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Synthesis, Study and Applications of Graphene Materials

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Extended Abstract

Different graphene materials attract great attention of scientists and technologists all over the world. Such materials are used in electronics, adsorption, catalysis and photocatalysis, sensors, batteries, composite materials, medicine, *etc* [1-6].

It is shown herein that the interaction of natural graphite with solutions of $(NH_4)_2S_2O_8$, $K_2S_2O_8$, $H_2S_2O_8$ or H_2SO_5 in sulphuric acid results in the formation of peroxosulfate graphite intercalation compounds that are able to expand at low temperature (20-60 ^oC). These expanded graphite intercalation compounds (EGICs) are composed of weakly bonded graphene nanoplatelets (GNPs), which can be easily exfoliated via different methods. Ultrasonic exfoliation is the most straightforward technique. Depending on sonication conditions, few- or multi-layered GNPs can be obtained (with or without using surfactants, respectively). They contain surface oxygen groups. The other way of EGIC exfoliation is through mechanical-chemical treatment.

To obtain GNPs with non-oxidized surface, EGICs were processed using ammonia. Due to the highly exothermic reaction of acidic EGIC with ammonia, the energy evolved ensures further exfoliation of graphene layers with simultaneous reduction of oxygen groups. Thus, the ultrasonic treatment, which is usually the bottle-neck restricting the productivity of the process, can be excluded. In this regard, spontaneous exfoliation, induced directly by the chemical energy, is very favorable for establishing large-scale industrial production of graphene materials. Multi-layered GNPs obtained through the chemical exfoliation possess high electrical conductivity in different formulations with organic and inorganic binders. GNPs obtained through the ammonia treatment method are highly electroconductive in polymeric compositions. For instance, polymer materials containing 10-20 wt.% ammonia-GNPs possess a conductivity of 5-15 S/cm, which exceeds that of any other electroconductive carbon filler.

Considering the aforementioned, methods for superficial modification of GNPs, which can allow improving their compatibility with organic polymers and the stability of their dispersions in solvents, were developed herein. The first method includes treating oxygen-containing GNPs with a phenol-formaldehyde resin (PFR); PFR-modified GNPs possess good solubility in water and epoxy resin. The second one involves the modification of GNPs using aminocumulene. High solubility (up to several wt.%) of materials obtained in water is an interesting peculiarity of these modification methods, which allows fabrication of films by drying aqueous dispersions.

Moreover, graphene/ferrites nanocomposites were synthesised. For this purpose, magnetite and cobalt ferrite nanoparticles were deposited on the GNP surface from aqueous solutions of iron and cobalt salts at appropriate pH and temperature mode.

The surface of GNPs can also be modified with nanoporous carbon. To perform such a synthesis, GNPs were modified with the PFR, then mixed with excess PFR, cured, carbonized, and chemically activated with a KOH melt at 750-800 ^oC. In such a way, GNPs modified with a nanoporous carbon surface layer (pore width ranging from 2 to 5 nm) were obtained. Typically, the specific surface area of these nanocomposites lies in the range of 2500-3500 m^2/g, and the pore volume is 2-3 cm^3/g.

The graphene materials and their modified forms synthesized herein can be used as efficient adsorbents (*e.g.*, for wastewater treatment purposes), electrode materials for supercapacitors, electromagnetic shielding materials, *etc*.

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