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Sandwich-structured graphene@Fe_3O_4@carbon nanocomposites with enhanced electromagnetic absorption properties

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ABSTRACT

Sandwich-structured graphene@Fe_3O_4@carbon nanocomposites were prepared by a rational route. Transmission electron microscopy measurements show that an amorphous carbon layer is covered on the surface of graphene@Fe_3O_4 and the sandwich-structured graphene@Fe_3O_4@carbon is formed, and the TGA results indicate that the carbon content is 42.4 wt%. Compared with graphene@Fe_3O_4, the as-prepared graphene@Fe_3O_4@carbon nanocomposites exhibit enhanced microwave absorption properties in terms of both the maximum reflection loss value and the absorption bandwidth. The maximum reflection loss of graphene@Fe_3O_4@carbon is −30.1 dB at 14.8 GHz with a thickness of only 1.8 mm, and the absorption bandwidths with a reflection loss below −10 dB ranges from 12.1 to 17.5 GHz.

1. Introduction

In recent years, microwave absorption materials have been drawn much attention owing to increasing electromagnetic interfaces problems. To date, the ideal electromagnetic absorbers are requested to have not only strong absorption and wide absorption frequency range, but also low density and good thermal stability [1]. Graphene, a new crystalline form of a two-dimensional sp^2 bond carbon sheet, possesses an excellent thermal conductivity (5000 W m^{-1} K^{-1}) [2], high specified surfaces area (1000 m^2 g^{-1}) [3] and excellent electronic conductivity (6000 S cm^{-1}) [4]. These properties make graphene or graphene-based materials very promising to meet the requirement for the ideal electromagnetic absorbers. However, its high conductivity may degrade the microwave absorption ability, and the microwave absorption property of pure graphene is very poor [5]. Therefore, how to design and prepare good electromagnetic absorbing materials based on graphene still remains a challenge.

Recently, it has been found that graphene-based heteronanostructures exhibit enhanced microwave absorption properties due to the presence of the different kinds of functional materials and the formation of heterojunctions at the interface. The formed heterointerface has played an important role in the enhanced absorption properties [6–10]. Herein, sandwich-structured graphene@Fe_3O_4@carbon nanocomposites were fabricated and their electromagnetic properties were investigated. The results show that the sandwich-structure exhibits enhanced EM absorption in the terms of both the maximum reflection loss value and the absorption bandwidth. The maximum reflection loss value can reach -30.1 dB at 14.8 GHz with a thickness of only 1.8 mm, and the absorption bandwidths with the reflection loss lower than -10 dB are 5.4 GHz.

2. Experimental

All of the chemicals and reagents were purchased from Sinopharm Chemical Reagent Co., Ltd, China and used as received. Deionized water was used for all experiments.

Preparation of sandwich-structured graphene@Fe_3O_4@carbon nanocomposites: Graphene oxide (GO) was synthesized busing natural graphite flakes according to the literature method [11]. The preparation of graphene@Fe_3O_4 was carried out by the reduction reaction between $FeCl_3$ and diethylene glycol (DEG) in the presence of GO [12]. Sandwich-structured graphene@Fe_3O_4@carbon was synthesized by coating amorphous carbon onto graphene@Fe_3O_4 through a hydrothermal route using glucose as the carbon source [13]. Briefly, graphene@Fe_3O_4 (200 mg) was dispersed in 120 mL deionized water and sonicated for 30 min. Then, 0.378 g glucose was added to the solution and stirred for 30 min at room temperature. The solution was transferred to an autoclave and heated to 180 °C for 10 h. The product was centrifuged and washed

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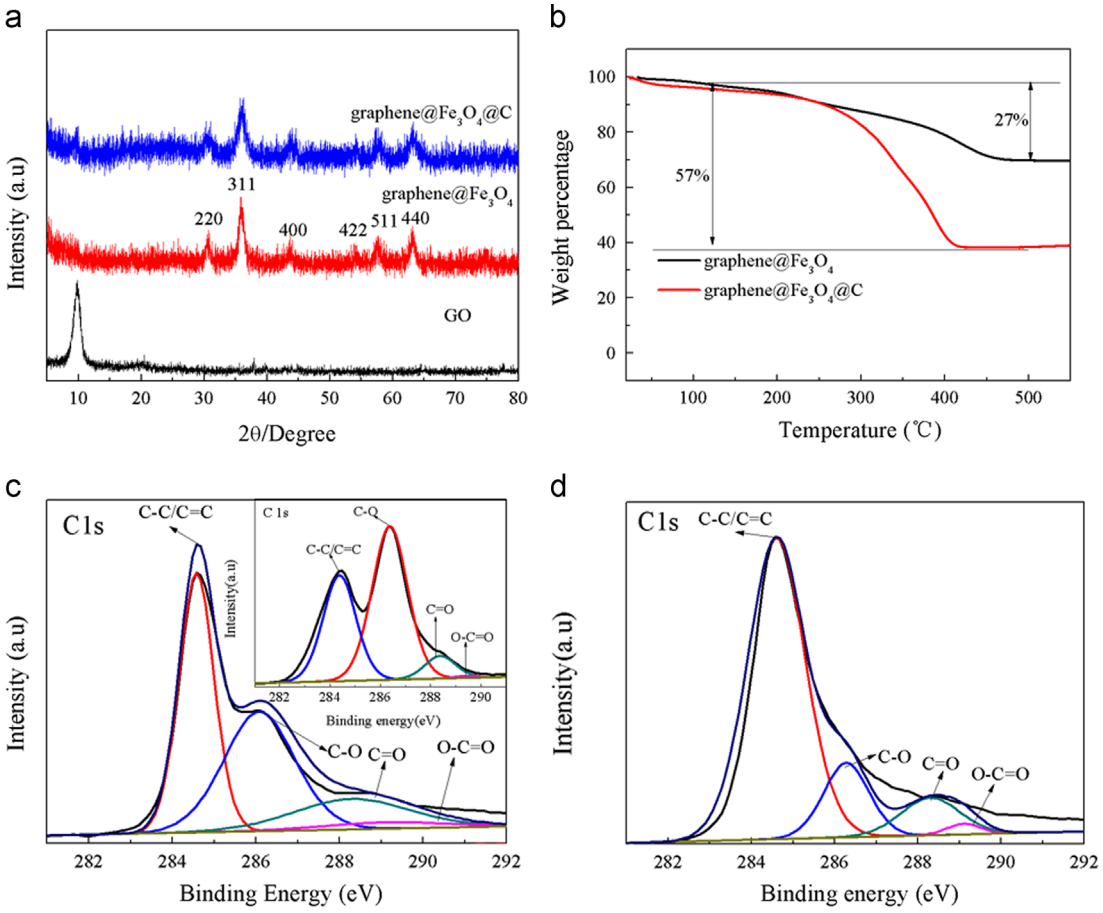

