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Synthesis of Ag-reduced graphene oxide nanocomposite by gamma radiation assisted method and its photocatalytic activity

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ABSTRACT

Silver-reduced graphene oxide (Ag-rGO) nanocomposite was prepared in the presence of Isopropyl alcohol (IPA) and polyvinyl pyrrolidone (PVP) by gamma irradiation assisted method. UV–Visible spectroscopic results showed the peak of rGO and surface plasmon resonance of Ag nanoparticles. X-ray powder Diffraction (XRD) results revealed the formation of face centered cubic structured Ag nanoparticles along with rGO signature after irradiation. Transmission electron microscopy (TEM) results showed the decoration of Ag nanoparticles of size 10 nm on rGO sheet corroborating the UV–Visible spectroscopic and XRD results. Raman spectroscopic results of Ag-rGO showed the increase in the ratio of D to G band (I_D/I_G) after gamma irradiation. The prepared Ag-rGO nanocomposite was tested for the degradation of methylene blue (MB) and results distinctly enhanced photocatalytic degradation compared to bare Ag nanoparticles and graphene oxide. The prepared Ag-rGO nanocomposites act as photo-catalysts that utilize visible light as an energy source.

1. Introduction

Graphene is a two dimensional material which has received an extensive attention due to its high surface area, excellent electrical and thermal properties, extended charge carrier mobility. Graphene oxide (GO) is considered as a precursor of graphene which is composed of nearly flat rigid of carbon atoms in which oxygen containing groups are covalently linked [1]. GO exhibits large surface area which can be used to decorate metal nanoparticles like silver. Silver nanoparticles can be synthesized by many methods like chemical reduction, photo reduction, electrochemical method, atom beam sputtering and radiation assisted method [2]. Among all these methods, gamma radiation assisted insitu synthesis of AgNPs has been termed as a simple, clean and efficient method [3]. Recently, some of the researchers have reported the reduction of graphene oxide by gamma, microwave and UV–radiation [4–8].

Ag-reduced graphene oxide nanocomposites can be synthesized by different method. Hsu and Chen [9] have synthesized Ag nanoparticles of size (10.3 ± 4.6), (21.4 ± 10.5) and (41.1 ± 12.6) nm by varying the microwave irradiation cycle number and deposited on rGO which showed increased surface enhanced raman scattering (SERS) with 4-aminothiophenol. The decoration of Ag nanoparticles of size (5–10) nm on rGO in the presence of ethanol synthesized by rapid microwave assisted method has been reported by Li and Hai [10] and it showed enhanced photocatalytic degradation of Rhodamine B. Chook et al. [11], have synthesized the Ag nanoparticles of size ~38 nm by modified Tollens' process using glucose as a reducing agent by microwave irradiation assisted method and simultaneously deposited on graphene oxide sheet. The Ag nanoparticles deposited graphene oxide showed enhanced antibacterial performance than of the bare nanoparticles. The ionic liquid facile synthesis of Ag nanoparticles of size 20 nm on rGO in the presence of 1-ethyl-3-methylimidazolium acetate by gamma radiation method at a dose of 160 kGy has been reported by Wang et al., [12]. The gamma radiation assisted synthesized Ag-rGO nanocomposite showed enhanced SERS effect. Hung et al. [13], have decorated the Ag nanoparticles of size (10–30) nm on rGO in the presence of ethylene glycol by solvothermal method and found the enhancement in the electroconductibility of the Ag-rGO film. One-pot synthesis of Ag nanoparticles decorated rGO has been synthesized by Tian et al. [14], by chemical method and its application for photocurrent generation in the visible spectral region. However, to the best of our knowledge, no one has synthesized the Ag-rGO nanocomposite in the presence of IPA and PVP by gamma radiation assisted method.

Therefore in the present work, we have synthesized the Ag

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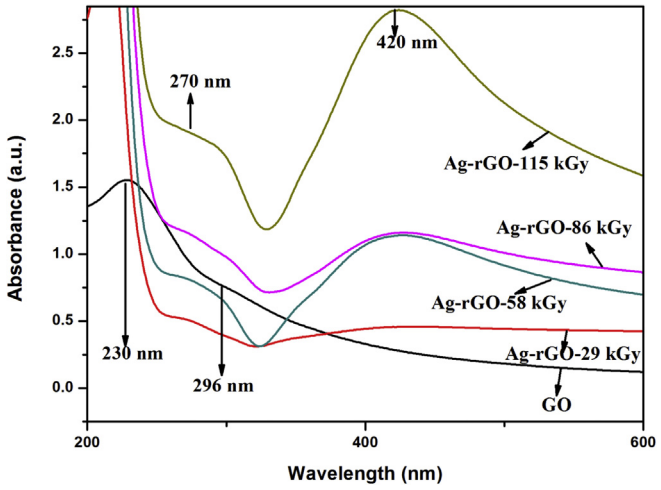

Fig. 1. UV–Visible absorption spectrum of GO and Ag-rGO nanocomposite prepared at different gamma doses.

nanoparticles-reduced graphene oxide nanocomposite in the presence of isopropyl alcohol and polyvinyl pyrrolidone by gamma radiation assisted method. The prepared Ag-rGO nanocomposites were characterized by UV–Visible spectroscopy, XRD, TEM and Raman spectroscopy. The prepared Ag-rGO nanocomposites were checked for the photocatalytic degradation of MB dye.

