Graphene oxide/Nanoparticle Hybrid Materials: Simple and Fast Route to Obtain Supported Metal Nanostructures for Energy Applications

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Abstract

The chemical functionalization of the graphene oxide allowed the in situ growth of highly dispersed metal nanoparticles.

Introdução

The unique and extremely attractive chemical and physical properties which have been exhibited by the graphene have boosted their use in several fields such as photonics, electronics, sensors, catalysis and energy applications[1]. Recent reports have also shown that the combination of graphene and its derivatives with other nanomaterials like metal and metal oxide nanostructures offers a huge number of additional properties and functions that greatly increase their potential applications. Such improvements are mainly related to synergistic properties that arise from the effective interactions among the components that are not present on each isolated component. This work describes the chemical functionalization of graphene oxide (GO) with a bipyridinium-derived cationic alkoxysilane (BP) and the subsequent in situ growth of highly dispersed noble metal nanoparticles in a quite simple and fast route that lasts around 10 minutes. The developed route allows the synthesis of graphene oxide-nanoparticle hybrid materials in many configurations such as suspensions, thin films, membranes and 3D porous structures.

Resultados e Discussão

The GO used in this work was prepared by the modified Hummers method. The synthetic route for the preparation of the supported metallic nanostructures was carried out in 3 sequential steps: (i) the functionalization of GO sheets with BP; (ii) adsorption of the metallic precursor through ion-exchange reaction and (iii) chemical reduction with $NaBH_4$. TEM of the resulting hybrid materials can be observed in **Figure 1(a)** and **(b)**.

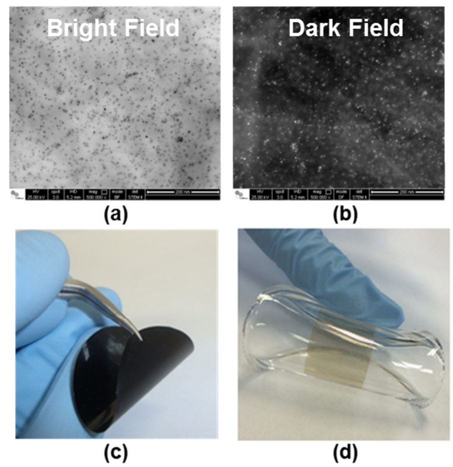

Figure 1. (a) Bright and **(b)** dark field STEM[§] images of Au nanoparticles supported on GO/BP thin films deposited on microscopy copper grids; (c) GO free-standing membrane and (d) GO thin film on PDMS which can be used for the synthesis of metallic nanostructures. [§]Scanning electron microscopy (transmission mode)

The synthetic route was applied for GO in several configurations such as free-standing membranes (Figure 1**(c)**), thin films on glassy and polymeric substrates (Figure 1**(d)**) and porous 3D structures. TEM images clearly show the presence of well dispersed metallic nanoparticles, homogeneous in size and stabilized on the GO surface.

Conclusões

The developed strategy has shown to be a simple and powerful tool to obtain graphene-oxide/nanoparticle hybrid materials with the metallic nanostructures highly dispersed and stabilized on the surface.

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[1] Ferrari, A. C. et al, *Chem. Rev.* **2015**, *7*, 4598.