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Synthesis and high-performance microwave absorption of reduced graphene oxide/zinc ferrite hybrid nanocomposite

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ABSTRACT

Reduced graphene oxide/zinc ferrite (RGO/$ZnFe_2O_4$) hybrid nanocomposite was fabricated by a facile solvothermal route. $ZnFe_2O_4$ nanoparticles with an average diameter around 10.2 nm were homogeneously anchored on the surface of RGO sheets without large aggregation. Moreover, the effect of filler content on the microwave absorption performance of the hybrid nanocomposite was explored in detail. The as-prepared hybrid nanocomposite exhibited excellent microwave absorption performance with the minimum reflection loss of −41.1 dB for a thickness of 2.5 mm and effective absorption bandwidth (less than −10 dB) of 3.2 GHz for a thickness of 2.0 mm. Our results indicated that the deposition of $ZnFe_2O_4$ nanoparticles on RGO sheets was an efficient way to fabricate RGO-based high-performance microwave absorbers.

1. Introduction

With the rapid development of electronic devices and wireless communication, the problem of electromagnetic pollution has become increasingly serious, which not only affects the operation of various commercial or industrial equipment but also has harmful effects on the human health [1–3]. Therefore, the design and development of high-performance microwave absorption materials have become a research focus in materials science field. Recently, reduced graphene oxide (RGO) has been reported as a promising candidate as microwave absorbers owing to its low density, high specific surface areas, residual defects and high dielectric loss [4,5]. However, the microwave absorption performance of sole RGO is weak due to its bad impedance matching characteristic as well as single dielectric loss mechanism toward microwave attenuation [5,6]. As we all know, a good microwave absorber needs to meet two requirements: well impedance matching and strong electromagnetic attenuation. Thus, a feasible route to improve the microwave absorption performance of RGO could be to fabricate the hybrid nanocomposites by incorporating dielectric or magnetic loss materials into RGO [4–7]. For instance, Chen et al. fabricated the RGO–hematite nanocomposites with high-efficient microwave absorption by a one-pot wet chemical method and demonstrated that the filler content had significant effect on the microwave absorption performance [4]. $ZnFe_2O_4$ as an important spinel ferrite, which has drawn much attention in microwave absorption because of its high magnetic loss, facile synthesis, low cost, stable chemical and physical properties [8]. In view of the advantages of dielectric RGO and magnetic $ZnFe_2O_4$ as microwave absorbers, we believe that the hybridization of $ZnFe_2O_4$ with RGO will achieve high-efficient microwave absorption owing to the improved impedance matching, synergistic effect and multiply heterogeneous interfaces between RGO and $ZnFe_2O_4$.

Herein, we reported a facile one-pot solvothermal route for the fabrication of hybrid nanocomposite of RGO/$ZnFe_2O_4$ as a thin thickness and high-efficient microwave absorber.

2. Experimental

Graphite oxide was prepared by the improved Hummers' method as described in our previous work [9]. RGO was obtained by the exfoliation and reduction of graphene oxide (GO) [6].

A facile one-pot solvothermal method was used to fabricate the RGO/$ZnFe_2O_4$ hybrid nanocomposite. In a typical procedure, RGO (17 mg) was firstly dispersed into ethylene glycol (40 mL) by ultrasonic treatment for 1.5 h to produce a homogeneous dispersion. Then, a mixture of $ZnCl_2$ (0.34 g, 2.5 mmol) and $FeCl_3·6H_2O$ (1.35 g, 5.0 mmol) were dissolved in the above dispersion. Next, NaAc (3.6 g) and PEG (1.0 g) were added into the above dispersion under vigorous stirring for 1 h at 50 °C. The obtained mixture was transferred into a 50 mL Teflon-lined stainless-steel autoclave and heated at 200 °C for 8 h. After the reaction was finished, the autoclave was cooled to room temperature. Lastly, the black products

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were collected by magnetic separation, and then washed with deionized water and anhydrous ethanol for several times and dried under vacuum at 60 °C for 24 h.

The crystal structure was characterized by X-ray diffraction (XRD, Shimadzu, LabX XRD-6000). The morphology was characterized by a field emission transmission electron microscopy (FETEM, FEI, TF20). Raman spectra were acquired at room temperature by using a laser confocal Raman spectrometer (Renishaw-2000). The magnetic properties measurements were carried out at room temperature on a vibrating sample magnetometer (VSM, Nanjing NanDa Instrument, Plant HH-20). Electromagnetic parameters (complex permittivity and complex permeability) were tested on a vector network analyzer (VNA, CETC, AV3629D) in the frequency range of 2–18 GHz. The measured specimen was prepared by uniformly mixing the as-prepared powders with different weight percentages (25 wt%, 50 wt% and 75 wt%, respectively) into paraffin matrix with a thickness of 2 mm, and then pressed the mixture into a toroidal shape with outer diameter of 7.0 mm and inner

