Synthesis and characterization of graphene-Ag nanoparticles hybrids

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Abstract

Graphite is a 3D form of carbon with a sheetlike structure. Within each layer, the carbon atoms are arranged in a hexagonal pattern through σ bonding involving sp^2 hybridization. The layers are held together by weak van der Waals forces. Due to the weak coupling-layered structure, graphite can be intercalated with certain atoms, molecules, and ions to form graphite intercalated compounds. Depending on the intercalated substance, the bonding between the carbon atoms and the intercalate can be covalent or ionic. Grafite oxide (GO) is the typical substance where the bonding is covalent. Graphene sheets can be obtained by chemical reduction of GO. Graphene, a single-layer sheet of sp^2-hybridized carbon atoms with high surface area and superior mechanical and electrical properties, provides and extraordinary platform for preparing composite nanomaterials [1,2]. Especially, the fabrication of graphene-metal particle nanocomposites is of significant interest due to their potential applications in catalysis, chemical sensing, surface enhanced Raman scattering (SERS), and battery electrodes [3,4].

In this communication, we report the synthesis of graphene-silver nanoparticles hybrids using graphene oxide (GO) in different alkaline environments by a simple one step hydrothermal method in the absence and the presence of an eco-friendly and nontoxic reducing agent, ascorbic acid, at moderate temperatures 40-100ºC. The thermal reduction of graphene oxide in the absence of silver precursor was also studied. The influence of the kind of alkali, NaOH and NH_4OH, on the formation of silver nanoparticles (AgNPs) was examined, as well as the presence of the reducing agent. The morphology and structure of the obtained materials were examined by UV-Vis and Raman spectroscopy, FT-IR, XRD, XPS, TEM and thermogravimetric analysis (TGA). The formation of AgNPs on GO sheets was monitored with UV-Vis spectroscopy by measuring the absorbance at definite time intervals at ~ 400 nm. The spectra showed the formation of nanometer-sized Ag particles and the reduction of the GO sheets. The formation of the AgNPs was indicated by the surface plasmon resonance peak of the AgNPs at around 400 nm. In the absence of reducing agent, the rate of AgNPs formation was faster with NaOH than with ammonia, whereas the presence of ascorbic acid led to a significant increase of the rate of AgNPs formation. The Raman spectra showed that the peak intensities of the D band and G band for the hybrids increased in comparison to the GO, which is attributed to the surface enhanced Raman scattering of AgNPs. The X-ray diffractograms and the XPS spectra of the composites indicated that the AgNPs were composed of pure crystalline silver. The generation of metallic silver nanostructures revealed by UV-Vis absorption spectroscopy, XPS and XRD was confirmed through direct observations by TEM. The graphene sheets were decorated randomly by AgNPs. The nanoparticles showed rounded shapes and different sizes.

References

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