Materials Letters xx (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Materials Letters

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

One-pot preparation of reduced graphene oxide/carbonyl iron/polyvinyl pyrrolidone ternary nanocomposite and its synergistic microwave absorbing properties

Xiaodi Weng[a], Xuliang Lv[a], Bingzhen Li[a], Yang Zhang[e], Hongfei Lou[a,d], Peigen Zhu[c,*], Guangxin Gu[b,*]

[a] *Key laboratory of Science and Technology on Electromagnetic Environmental Effects and Electro-optical Engineering, PLA University of Science & Technology, Nanjing 210007, PR China*
[b] *Department of Materials Science, Fudan University, Shanghai 200433, PR China*
[c] *National Defense Engineering Institute, PLA University of Science & Technology, Nanjing 210007, PR China*
[d] *Ning Jing Artillery Academy, Nanjing 211100, PR China*
[e] *Jiangsu Qiurun Nanotechnology Company, Nantong 226001, PR China*

ARTICLE INFO

Keywords:
Nanocomposites
Carbon materials
Microwave absorbing
Wideband

ABSTRACT

This paper reported a novel ternary nanocomposite consisting of reduced graphene oxide, carbonyl iron and polyvinyl pyrrolidone through a facile one-pot fabrication approach. The generation of ternary nanocomposite and its synergistic microwave absorbing properties were confirmed by various characterization methods and theoretical calculations. Attributing to the combination of three components with different futures, as-prepared ternary nanocomposite possesses excellent microwave absorbing properties including an ultra-wide low reflection (reflection loss <-10 dB) bandwidth (12.52 GHz, from 5.48 to 18 GHz) at the thickness of 2.8 mm, with the minimum value of −41.76 dB at 10 GHz. It is believed that such ternary nanocomposite has a significant potential in microwave absorbing applications.

1. Introduction

Synergistic microwave absorbing materials (MAM)based on the combination of dielectric/magnetic constituents [1] have drawn considerable attention in controlling electromagnetic wave pollution and stealth technology. Carbonaceous materials are widely utilized as the dielectric constituent for high performance synergistic MAM, including colloidal graphite, carbon nanofibers, carbon nanotubes, grapheme [2,3] *etc.* Among them, graphene exhibits exceptional superiorities in microwave absorbing property, such as wide working band and lighter weight, due to its unique carbon atoms structure [4]. Besides dielectric constituent, the choice of magnetic constituent is also vital because high performance MAM requires good balance between permittivity and permeability. Carbonyl iron is much more preferred as magnetic constituent if compared to spinel ferrites, cobalt ferrites and Fe_3O_4, due to its stronger magnetic loss at Giga Hertz. After being mechanically milled, carbonyl iron (MCI) in flaky shape can further improve the Snoek's limit [5] and avoid skin effect at high frequency [6]. In composite MAM system, polymer is often used as continuous shell to encapsulate inorganic core [7–9]. However, polymer shell reduces the content of magnetic constituent, which deteriorate the magnetism property.

Here we report a one-pot approach to prepare ternary nanocomposite MAM consisting of PVP nanoparticles decorated on reduced graphene oxide (rGO)/MCI composite, which is schematically demonstrated in Fig. 1(a). Polyvinyl pyrrolidone (PVP) is an easily acquirable nonconductive polymer with very low permeability, which can adjust the permittivity of rGO and further broaden MAM's bandwidth with improved impedance match in a wide frequency regime after being anchored on rGO nanosheet with the assistance of L-ascorbic acid (L-AA) [10]. In our work, PVP is deposited as individual nanoparticles on rGO surface, which not only significantly reduces the content of nonmagnetic polymer but also can generate defects in rGO conductive networks and act as interfacial polarization centers for wider bandwidth.

2. Experimental

rGO/MCI/PVP dispersion was prepared by simultaneous addition of MCI dispersion, hydrochloric acidic, GO dispersion L-AA solution

* Corresponding authors.
E-mail addresses: Peigenzhu@163.com (P. Zhu), Guangxingu@fudan.edu.cn (G. Gu).

http://dx.doi.org/10.1016/j.matlet.2016.10.111
Received 12 August 2016; Received in revised form 21 October 2016; Accepted 23 October 2016
Available online xxxx

