Single-Walled Carbon Nanotube/Poly(methyl methacrylate) Composites for Electromagnetic Interference Shielding

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Single-walled carbon nanotube (SWNT)/poly(methyl methacrylate) (PMMA) composites were prepared using coagulation method. The electrical conductivity and the electromagnetic interference (EMI) shielding of SWNT/PMMA composites over the X-band (8–12 GHz) and the microwave (200–2000 MHz) frequency range have been investigated. The electrical conductivity of composites increases with SWNT loading by 13 orders of magnitude, from 10^{-15} to 10^{-2} Ω^{-1} cm^{-1} with a percolation threshold of about 3 wt% SWNTs. The effect of the sample thickness on the shielding effectiveness has been studied, and correlated to the electrical conductivity of composites. The data suggest that SWNT/PMMA composites containing higher SWNT loading (above 10 wt%) be useful for EMI shielding and those with lower SWNT loading be useful for electrostatic charge dissipation. The dominant shielding mechanism of SWNT/PMMA composites was also discussed. POLYM. ENG. SCI., 49:1627–1634, 2009. © 2009 Society of Plastics Engineers

INTRODUCTION

The electromagnetic interference (EMI) remains a technical challenge for many electrical and electronic devices to function properly. EMI tends to degrade the interception of signals and adversely affect the equipment performance. Hence, it is important to shield electrical and electronic devices over the EMI frequency spectrum to ensure the proper function. Conventionally, metal sheeting is used for this purpose; but seams commonly encountered in metal sheeting can cause radiation leakage and diminish the effectiveness of shielding. Polymer composites containing conductive fillers are attractive alternatives as EMI shielding material because seams are usually significantly reduced or completely eliminated [1, 2]. In addition, polymers possess general advantages of easy processing, low cost, lightweight, design flexibility, corrosion resistance, and ease of mass production comparing to metals [3–5]. Flexible conductive polymer composites may be used in various advanced technological applications such as lightning-protected aircraft composites panel, avionics line replaceable unit (LRU) enclosures, energy storage, antistatic packaging, electro-optical devices, plastics welding, various electronic pressure sensitive switches or sensors, and EMI shielding [6–10]. Polymer composites containing conductive polymers like polyaniline or polypyrole as EMI shields have been reported in the literature [11, 12], but their mechanical strength is often very poor. The use of carbon materials (e.g., graphite, carbon black, carbon fibers, carbon nanofibers) as fillers in polymer composites for EMI shielding has been extensively investigated owing to their unique combination of electrical, thermal and as they can significantly enhance the mechanical properties of composites [13–20].

Carbon nanotubes (CNTs) have received great attention since the first report by Iijima in 1991 [21]. A wide range of properties and potential applications of CNTs, such as the ballistic charge transport [22], field emission [23], molecular quantum wires [24], hydrogen storage [25], high thermal conductivity [26], gas sensors [27], and biomolecular recognition [28], have been reported. Exceptional structural, mechanical, electrical properties, much higher conductivities of carbon nanotubes when compared with conventional carbon fillers has drawn attentions towards their use in filled composites. However, it is the combination of the exceptional electrical and thermal conductiv-

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