Synthesis and characterization of gold nanoparticles/graphene hybrid materials

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Abstract

In recent years, graphene has been utilized as a support material to anchor a large variety of nanoparticles including noble metals such Pt, Au, Pd and oxides such TiO_2, ZnO and CeO_2[1]. Such composites are expected to have superior electronic or optical properties[2]. Gold nanoparticles (AuNP) are one of the most interesting nanostructures, having found many applications in fields such as medicine, sensors, and catalysis. Due to their small size, these particles show some properties that differ from those of the bulk. Among those properties, the presence of a surface plasmon band in the visible region of the electromagnetic spectrum makes these materials suitable for many attractive applications in catalysis, optics and nanobiotechnology[3]. For these applications, an optimization of the gold particle size, the distribution of particle sizes and their dispersion on the graphene surface is desirable.
In this communication, we report the synthesis and characterization of gold nanoparticles dispersed on few layer graphene (FLG) wherein we have compared a number of deposition methods. Different graphene derivatives such as purified FLG flakes (GP), functionalized FLG (FGP), defunctionalized FLG (DFGP), N-doped FLG (NGP) and fully oxidized graphene (GO) have been investigated as support. All the supports were prepared by in house CVD process by the catalytic decomposition of ethylene[4]. Nitrogen doping was carried out using a mixture of ethylene and ammonia as precursors. The FLG flakes were purified by dissolving the catalyst in 35% HCl at 25°C and characterized by SEM, TEM and Raman spectroscopy. Nitrogen doping was confirmed by chemical analysis and XPS. Prior to gold deposition, the surfaces of the FLG were functionalized by boiling in 65% HNO_3 at 120°C for 3-6h (FGP). The extent of functionalization was determined by the Boehm's titration and XPS.
From the several methods available for the preparation of AuNP on graphene derivatives we have chosen the following ones: a) a modification of the literature sonolytic method[5], which consists in the sonication of the support and the Au salt in aqueous suspensions, b) an impregnation/reduction method developed by us, and c) the simple mixing of pre-synthesized AuNP with the support. The size and dispersion control of the AuNP were assessed from TEM images. The interaction between the gold nanoparticles and the support was further investigated using Raman analysis. Nitrogen doping was found to have a strong influence on the particle density and size distribution (Fig.1).Very fine particles in the size range of 1-3 nm were observed even though some particles were much bigger in size even up to 20 nm.

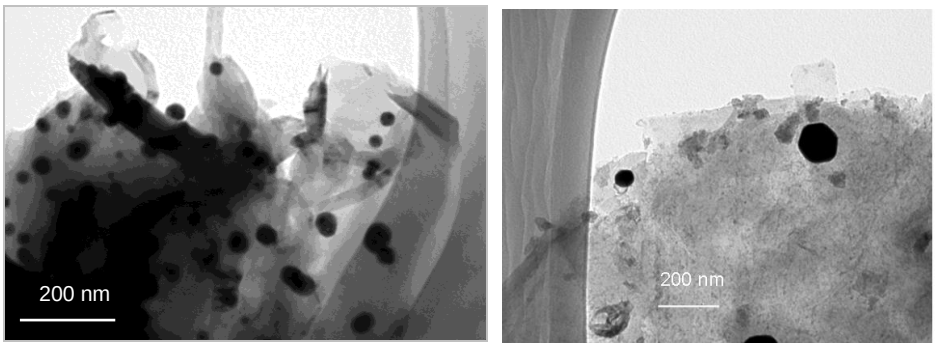

Figure 1. Gold particles deposited on FGP (left) and NGP (right)

References

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