Graphene-polycarbonate composites: tailoring electrical and mechanical properties

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Abstract

Graphene, a monolayer composed of sp^2-hybridized carbon atoms in a 2-dimensional honeycomb lattice, is one of the most investigated material in the last years due to its excellent properties [1]. In this view, exploiting its outstanding properties for the preparation of the polymer-based graphene nanocomposites is some of the most scientifically promising efforts [2]. Despite the rapid developments of the macromolecule or inorganic matrix-based hybrid materials, there are still numerous challenges and open subjects in the field of the production and up-scaling of these materials to unfold their full performances [3].

In this work, we exploit graphene flakes, produced by liquid phase exfoliation (LPE) of natural graphite flakes [4-5], applied as filler in a polycarbonate (PC) matrix. The exfoliation process was carried out dispersing graphite in N-methyl-2-pyrrolidone (NMP) by means of ultra-sonication [5,6,7]. Then the dispersion was ultra-centrifuged at 17,000g using sedimentation-based separation to remove un-exfoliated graphite and thicker flakes. After the ultra-centrifugation step, a solvent-exchange process was carried out with the graphene flakes re-dispersed in a more environmentally friendly solvents (being non-halogenated and non-aromatic), *i.e.* cyclopentanone or dioxolane, which are the same solvents used for the dispersion of the PC pellets (Fig. a). The graphene (Fig. b) and PC dispersions were mixed together by ultra-sonication allowing a thorough mixing of graphene flakes and the PC, keeping the graphene filler contents at low loadings (<5%). The resulting dispersion (Fig. c) is then pelletized by pouring to water, which precipitates the polymer-graphene hybrid. Finally, the pellets were compressed to form films (Fig. d) using compression molding. Solution blending can be an easier and cheaper alternative than melt blending, for the realization of polymer-composites, which requires additional steps for the thermal treatment.

Morphological and structural measurements were performed on the PC/graphene composite samples using atomic force, scanning electron microscopies, and Raman spectroscopy analysis, respectively proving the presence of the graphene flakes in the PC matrix. Mechanical tests and electrical conductivity measurements were carried out to investigate the effect of low loading of graphene for the reinforcement of these physical properties, comparing to the pristine PC, *i.e.* the elastic modulus improved to 26% with 1% graphene content. The as-produced polycarbonate-based hybrid materials can be ideal substrates for 3D printing applications.

References

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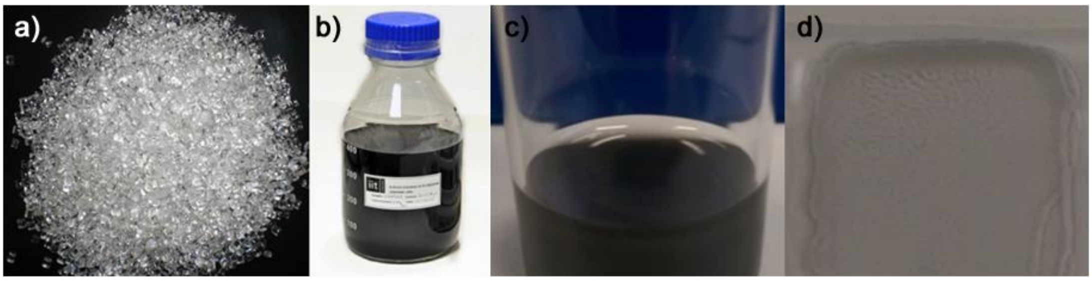

Figure: (a) PC pellets, (b) graphene dispersion, (c) graphene/PC composite dispersion and (d) the graphene/PC composite film.