Controlling Interphase Formations in Polymer/Nano-Carbon Composite Fibers for Improving Mechanical Performance

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Abstract

Controlling the structural development in the interphase regimes during composite processing is necessary in order to improve stress transfer between polymer matrices and nano-fillers. Shear-crystallization and gel-spinning under flow were combined to fabricate polymer/nano-carbon composite fibers with controlled interphase structure. Interfacial crystallization of the polymer in the vicinity of the nano-carbon was controlled by tailoring the degree of polymer under-cooling during the composite solution preparation and the flow parameters of spinning. The resultant fibers demonstrate superior tensile strength, modulus, and toughness properties. For example, poly(vinyl alcohol) (PVA)/SWNT fibers were spun with tensile strength, modulus, and toughness of 4.9 GPa, 128 GPa, and 202 J/g, respectively. X-ray diffraction/scattering was used to show that interfacial polymer crystal structure is distinct from the semi-crystalline bulk polymer matrix. The results show that the polymer interfacial regions around the nano-carbon have denser crystalline chain-packing and more extended-chain structure, which are key micro-structural components for producing composite materials with exceptional axial mechanical properties. This work highlights these unique polymer processing methods for nano-composites in order to tailoring the polymer morphology within interphase structures.