyl methacrylate)/carbon nanotubes composites, *Materials Science and Engineering A271* (1999), pg. 395-400.

² D. Zhang et al, Transparent, Conductive, and Flexible Carbon Nanotube Films and Their Application in Organic Light-Emitting Diodes, *Nano Lett.*, Vol. 6, No. 9, 2006.

Table 1. Mean values of surface resistivity, thickness and volume conductivity of the PMMA/MWCNT films obtained by casting.

Test	Concentration of CNTs (wt%)	Amplitude (%)	Sheet Resistivity (Ω/□)	Conductivity (S/m)	Thickness (μm)
1	1	26	7808	1,3	98
2	2	26	806	11,6	109
3	1	50	4076	2,4	103
4	2	50	1397	7,0	106
5	1.5	38	2136	4,8	99
6	1.5	38	2651	3,9	99
7	1.5	38	2727	3,8	99

Thin film polymers were obtained by two deposition methods, asperion and casting. Although the transparency and thickness of the films obtained by asperion were closer to the desired, the casting samples performed better in sheet resistivity (Table 1). Electrical