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Fabrication and Mechanical Properties of Carbon Nanotubes and Rubber Composites

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ABSTRACT

In this research, the composite materials between carbon nanotubes (CNTs) and natural rubber was studied. CNTs which used as dispersed phase were synthesized from NiO via chemical vapour deposition (CVD) method. The composites sample was fabricated by casting technique. CNTs was added into rubber for 0 – 1.0 % by volume. The physical and mechanical properties such as density, tensile strength, toughness, hardness and wear test of composite samples were examined, respectively. Furthermore, microstructures of samples were also investigated by scanning electron microscopy (SEM). From the results, it can be seen that the mechanical properties such as hardness of rubber was improved with the adding of CNTs.

Keywords: CNTs, Rubber, Composites

INTRODUCTION

In the present day, Polymer Matrix Composites (PMCs) with a small percentage of strong disperse are designed for many applications because of the significantly improve the mechanical, thermal and barrier properties of the pure polymer matrix (Chisholm *et al*., 2005). With their excellent stiffness and weight characteristic, PMCs especially, fiber reinforced composites are widely used in many structural materials and industries which take place of metal, for example, aerospace, automobile, sporting goods, marine and other industries (Walker and Smith, 2002; Mel, 1994). There are many type of reinforcing fibers using in nowadays such as, glass fiber, carbon fiber, alumina fiber and aramid fiber (Kevlar), etc. which exhibits different properties. However, fiber with the extremely high mechanical properties which much more than that of metal is the challenging of technology improvement. Carbon nanotube (CNTs) is one of the novel material which can be the candidate of fillers in PMCs (Krumova *et al*., 2001; Allaoui *et al*., 2002; Kim *et al*., 2006). Because of their unique properties, interesting mechanical (axial Young modulus 1-5 TPa) (Allaoui *et al*., 2002), high flexibility, bending fully reversible up to a 110° critical angle for SWNT (Kim *et al*., 2006). The CNTs-based composites, the new type of materials which can be one of the most promising applications have been intensively researched. In this work, the composites samples between multi-wall carbon nanotubes (MWNTs) and rubber were fabricated using ultrasonic mixing and casting techniques. The reinforced fiber, MWNTs were synthersized by a novel method, infusion chemical vapor deposition (Singjai *et al.*, 2007). Physical and mechanical properties such as hardness, tensile strength and density of composites samples were investigated. Besides, microstructure of samples was determined using SEM technique.

METHODOLOGY

The carbon nanotubes were synthesized from NiO via chemical vapour deposition (CVD) method (Singjai *et al.*, 2007). CNTs were milled for 3 hr to get rid of the agglomeration. To fabricate composites samples, firstly, the nanotubes were then weighed (vary from 0.1-1.0 vol%) and dispersed in water using ultrasonic technique for 2 hr. Secondly, the dispersed nanotubes were mixed with rubber in ultrasonic bath. Thirdly, the mixture was poured into plastic mould with a sample thickness of 1 mm. It is noted that mylar films were put at the upper and the lower of the samples in order to obtain a smooth surface on the both sides. Finally, the composite sample was left to settle at the room temperature for 2 days and then removed from the mould. Density of samples was measured by using Archimedes method. Composites samples were then cut into standard shape (Figure 1) to investigate mechanical properties. Tensile strength and maximum force of the samples were measured by the universal testing machine (Lloyd Instruments, LRX) with a cross-head rate at 50 mm/min. The hardness was tested by Durometer technique (Shore A). Furthermore, the microstructure of CNTs and CNTs composites was examined using SEM technique.

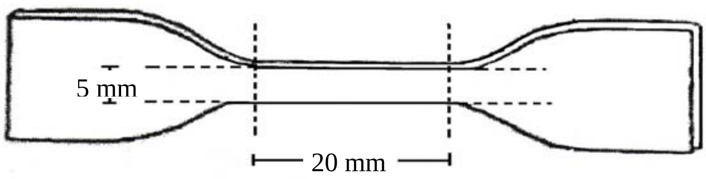


Figure 1 Schematic of standard sample for tensile testing.