2. Experimental details

Graphite powder, $NaNO_3$, H_2SO_4, $KMnO_4$, H_2O_2, $AgNO_3$, PVP, Isopropyl alcohol were procured from Sigma Aldrich Company.

2.1. Synthesis of GO and Ag-rGO nanocomposite

GO was synthesized by modified Hummers' method [15]. In brief, graphite powder (0.5 g), sodium nitrate (0.5 g) and sulfuric acid (23 mL) were mixed in an ice-bath under a continuous stirring. Potassium permanganate (3.0 g) was slowly added into the reaction mixture at 20 °C. Flask was then transferred to water bath (35 ± 5) °C and solution was stirred for an hour to get thick pasty product. 100 mL water was added and temperature of the bath was raised to (90 ± 5) °C under constant stirring for another 15 min. The solution was diluted by adding 500 mL water and 3 mL H_2O_2 (30% v/v) was subsequently added which led to color change from dark brown to yellow. The mixture was filtered and washed several times with hot water to eliminate the acid residue. The resultant solid was dried under vacuum and stored in a desiccator for subsequent use. This prepared GO was dispersed in Isopropyl alcohol (0.5 mg/ml) and sonicated for 1 h.

25 mM of $AgNO_3$ solution was prepared. 10% PVP was added to it and stirred it for 30 min. 2 ml of $AgNO_3$-PVP solution was added to

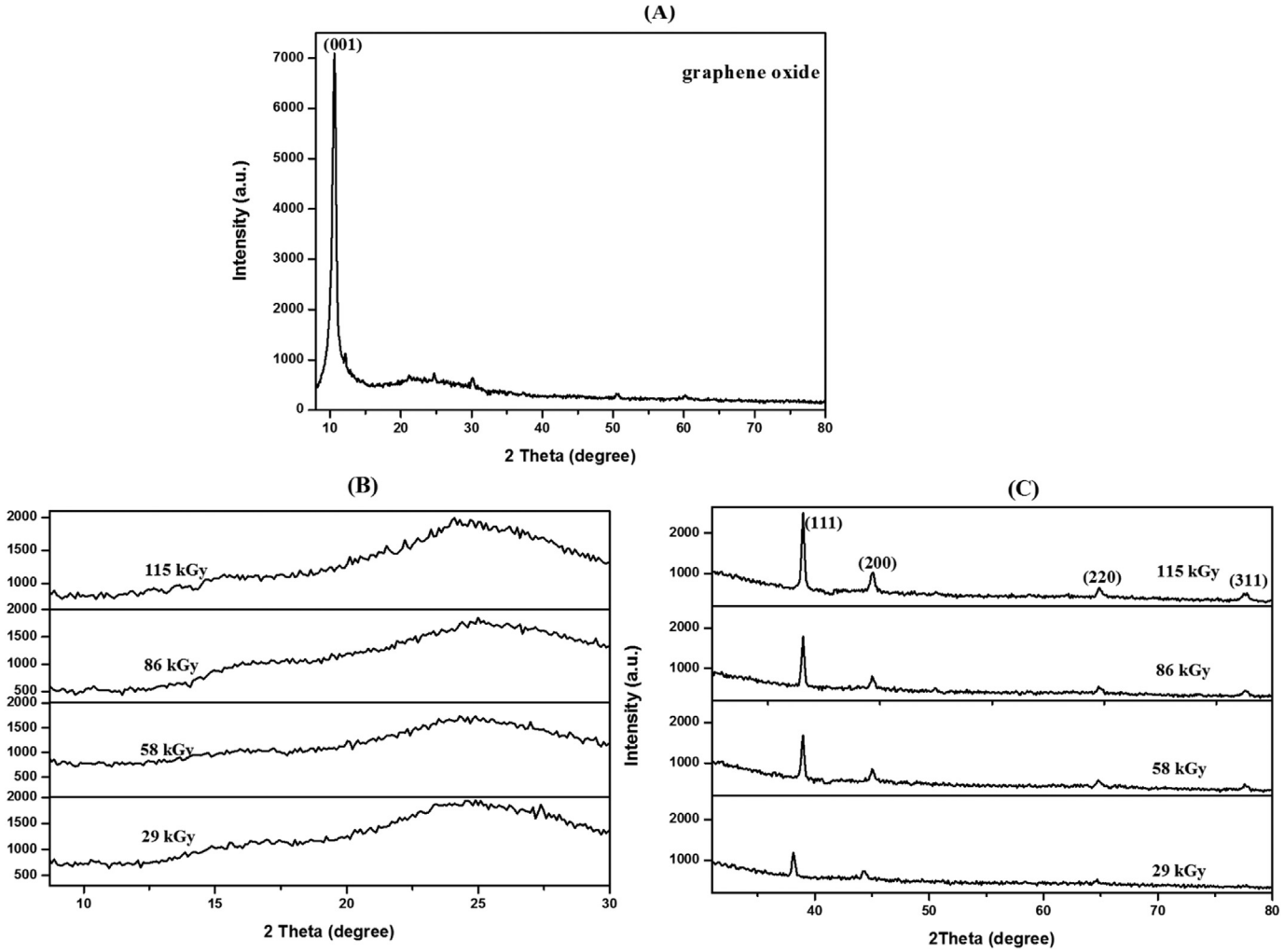

Fig. 2. XRD of (A) GO and Ag-rGO nanocomposites in the 2 Theta range (B) 8–30° and (C) 31–80°.