Aqueous suspensions of few-layer graphene for composite thin films

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Abstract

In the last decade graphene has emerged as an exciting material revealing potential applications in various fields including in the polymer nanomaterials science. [1]

The most commonly used method to produce graphene in large scale is through oxidation of graphite followed by exfoliation and reduction of the oxidation products. However, this method leads to the production of graphene with structural defects and remaining oxidation, and thus with lower electrical and mechanical properties compared to graphene. [2] Liquid-phase exfoliation of graphite is another mass-scalable approach for the production of graphene, [3] typically using organic solvents and application of shear. Still, the use of large volumes of organic solvents has negative environmental consequences.

Alternative approaches to produce good quality graphene by graphite exfoliation using “green” solvents such as water are thus necessary. Recently, the production of graphene based on graphite exfoliation through non-covalent interactions with pyrene derivatives was reported. [4,5] This approach was used for the exfoliation and stabilization of graphene in water, leading to the production of few- and single-layer graphene without structural damage. The suspension of graphene in water allows its easy mixture with water-soluble polymers and with polymers that form stable suspensions in water.

Waterborne polyurethane (WPU) is a synthetic polymer used as high quality surface coating, providing an environmentally friendly process without emission of volatile organic compounds (VOCs). The potential applications of waterborne polyurethane/ graphene thin films in antistatic coatings, electromagnetic shielding and corrosion-resistant coatings have been reported. [6-10]

The present work reports the preparation of stable aqueous suspensions of few-layer graphene and highly exfoliated graphite using solutions of pyrene derivatives at low concentration, and the production of thin films of WPU/ few-layer graphene at low loading level (from 0,025% to 0,5% wt). The aqueous suspensions of few-layer graphene were analyzed by UV-Visible spectroscopy. The graphene and exfoliated graphite-based materials were deposited on substrates and characterized by Raman spectroscopy. The nanoparticles were observed by scanning transmission microscopy. The mechanical properties of the composite films were measured by tensile testing showing an increase of the Young´s modulus up to 39%. Figure 1a presents the Raman spectra of graphite GnP and few-layer graphene obtained by exfoliation with a pyrene derivative (PY XGnP), illustrating a downshift of the 2D band at 2702 cm^{-1} (532nm laser), consistent with the occurrence of exfoliation. Figure 1b shows scanning transmission electron microscopy image of the few-layer graphene flakes obtained. Other relevant coating properties were investigated, such as thermal stability and water vapor permeability.

Acknowledgement

The authors acknowledge FCT, project PEst-C/CTM/LA0025/2011 and PhD grant SFRH/BD/87214/2012.

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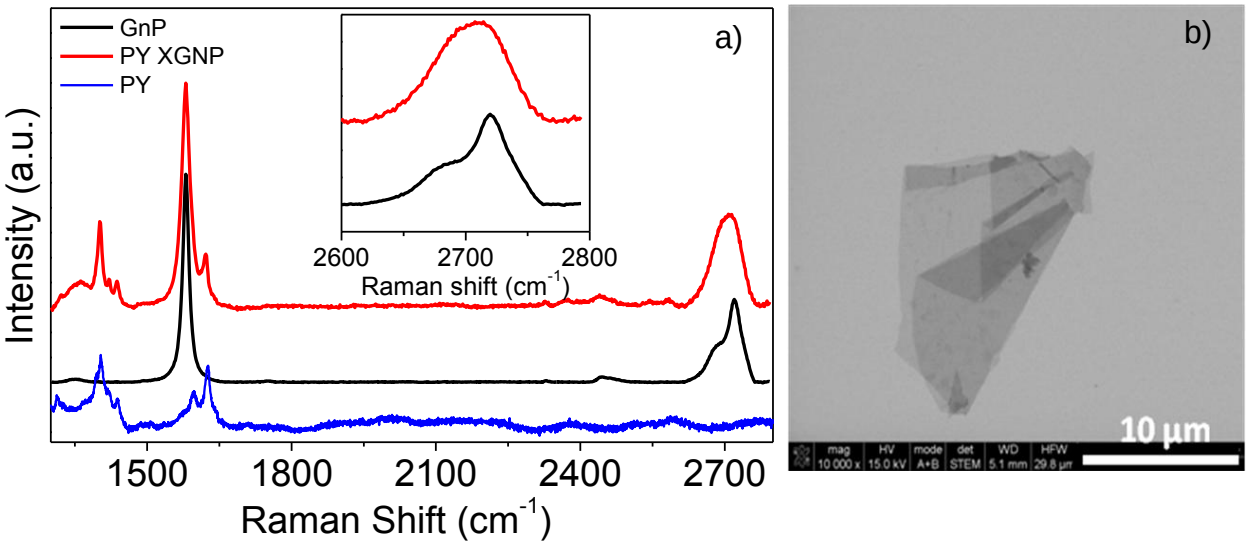

Figure 1: a) Raman spectra of pristine graphite (GnP) and few-layer graphene (PY XGnP), obtained by exfoliation with a pyrene derivative (Py) in aqueous suspension; b) scanning transmission electron microscopy image of few-layer graphene.