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Controlling the Wettability and Adhesion of Carbon Fibers with Polymer Interfaces via Grafted Nanofibers

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Abstract

Interfacial properties in carbon fiber composites is one of the key parameters controlling their structural functionality. Here, we introduce a novel method to engineer carbon fiber-epoxy interfaces, via inclusion of nanofibers, towards higher interfacial strength and energy dissipation. In our method, stabilized polyacrylonitrile (PAN) nanofibers are grafted onto carbon fibers via electro-spinning process, followed by nanofiber consolidation via solvent vapor and thermal treatment. These treatments partially dissolves nanofibers along the nanofiber-fiber interface and trigger entropic elasticity in nanofibers, thus, increasing the nanofiber-fiber interactions. The hybridization of carbon fibers with PAN nanofibers increased the interfacial shear strength (IFSS) by ~48%, from 10.8±2.6 to 15.9±4.9 MPa. Postmortem fractography points to mechanical interlocking between nanofibers and epoxy and reinforcing effects of nanofibers in matrix as root causes of IFSS enhancement. As a result of adding nanofibers to carbon fiber, junction failure mode changes from a dominantly adhesive failure (at epoxy-fiber interface) to dominantly cohesive failure, and failure plane slightly shifts away from epoxy-fiber interface to within the epoxy. Compared to other types of whiskers grown on carbon fibers, such as CNTs, the method proposed here requires low temperatures (below 300°C), during which no surface damages are expected to accumulate on carbon fibers.

Keywords: Hybrid composites, Polymer-matrix composites (PMCs), Interface, Electro-spinning, Fiber/matrix bond