Materials Letters 216 (2018) 101–105

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/mlblue

Covalently bonded GNPs-NH-PANI nanorod arrays modified by Fe_3O_4 nanoparticles as high-performance electromagnetic wave absorption materials

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ARTICLE INFO

Article history:
Received 19 November 2017
Received in revised form 15 December 2017
Accepted 2 January 2018
Available online 3 January 2018

Keywords:
Graphene nanoplatelets
PANI nanorod arrays
Absorbing materials
Carbon materials
Nanoparticles
Magnetic materials

ABSTRACT

To meet the demand of electromagnetic interference shielding, low-cost and easily available microwave absorbers are urgently required. A novel kind of covalently bonded GNPs-NH-PANI nanorod arrays modified by Fe_3O_4 nanoparticles (Fe_3O_4/GNPs-NH-PANI) with hierarchical structures was synthesized. The Fe_3O_4/GNPs-NH-PANI composite shows the maximum absorption of −40.31 dB at a thickness of 2.6 mm, and the corresponding bandwidth with effective attenuation (RL <−10 dB) is up to 9.62 GHz (7.85–17.47 GHz), suggesting that this cheap and available absorber is believed to be an optimal choice for the application of microwave attenuation.

1. Introduction

In recent years, electromagnetic pollution, generated by the increasing usage of electronic devices and communication facilities in the fields of industry, has attracted tremendous attention [1]. It is well known that the absorption properties are closely related to the structures of microwave absorbers. Up until now, various materials with different structures have been fabricated to construct eminent microwave absorbents [2].

As important electromagnetic functional materials, Graphene [3–5], polyaniline and ferrites have been intensively investigated in absorbing materials. In previous reports, the reflection loss (RL) of the covalently bonded polyaniline/graphene composites can reach −51.5 dB, and the absorption bandwidths with effective attenuation (RL <−10 dB) are 4 GHz [6]. The maximum absorption of Fe_3O_4/polyaniline/graphene composites was up to −40.8 dB at 14.8 GHz and the absorption bandwidth with effective attenuation (RL <−10 dB) was up to 5.1 GHz [7]. Unfortunately, it is still a great challenge to develop an absorber that simultaneously possesses the advantages of easy fabrication, low-cost, ultra-wide bandwidth and strong absorption. Hence, to develop a simple and convenient absorber with efficient performance is attracting significant attention because of the urgent requirement of this type of absorbers [8]. Thus, controlled fabrication of covalently bonded GNPs-NH-PANI nanorod arrays modified by Fe_3O_4 nanoparticles (Fe_3O_4/GNPs-NH-PANI) with hierarchical structures becomes an important task. The Fe_3O_4/GNPs-NH-PANI composites with hierarchical structures not only have eminent electromagnetic properties owing to the similar composition and structure of Fe_3O_4/polyaniline/graphene, but also possess advantages of facile preparation and low-cost. However, there is no report concentrating on the Fe_3O_4/GNPs-NH-PANI composites with hierarchical structures as well as their absorbing properties.

Herein, the Fe_3O_4/GNPs-NH-PANI composites with hierarchical structures were synthesized by hydrothermal reaction and in-situ polymerization. The structure, morphology and absorbing properties of as-prepared materials were investigated.

2. Experimental section

Graphene nanoplatelets (GNPs) were obtained in previous report [9]. To synthesize the Aniline functionalized GNPs (GNPs-NH_2), p-Phenylenediamine (8 mmol) and H_2SO_4 (8 mmol) were dissolved in the 500 mg GNPs was dispersed into 480 mL of deionized water. A 5 mL solution containing $NaNO_2$ (8 mmol)

