Nanotechnology Letters

Extended Abstract

Vol. 4, Iss. 2

2019

# Nanotechnology & Smart Materials 2018: Tailoring the properties of structural adhesives and fibre reinforced plastics using nanoadditives - A Ivankovic - University College Dublin, Ireland

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This work examines the effects of nano-additives, including core-shell rubber (CSR) nanoparticles, silica nanoparticles, multi-walled carbon nanotubes (MWCNTs), graphene nanoplatelets and their hybrid combinations on the mechanical properties, electrical conductivity and fracture toughness of epoxy based structural adhesives and carbon reinforced plastics (CFRPs). The addition of CSR nanoparticles significantly increased the fracture toughness of epoxies with the main toughening mechanisms being rubber cavitation followed by plastic void growth and shear band yielding. For example, the addition of 30 vol% CSR nanoparticles increased the fracture energy of a structural adhesive joint by over ten fold. However, the addition of CSR nanoparticles reduced the mechanical properties, i.e. stiffness of the modified resin. Hybrid nano-composites where silica/CSR nanoparticles were mixed into the resin at appropriate ratios eliminated this problem and a good balance between the toughness and mechanical properties is achieved i.e. nano-composites with a fracture energy five times that of the unmodified epoxy were obtained with no discernible drop in mechanical properties. The addition of a small amount of MWCNTs/graphene yielded reasonable increase in the fracture energy of epoxy. However, the agglomeration of MWCNTs/graphene at a higher concentration resulted in decrease in the mechanical properties and fracture toughness. Excellent electric conductivity was obtained for adding only a small amount of MWCTNs/graphene (<0.5%) in the epoxies. The incorporation of MWCNTs to bulk epoxy and CFRPs moderately increased the mode-I fracture energy, and significantly increased the mode-II fracture energy, i.e. the average mode-II fracture energy of CFRPs increased from 2026 J/m2 to 5491 J/m2 due to the addition of 1 wt% MWCNTs. The superior toughening performance of MWCNTs in mode-II fracture is attributed to two reasons: 1) increased MWCNT breaking and crack deflection mechanisms under shear load, and 2) large fracture process zone accompanied with extensive hackle markings and micro-cracks ahead of the mode-II crack tip of CFRPs, which resulted in significant number of MWCNTs contributing to toughening mechanisms.

This work is partly presented at EuroSciCon Conference on Nanotechnology & Smart Materials, October 04 -06, 2018 held at Amsterdam, Netherlands