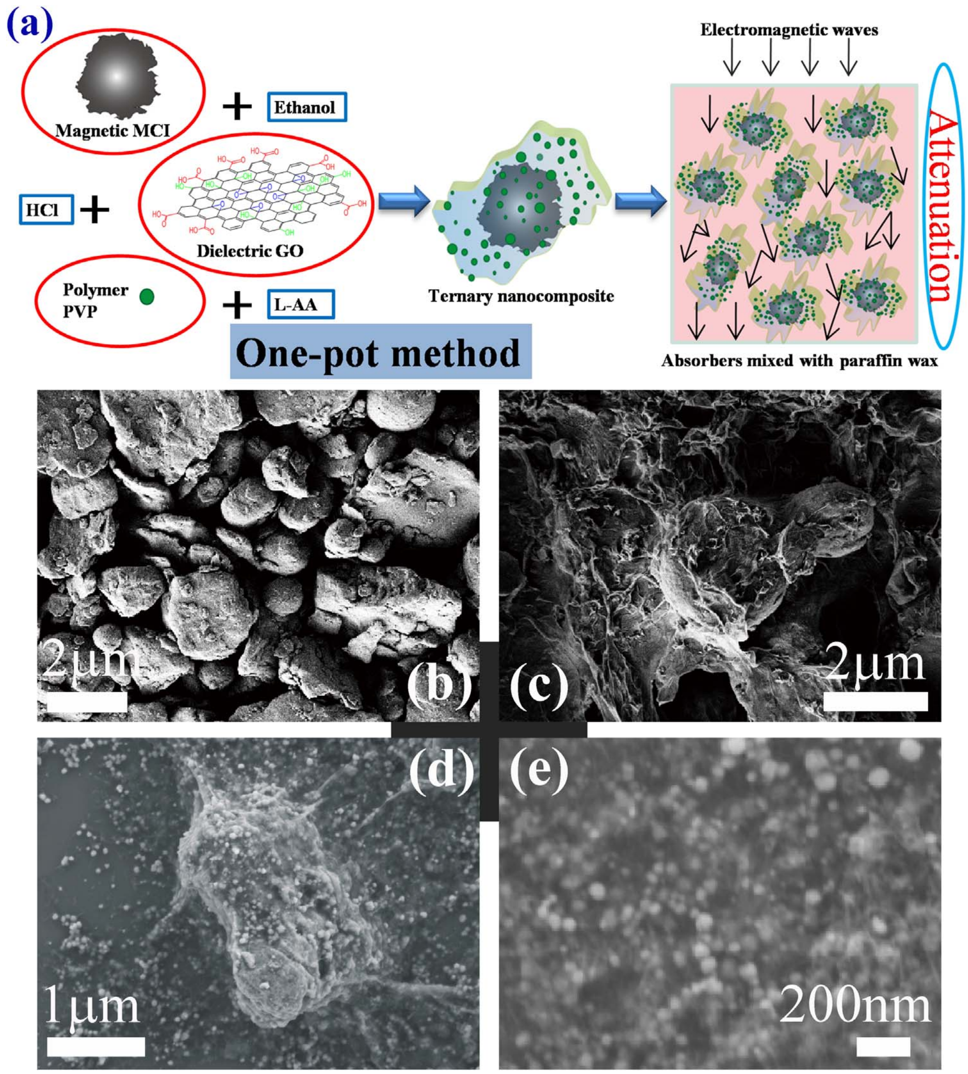

Fig. 1. (a) Schematic of one-pot method and microwave absorbing mechanism. FE-SEM images of (b) MCI, (c) rGO/MCI, (d) rGO/MCI/PVP and (e) PVP nanoparticles grafted rGO surface under different magnifications.

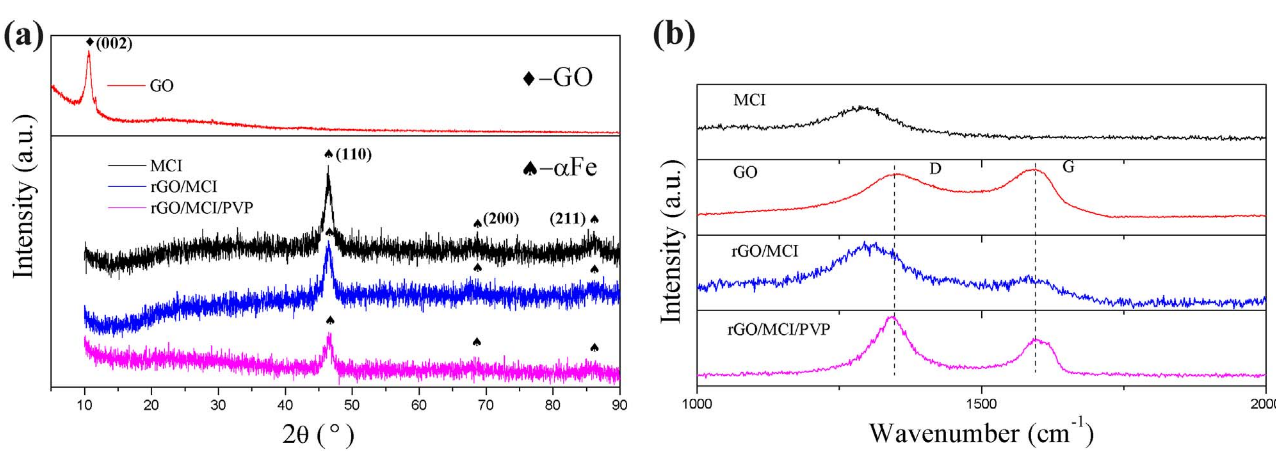

Fig. 2. (a) XRD patterns and (c) RAMAN spectra of the products and raw materials.

and PVP solution into a beaker which was sonicated for 30 min and heated up to 80°Cfor 4 h. GO was expected to be reduced by Fe/Fe^{2+} on carbonyl iron surface [6,11] and L-AA in solution in this process. Subsequently, rGO/MCI/PVP ternary composite was obtained after magnetic separation and drying, which was further characterized with field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and RAMAN scattering spectroscopy. Complex permittivity and complex permeability were measured by a vector network analyzer (VNA). For comparison, binary composite rGO/MCI without PVP decoration was also prepared and characterized. All the experimental and characterized details can be found in Electronic Supplementary Material.