RESULTS AND DISCUSSION

Figure 2 shows SEM micrograph of CNTs with the mean diameter of 68.21 nm. Figure 3 shows the photographs of casting rubber and casting CNTs/rubber composites. It can be seen that after mixing CNTs and rubber together, the color of rubber changed from grey to black which is the color of CNTs. Table 1 shows the physical and mechanical properties of CNTs/rubber composites. It is shown that quantity of CNTs is not significantly changed in density of composites (1.07-1.11

g/cm^3). It is may be due to adding quantity is too small. In the contrary, CNTs adding shown the significantly changed in mechanical properties, for example, tensile strength (19.34-10.90 MPa), toughness (135-85 N/cm^2) and hardness (54.1-70.0 type A). It can be noted that tensile strength and toughness of elastic rubber are decreased with increasing of CNTs. This is the effect of ceramics filler characteristics. However, the ceramics filler promote the hardness of rubber which is meaning the rubber is encourage its compressive property. Furthermore, SEM micrographs of the samples were shown in Figure 4. It has been seen that the dark phase and the bright are belong to rubber and CNTs phase, respectively. Besides, it is also found that rubber phase covered entirely of CNTs. It indicated that very good distribution and adhesion between CNTs reinforcement fiber and rubber matrix phase obtained from composites samples.

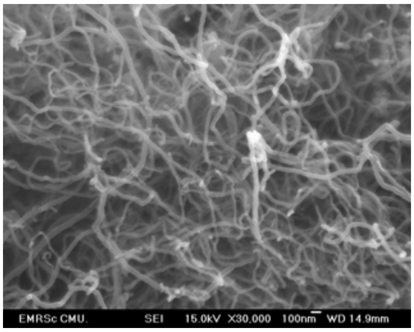


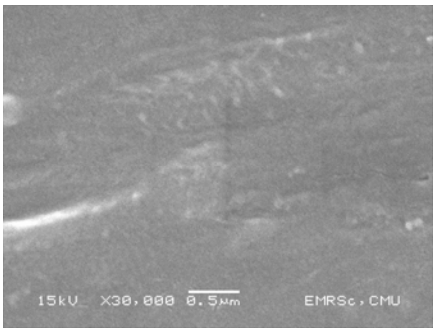
Figure 2 SEM micrograph of CNTs

(a) (b)

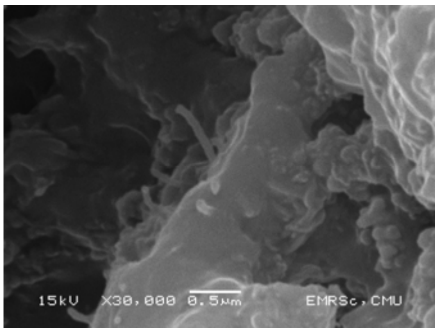
Figure 3 Photographs of (a) rubber and (b) CNTs/rubber composites

Table 1 The physical and mechanical properties of CNTs/rubber composites

CNTs (vol%)	Density (g/cm^3)	Tensile strength (MPa)	Toughness (N/cm^2)	Hardness (Type A)
0.0	1.10	19.34	135.00	54.1
0.1	1.08	16.26	116.25	55.3
0.2	1.11	17.60	117.50	55.5
0.3	1.10	17.80	115.00	58.8
0.4	1.08	16.20	105.00	59.5
0.5	1.11	16.60	100.00	61.7
0.6	1.08	17.66	108.75	63.5
0.7	1.10	18.20	123.75	63.8
0.8	1.07	16.60	105.00	66.8
0.9	1.07	16.00	108.75	66.9
1.0	1.08	10.90	85.00	70.0



(a)



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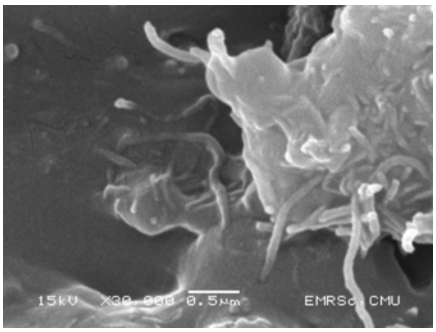
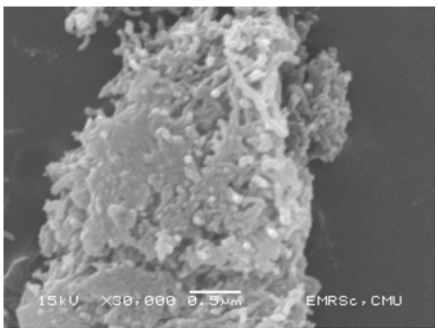


(c)



(d)

Figure 4 SEM micrographs of CNTs/rubber composites (a) 0 (b) 0.3 (c) 0.7 and (d) 1.0 vol%

CONCLUSION

CNTs/rubber composites were fabricated by using ultrasonic mixing and casting technique. The CNTs were used as reinforcement fiber to promote the mechanical property (hardness) of composites where as there is no significant change in weigh. The SEM results also revealed the well-dispersion of CNTs within rubber matrix.

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