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Enhancing the mechanical performance of multifunctional carbon fibre reinforced polymer/carbon nanotube composites

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ABSTRACT

Polymer nanocomposites containing conductive carbon-based nanostructures open a new horizon for carbon fibre reinforced polymer (CFRP) composites in functional and smart applications. Carbon nanotubes (CNTs) are known for their unusual physical properties, including elastic modulus (1 TPa), tensile strength (up to 60 MPa), thermal conductivity higher than 3000 $W.m^{-1}.K^{-1}$, and electrical conductivity from 10^6 to 10^7 $S.m^{-1}$ [1]. These attributes offer CNTs great potential for developing CFRP composites with enhanced fracture toughness, impact resistance or delamination strength. However, when used in polymer-based composites, their intrinsic properties are severely restricted by the dispersion state and by the interfacial bonding with the matrix. Although a homogeneous dispersion and distribution of CNTs is desirable to maximize performance, it remains a challenge due to the strong van der Waals interactions, and lack of chemical functionalities at the surface that creates weak interfaces with most of common polymers. Therefore, chemical modification of CNTs by non-covalent or covalent approaches has been widely exploited [2, 3].

In this work, as-received and functionalized CNTs were incorporated in a resin based on diglycidylether of bisphenol A, which was then reinforced with carbon fibres by means impregnation strategies. Functionalization of CNTs was conducted *via* 1.3 dipolar cycloaddition (DCA) of azomethine ylides generated *in-situ* by thermal condensation of an amino acid and an aldehyde, at 250 °C for 3 hours, according to Figure 1 [4].

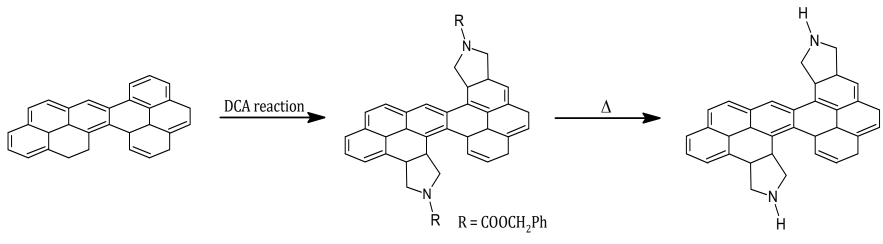

Figure 1: Schematic representation of the functionalization route of CNTs *via* 1.3 dipolar cycloaddition [4].

The dispersion state of CNTs attained during mixing was evaluated at different length scales, by either optical microscopy or transmission electron microscopy. The mechanical and electrical performance of modified epoxy-based nanocomposites was also investigated, and correlated with the dispersion degree. Afterwards, pre-impregnated materials were prepared using a laboratory drumwinder, under optimized processing conditions, and converted into CFRP laminates using an

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autoclave. Specimens were characterized by different techniques in order to study the influence of as-received and functionalized CNTs on the transversal tensile properties or mode-I interlaminar fracture toughness (G_{IC}), and some of these results are depicted in Figure 2.

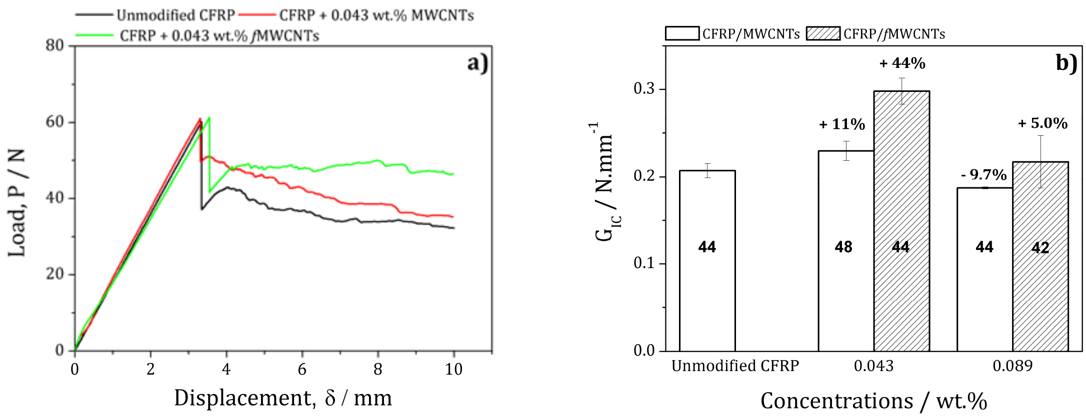

Figure 2: Representative load *vs* displacement curves a) and mode-I interlaminar fracture toughness (G_{IC}) b), respectively.

The interlaminar fracture toughness (G_{IC}) was determined at the propagation crack plateau of the R-curves until a steady-state valued is reached. After the incorporation of only 0.043 wt. % of as-received and functionalized MWCNTs, G_{IC} increases 11 and 44 %, respectively. These results evidence that an effective interface was achieved by 1.3 dipolar cycloaddition, suggesting that MWCNTs can be used as effective reinforcements in the midplane of CFRP composites.

References

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