Electrical and Thermal Conductivity and Tensile and Flexural Properties of Carbon Nanotube/Polycarbonate Resins

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ABSTRACT: Adding conductive carbon fillers to insulating thermoplastic polymers increases the resulting composite's electrical conductivity. Carbon nanotubes (CNTs) are very effective at increasing composite electrical conductivity at low loading levels without compromising composite tensile and flexural properties. In this study, varying amounts (2–8 wt %) of CNTs were added to polycarbonate (PC) by melt compounding, and the resulting composites were tested for electrical conductivity (1/electrical resistivity), thermal conductivity, and tensile and flexural properties. The percolation threshold was less than 1.4 vol % CNT, likely because of CNTs high aspect ratio (1000). The addition of CNT to PC increased the composite electrical and thermal conductivity and tensile and flexural modulus. The 6 wt % (4.2 vol %) CNT in PC resin had a good combination of properties for electrical conductivity applications. The electrical resistivity and thermal conductivity were $18 \, \Omega \cdot \text{cm}$ and 0.28 W/m $\cdot$ K, respectively. The tensile modulus, ultimate tensile strength (UTS), and strain at UTS were 2.7 GPa, 56 MPa, and 2.8%, respectively. The flexural modulus, ultimate flexural strength, and strain at ultimate flexural strength were 3.6 GPa, 125 MPa, and 5.5%, respectively. Ductile tensile behavior is noted in pure PC and in samples containing up to 6 wt % CNT. © 2010 Wiley Periodicals, Inc. J Appl Polym Sci 118: 2512–2520, 2010

Key words: composites; fillers; injection molding; nanocomposites

INTRODUCTION

Most polymer resins are electrically insulating. Increasing the electrical conductivity of these resins allows them to be used in other applications, such as static dissipative (e.g., handling trays used in electronic equipment assembly, etc.) and moderate electrical conductive (e.g., fuel gauges, etc.) applications. One approach to improve the electrical conductivity of polymer is through the addition of a conductive filler material, such as carbon and metal.1–14 Recently, carbon nanotubes (CNTs) have been used to increase the electrical conductivity of a resin.15–26 CNTs have many unique characteristics. For example, only a small amount of CNTs need to be added to a polymer to increase the composite’s electrical conductivity without decreasing the material’s mechanical properties and without significantly increasing the melt viscosity.

In this work, researchers performed compounding runs followed by injection molding of CNT filled polycarbonate (PC) resins. Composites containing varying amounts of CNTs were fabricated and tested for electrical and thermal conductivity, along with tensile and flexural properties. The goal of this project was to determine the effects of the CNTs on the composite thermal conductivity, electrical conductivity (1/electrical resistivity), and tensile and flexural properties.

MATERIALS AND EXPERIMENTAL METHODS

Materials

The matrix used for this project was Sabic Innovative Plastics’s (Pittsfield, MA) Lexan HF1130-111 PC resin. The properties of this polymer are shown in Table I.27

Hyperion Catalysis International’s (Cambridge, MA) FIBRIL™ nanotubes were used in this study.