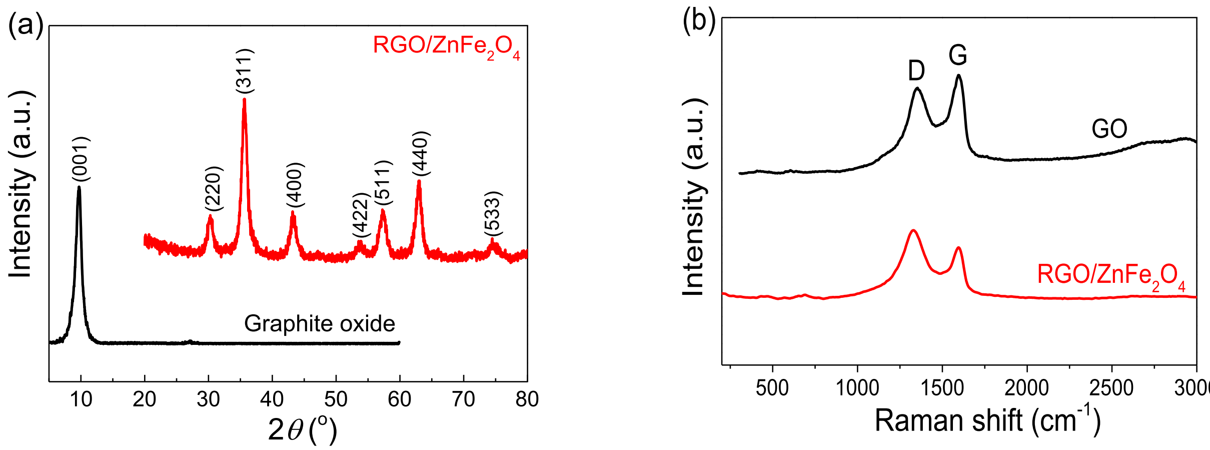

Fig. 1. (a) XRD patterns of graphite oxide and RGO/$ZnFe_2O_4$ hybrid nanocomposite, (b) Raman spectra of GO and RGO/$ZnFe_2O_4$ hybrid nanocomposite.

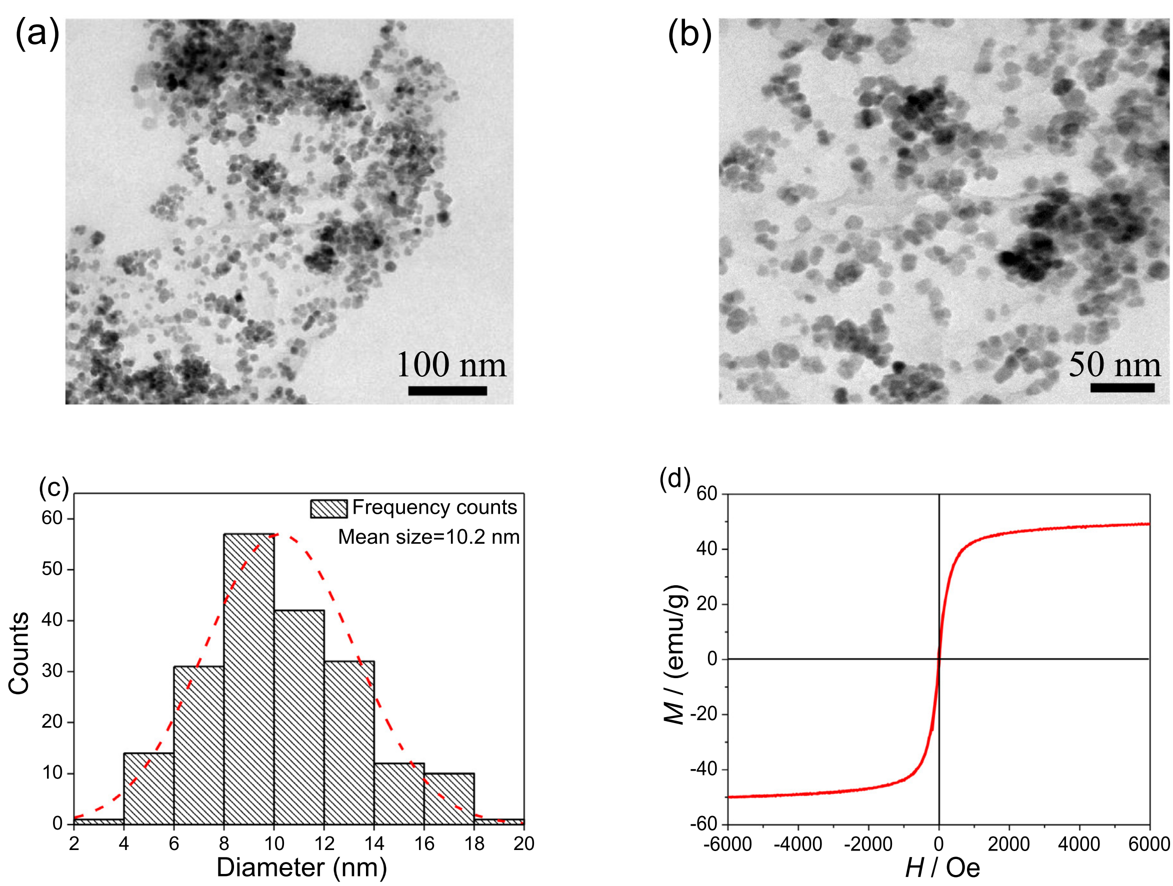

Fig. 2. (a)–(b) TEM images of RGO/$ZnFe_2O_4$ hybrid nanocomposite with different magnifications, (c) particle size distribution histogram of $ZnFe_2O_4$ nanoparticles and (d) magnetic hysteresis loop of RGO/$ZnFe_2O_4$ hybrid nanocomposite.