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https://doi.org/10.1016/j.matlet.2018.01.008
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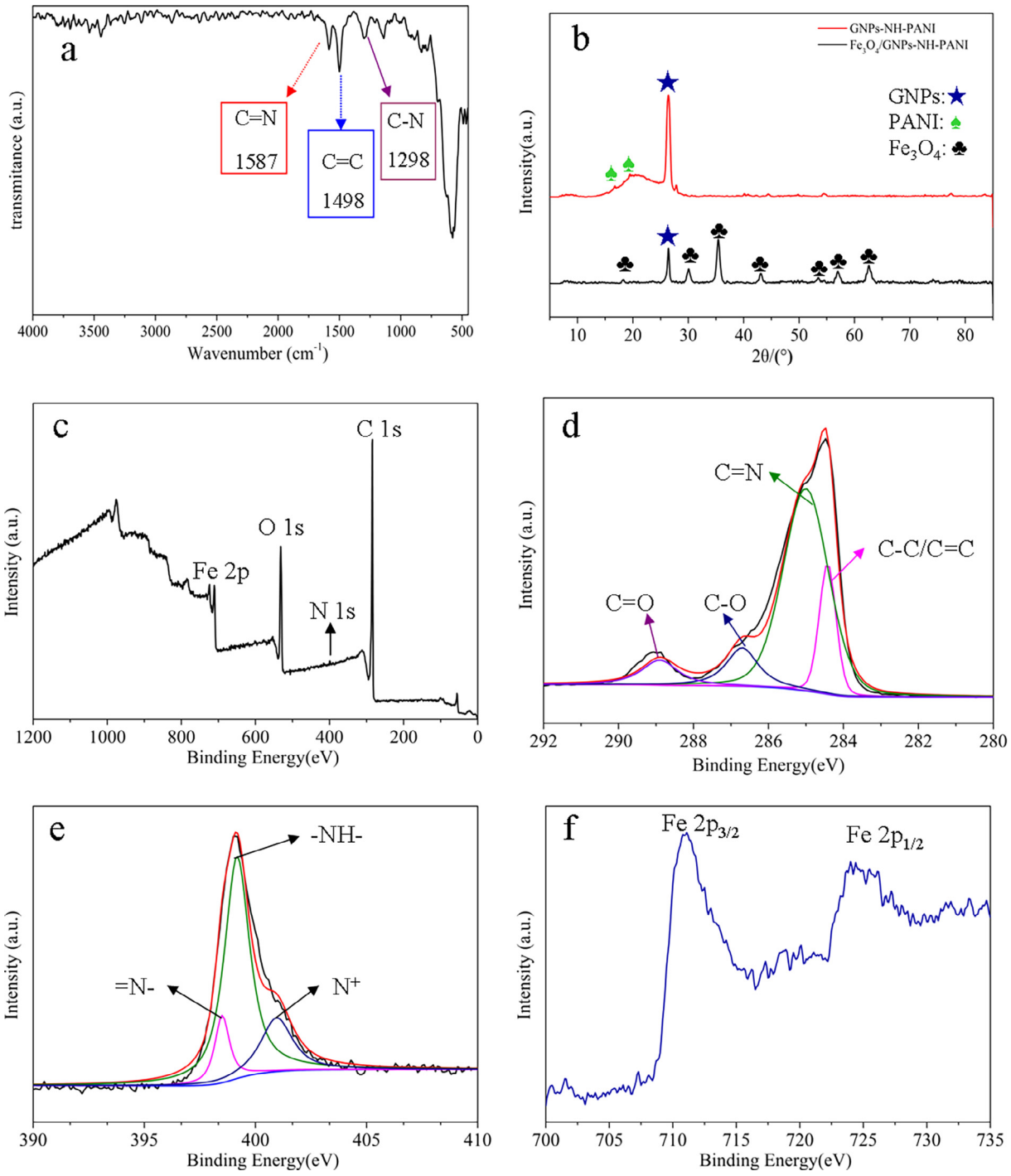

Fig. 1. FT-IR spectra (a), XRD patterns (b) and XPS spectra of Fe_3O_4/GNPs-NH-PANI composites (c, d, e and f).

was added while stirring. The solution was then heated at 60 °C for 4 h. Then obtained GNPs-NH_2 were dispersed into 500 mL of 1 M aqueous $HClO_4$ solution. 0.5 mL aniline was added into the above solution and stirred for 30 min at 0–5 °C. 0.8375 g $(NH_4)_2S_2O_8$ (APS) was dissolved in 10 mL $HClO_4$ solution and cooled to 0–5 °C. The polymerization was performed by rapid addition of the precooled oxidant solution and the mixture was stirring for 24 h. To obtained the Covalently bonded GNPs-NH-PANI nanorod arrays modified by Fe_3O_4 nanoparticles, GNPs-NH-PANI (240 mg) were dispersed into 60 mL of ethanol/water solution ($V_{(ethanol)}$: $V_{(water)}$ = 1:1). Then, 10 mL solution contain 0.3500 g ferric chloride ($FeCl_3$, 2.16 mmol) and 0.2140 g ferrous chloride ($FeCl_2{\cdot}4H_2O$, 1.08 mmol) were added into above suspended solution. Then, transformed into a Teflon-lined stainless-steel autoclave of 80 mL capacity. And 2.5 mL of ammonia solution (NH_4OH) (26 wt%) was injected into the mixed solution. Finally, after the reaction had taken place at 110 °C for 5 h, the as-prepared black Fe_3O_4/GNPs-PANI composites were collected by using magnetic field after being washed with pure ethanol and water repeatedly.

The characterizations of samples are performed with the FE-SEM Hitachi S4800 microscope, Bruker D8 Advanced X-ray diffractometer and PHI 5000 Versa Probe equipped. The