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Ravikumar Vijayan, Ali Ghazinezami, Sean R. Taklimi, Moheimin Khan, Davood Askari

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The Geometrical Advantages of Helical Carbon Nanotubes for High-Performance Multifunctional Polymeric Nanocomposites

Ravikumar Vijayan, Ali Ghazinezami, Sean R. Taklimi, Moheimin Khan, and *Davood Askari

Multifunctional Nanocomposites Lab
Department of Mechanical Engineering, Wichita State University
1845 Fairmount, Wichita, KS 67260-0133

*Email: davood.askari@wichita.edu ; Office Phone: (316) 978-6455

1. ABSTRACT

Polymer Matrix Composites (PMCs) with their low densities exhibit remarkable material properties, making them as an excellent choice for high-performance structural applications. However, the polymer matrix used to bond the fibres are very weak and exhibit poor mechanical properties. The focus of this study was to take advantage of the unique helical (i.e., coil-like) geometries of Carbon Nanotubes (CNTs) to improve the properties of polymer matrix, more effectively and at very low concentrations (e.g., less than 0.2% by weight to reduce the nanomaterials' cost). One of the unique characteristics of the helical CNTs is their 3-dimensional helical geometry that can physically intertwine/ entangle/interlock with traditional microfiber reinforcements and be mechanically interlocked within the solidified resin system, when they are used as reinforcements in polymeric composites. Nanocomposite samples were fabricated using CNTs with different geometrical configurations (i.e., straight and helical) and loading percentages and their properties (e.g., mechanical, thermal, and electrical) were evaluated according to the ASTM standards. Based on the results, the optimum weight percentage of the CNTs reinforcements that exhibit maximum properties improvements for the matrix system were identified, considering their geometrical configuration. The main objective here was to demonstrate/prove that helical structures of CNTs can perform better than straight CNTs, because of their 3-D helical interlocking mechanism. The 2nd objective of this work was to demonstrate/proof that inclusion of CNTs with various geometries in polymeric resins can improve their electrical and thermal conductivities, as well, even at low concentrations.

Keywords: Straight Carbon Nanotubes, Helical Carbon Nanotubes, Multifunctional Nanocomposites, Material Properties, Testing and Characterization