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Method for Dispersion and Orientation of Carbon Nanotubes and Fibrils in PMMA

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Carbon nanotubes have attracted considerable scientific attention because of their unique physical properties. They have diameters of 1.2 - 1.4 nm and are tens of microns long. Compared with carbon fibres, which typically have a Young's modulus of ~600 GPa, the elastic modulus of carbon nanotubes have been measured to be approximately 1 - 2 TPa [1]. Carbon fibrils are sized somewhere in-between carbon fibres and nanotubes (200 nm diameter, hundreds of microns long). One of the goals of composite scientists is to achieve the best reinforcing levels of fibres within the matrix in terms of mechanical properties. Carbon fibrils and nanotubes offer an attractive alternative to carbon fibres because of their small size and large aspect ratio. This means that nanocomposites using these particles can be processed into intricately shaped components using simple processing methods (unlike long fibres) and yet have a high enough aspect ratio to achieve good stress transfer. The aim of the study was to produce a better composite, in terms of improved mechanical performance and ease of fabrication compared with those currently available.

Nanocomposites comprising of different weight percentages of carbon nanotubes and fibrils in a high impact PMMA matrix have been fabricated using polymer extrusion and injection moulding techniques. The carbon materials were first dispersed in the matrix using a dry powder mixing method. SEM and TEM micrographs show that the carbon materials have been well dispersed over the PMMA particles in the dry powder pre-mix, and that the final specimens contain well distributed and aligned carbon nanotubes and fibrils. The nanocomposites have been mechanically tested using tensile and impact testing techniques. Comparisons were made between nanocomposites with different sizes of PMMA particles, different weight percentages of reinforcement and the different types / geometry of reinforcements.

It will be shown that the failure strain, energy-to-break, modulus and tensile strength have been improved significantly. Raman spectroscopy has been used to map the change of orientation of the nanotubes and fibrils within the nanocomposites and to follow the stress-induced Raman peak shift. In this way, the load transfer efficiency of the reinforcements has been demonstrated. We believe that this method for the dispersion and orientation of the carbon nanotubes and fibrils in a polymer matrix can be used for the manufacture of outstanding engineering composites.

Reference

1. Salvetat, J. -P., Bonard, J. -M., Thomson, N.H., Kulik, A.J., Forró, L., Benoit, W., Zuppiroli, L., Mechanical Properties of Carbon Nanotubes, *Appl. Phys. A*, 69 (1999) 255