Fig. 1. XRD patterns of GO, graphene@Fe_3O_4 and graphene@Fe_3O_4@carbon (a); TGA curves of graphene@Fe_3O_4 and graphene@Fe_3O_4@carbon (b), XPS spectra of C1s of graphene@Fe_3O_4 (c) and graphene@Fe_3O_4@carbon (d). Inset: XPS spectra of C1s of GO (c).

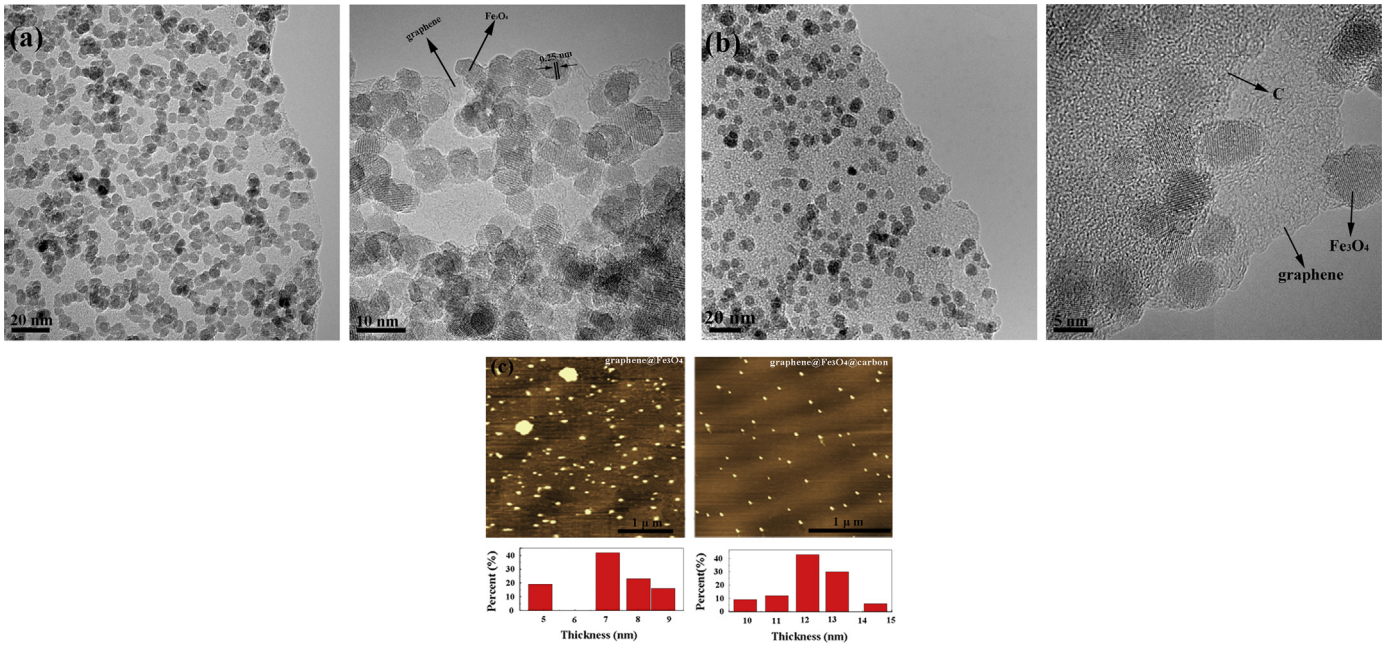

Fig. 2. TEM images of graphene@Fe_3O_4 (a) and graphene@Fe_3O_4@carbon (b); AFM images of graphene@Fe_3O_4 and graphene@Fe_3O_4@carbon (c).

with deionized water several times and dried in a vacuum oven at 60 °C to obtain graphene@Fe_3O_4@carbon.

Characterization: The obtained products were characterized by X-ray diffraction (XRD, PANalytical, Holland), thermogravimetric analysis (TGA/DTA92 Setaram II testing system), transmission electron microscopy (TEM, Philips Tecnai-12), field emission scanning-electron microscope (FESEM, Hitachi S-4800), X-Ray photoelectron spectroscopy (XPS, ESCALAB 250, Thermofisher Co). The electromagnetic parameters were analyzed using a HP8753D vector network analyzer.