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Multi-scaled reinforcement in ternary epoxy composite materials: Dispersion and Electrical Impedance study

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Abstract

The following study, is focused on developing a ternary epoxy based composite material by the combined inclusion of two types of carbon fillers. The selected fillers (i.e. multi-walled carbon nano-tubes, MWCNTs and carbon black, CB), were dispersed using high speed shear mixing while the effect of dispersion duration, filler type and weight contents was studied using Impedance Spectroscopy (IS), fracture toughness tests and Dynamic Mechanical Thermal Analysis (DMTA). SEM was also employed in order to qualitatively assess the dispersion quality by means of mean agglomerate size and identify the fracture mechanisms. IS results indicated an inverse dependence between the magnitude of impedance and the dispersion duration. The decrease of the impedance with increasing dispersion duration was attributed to the formation of the conductive network. The synergistic effect between the two fillers was evident in the more rapid decrease in the maximum imaginary impedance values followed by a concurrent shift of the observed peaks towards higher frequencies with increasing dispersion duration. The synergy of the two fillers was also evident in the superior fracture toughness and thermomechanical performance of the ternary composites. The SEM micrographs revealed that the fracture surfaces of the ternary composites combined all the fracture mechanisms observed on the respective binary composites i.e. particle pull-out, crack bifurcation and pinning. DMTA revealed a significant increase in the storage modulus while glass transition temperature was marginally affected. Overall, the formation of the hybrid conductive network resulted in ternary composite materials with improved electric, mechanical and thermomechanical performance.