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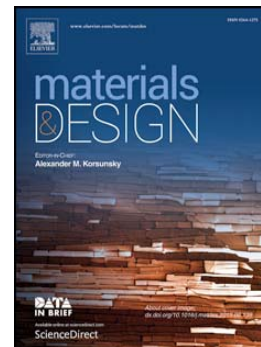
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Multifunctional Properties of Epoxy Nanocomposites Reinforced by Aligned Nanoscale CarbonRaj B. Ladani¹, Shuying Wu¹, Anthony J. Kinloch², Kamran Ghorbani¹, Jin Zhang³Adrian P. Mouritz¹, and Chun H. Wang^{1*}¹Sir Lawrence Wackett Aerospace Research Centre, School of Engineering, RMIT University, GPO Box 2476, Melbourne, VIC 3001, Australia.²Department of Mechanical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, U.K.³Institute for Frontier Materials, Deakin University, Geelong Waurn Ponds Campus, VIC 3220, Australia**Abstract**

The present paper compares improvements to the fracture energy and electrical conductivity of epoxy nanocomposite materials reinforced by one-dimensional carbon nanofibres (CNFs) or two-dimensional graphene nanoplatelets (GNPs). The effects of the shape, orientation and concentration (i.e. 0.5, 1.0, 1.5 and 2.0 wt%) of nanoscale carbon reinforcements on the property improvements are presented. Alignment of the nano-reinforcements in the epoxy nanocomposites is achieved through the application of an alternating current (AC) electric-field before gelation and curing of the epoxy resin. Alignment of the nano-reinforcements increased the electrical conductivity and simultaneously lowered the percolation threshold necessary to form a conductive network in the nanocomposites. Nano-reinforcement alignment also increased greatly the fracture energy of the epoxy due to a higher fraction of the nano-reinforcement participating in multiple intrinsic (e.g. interfacial debonding and void growth) and extrinsic (e.g. pull-out and bridging) toughening mechanisms. A mechanistic model is presented to quantify the contributions from the different toughening mechanisms induced by CNF and GNP nano-reinforcements on the large improvements in fracture toughness. The model results show that one-dimensional CNFs are more effective than GNPs at increasing the intrinsic toughness of epoxy via void growth, whereas two-dimensional GNPs are more effective than CNFs at improving the extrinsic toughness via crack bridging and pull-out.

Keywords: Nanocomposite, Electrical conductivity, Fracture toughness, Modelling,**1. Introduction**

Thermosetting polymers, such as epoxies, are used in a wide range of fibre reinforced composite and coating applications. Despite having many desirable properties, unmodified epoxies typically have low toughness and electrical conductivity. Nanoscale carbon-based reinforcements, such as graphene nanoplatelets (GNPs) [1–3], carbon nanotubes (CNTs) [4–6] and carbon nanofibres (CNFs) [7–10], have been used to increase the toughness and electrical conductivity of commercial epoxies. In addition, carbon-based nano-reinforcements

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