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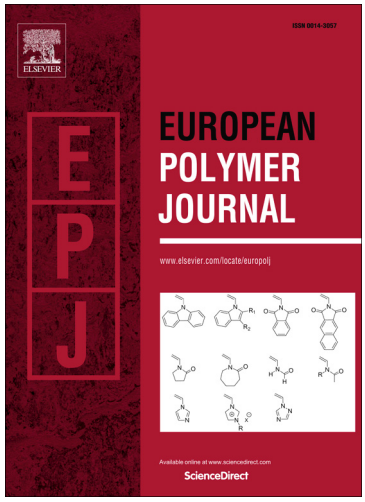

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Ashraful Alam, Chaoying Wan, Tony McNally

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Surface amination of carbon nanoparticles for modification of epoxy resins: plasma-treatment vs. wet-chemistry approach

Ashraful Alam[1], Chaoying Wan[2*], Tony McNally[2]

[1, 2] School of Engineering, University of South Australia, SA5095, Australia

[2.] International Institute for Nanocomposites Manufacturing, WMG, University of Warwick, UK, CV4 7AL

*Corresponding author, E-mail: chaoying.wan@warwick.ac.uk

Abstract

Composites of polymers and nanoparticles continue to find increasing applications from biomedical to electronics to transport systems. Nanostructured carbon materials (CNPs) having geometries from zero dimension (0D) to 3D are important functional additives for polymers, having great potential to produce composite materials with a range of enhanced properties including mechanical, optical, electrical and thermal. However, these possibilities have not been fully realised due to the difficulties associated with CNP dispersion in and their interaction with polymer matrices across the length scales. The surfaces of CNPs are intrinsically chemically inert and hydrophobic, and they tend to form agglomerates or bundles. Therefore, surface functionalisation of CNPs becomes a critical pre-requisite in the fabrication of polymer nanocomposites. Various functionalisation methods have been developed including, chemical, mechanochemical, electrochemical, and irritation reactions in order to activate the carbon surface, which subsequently interact with polymers through covalent bonding or non-covalent interactions. Wet-chemistry methods consume large amounts of organic solvents, hazardous chemicals, require multi-step purification with typically low yields. Mechanochemistry techniques such as ball milling can produce edge-functionalised CNPs at the expense of reduced aspect ratio. In contrast, cold plasma treatment offers a simple, clean, solvent-free, and scalable technique for modifying CNPs with variable functional groups. Recent developments in plasma-treated CNPs have driven its applications extensively in epoxy-based composites. Amino-functionalisation of CNPs is particularly favourable, as the amine group offers a rich reaction platform to enhance the activity of the CNP as both modifier and crosslinker for epoxy resins. Research activity in this area is under development but growing rapidly. In this review, we introduce the working mechanism for plasma functionalisation of CNPs, and compare this approach with the efficiency and effectiveness of wet-chemistry methods. The discussion will focus on amine-functionalised CNPs (carbon nanotubes, graphene/GO and carbon fibre) and their use in the modification of the properties of epoxy resins.

Keywords: Plasma; surface modification; carbon nanoparticles; epoxy resin; nanocomposites