Chapter 10
Metal Oxide–Graphene Nanocomposites: Synthesis to Applications

Ponchami Sharma
CSIR-North East Institute of Science and Technology, Jorhat, India

Najrul Hussain
CSIR-North East Institute of Science and Technology, Jorhat, India

Manash R. Das
CSIR-North East Institute of Science and Technology, Jorhat, India

Ashvini B. Deshmukh
CSIR-National Chemical Laboratory, India

Manjusha V. Shelke
CSIR-National Chemical Laboratory, India

Sabine Szunerits
Institut de Recherche Interdisciplinaire Université Lille 1, France

Rabah Boukherroub
Institut de Recherche Interdisciplinaire Université Lille 1, France

ABSTRACT

Graphene is one of the most interesting materials in the field of nanoscience and nanotechnology. Metal oxide nanoparticles exhibit unique physical and chemical properties due to their reduced size and high density of corner or edge surface sites. The metal oxide-graphene nanocomposites not only possess favorable properties of graphene and metal oxide, but also greatly enhance the intrinsic properties due to the synergistic effect between them. These composites are used for catalysis, supercapacitors, lithium ion batteries, solar cells, sensors, removal of pollutants from water, etc. There is a very broad scope of further research for the development of metal oxide-graphene nanocomposites with enhanced properties for different applications. This chapter deals with a comprehensive review of the current research activities from the viewpoint of chemistry and materials science with a special focus on the synthesis, characterization, and applications of metal oxide-graphene nanocomposite materials.

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INTRODUCTION

In the recent years, graphene the mother of all the graphitic materials has drawn the attraction of researchers worldwide (Geim & Novoselov, 2007). Graphene is a single layer of carbon atoms closely packed into honeycomb two dimensional (2D) lattice with a carbon-carbon distance of 0.142 nm. The sp² hybridized carbon network as well as its high electron mobility at room temperature (250,000 cm²/Vs), exceptional thermal conductivity (5000 W m⁻¹K⁻¹) and superior mechanical properties with Young’s modulus of 1 TPa make it the material of choice for a wide range of applications in the field of materials science, physics, chemistry and nanotechnology (Novoselov, Geim, Morozov, Jiang, Katsnelson, Grigorieva, et al., 2005; Li, Wang, Zang, Lee, & Dai, 2008; Stankovich, Dikin, Dommett, Kohlhaas, Zimney, Stach, et al., 2006; Schedin, Geim, Morozov, Hill, Blake, Katsnelson, et al., 2007; Singh, Singh, Nayak, Kumari, Grácio & Dash, 2011). Two dimensional, atom-thick graphene can be considered as the ideal substrate for the synthesis of hybrid composites with three-dimensional (3D) architectures with unique chemical, physical and structural properties (Zhao, Song, Song, Yin, Wu, Zhou, et al., 2010). The fabrication of metal and metal oxide-graphene/graphene oxide (GO) nanocomposites has drawn special interest in this regard. The presence of metal and metal oxide nanoparticles (NPs) on reduced graphene oxide (rGO) sheets prevents the restacking of the individual graphene sheets which arises due to strong Van der Waals interactions between the sheets (Zhao et al., 2012). Metal oxide NPs exhibit unique physical and chemical properties upon a decrease of their particle size and structural geometry. The decrease of the particle size has a direct influence on the band gap of the oxide particles and is reflected on their conductivity and chemical reactivity. However, these properties are greatly affected by the aggregation of the NPs. Therefore, prevention of such aggregation is necessary when synthesizing metal oxide NPs. Graphene or GO nanosheets can effectively stabilize such NPs to prevent their aggregation, and the properties of the NPs could be enhanced by anchoring them onto the graphene sheets (Bai & Shen, 2012). Therefore, current research trends are focused on the preparation and application of metal oxide-graphene nanocomposites. A number of research activities have been carried out in this area in recent years. This chapter consists of a comprehensive review of current research activities in the synthesis and applications of metal oxide-graphene nanocomposites.

BACKGROUND

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