Improvement of the Mechanical and Electrical Properties of Waste Rubber with Carbon Nanotubes

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ABSTRACT: The effect of carbon nanotubes (CNTs) on the stability of the mechanical and electrical properties of recycled waste rubber was experimentally investigated. The stress–strain curves of the composites were studied. The results show that the toughness, the area under the stress–strain curve, of the recycled rubber increased monotonically as a result of the addition of CNTs. The modulus of the nanocomposites increased by 28 times when only 5 wt % CNTs was added to the recycled rubber matrix. The effects of the cyclic fatigue and hysteresis for the composites were also examined. The strain energy density, dissipation energy, and linear damage accumulation versus the number of cycles are discussed for all of the samples. The analysis of the results showed that the strain energy density increased by 15 times at a CNT concentration of 5 wt %. The electrical properties were measured for all of the samples. The results indicate that the addition of CNTs to the recycled rubber improved its electrical conductivity by more than two orders.
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Key words: rubber; recycle; carbon nanotubes; mechanical; electrical

INTRODUCTION

Elastomers with a high electrical conductivity are critical for applications ranging from seals between pipes used for the transfer of flammable gases, electrostatic automotive painting, and electromagnetic shielding for mobile electronics. Traditionally, conductive fillers, such as carbon black, chopped carbon fiber, or metallic flakes are used.[1–3]

Carbon nanotubes (CNTs), as self-assembling nanostructures, have attracted a great deal of attention as model systems for nanoscience and for various potential applications, including composite materials, battery electrode materials, field emitters, nanoelectronics, and nanoscale sensors. The interest in CNTs stems from their unique structure and properties, including their very small size (down to 0.42 nm in diameter); the possibility of CNTs to be metallic or semiconducting, depending on their geometrical structure; their exceptional properties of ballistic transport; their extremely high thermal conductivity and optical polarizability; and the possibilities of high structural perfection.

The main purpose of introducing CNTs into polymer composites is to exploit the CNTs' inherent properties of stiffness, tensile strength, damping properties, flame resistance, and thermal and electrical properties.[4–9] Therefore, many efforts have been concerned with retaining the CNTs' large aspect ratio in the polymer matrix to achieve good interfacial stress transfer (surface modification) and to improve dispersion and alignment during composite processing.[10,11]

The reclamation of scrap rubber products, for example, used automobile tires and tubes, hoses, and conveyor belts, is the most desirable approach for solving their disposal problem. The recovery and recycling of rubber from used and scrap rubber products can, therefore, save some precious petroleum resources and solve scrap/waste rubber disposal problems. For such an approach, the aim of this study was to examine the effect of CNTs on the stability of the mechanical and electrical properties of recycled rubber.

EXPERIMENTAL

Car tire waste rubbers were collected. These tires were washed by distilled water and acetone many times to remove any dust and other wastes from them, and then, they were left it in sunlight inside a homemade glass room to dry completely. The collected waste rubbers were subjected to degradation by oxygen and ozone; this resulted in the characteristic cracking shown by very old rubber products. The cracking was accelerated by heat and

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