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Enhanced microwave absorbing properties and heat resistance of carbonyl iron by electroless plating Co

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ABSTRACT

Co coated carbonyl iron particles (Co (CI)) are fabricated through electroless plating method, and the electromagnetic microwave absorbing properties are investigated in the frequencies during 8.2–12.4 GHz. The complex permittivity of CI particles after electroless plating Co is higher than that of raw CI particles due to improvment of the polarization process. Furthermore, according to the XRD and TG results, the Co layer can enhance the heat resistance of CI particles. The bandwidth below −10 dB can reach 3.9 GHz for the Co(CI) absorbent. The results indicate that the electroless plating Co not only enhances the absorbing properties but also improves the heat resistance of CI.

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1. Introduction

In recent years, with the increasing electromagnetic pollution due to the drastic development of gigahertz (GHz) electronic systems and telecommunication, considerable investigations have been focused on the electromagnetic wave absorption materials with the properties of wide frequency range, strong absorption, low density and high resistivity [1,2]. Carbonyl iron (CI) as a kind of conventional magnetic fillers with the advantages of high saturation magnetization, high Curie temperature and large value of magnetic permeability which can be obtained in GHz have been studied by many researchers [3–5]. Nevertheless, the using of CI is often limited by the oxidation sensitivity due to the high oxidation activity of iron at high temperature, which has worsened the magnetic properties of CI particles [6]. Therefore, using surface coating technology to form core–shell material is a good way to protect CI from oxidation.

Previously, Liu et al. [6] prepared a-Fe/C(a) nanocomposites through the arc-discharge method and the good electromagnetic wave absorption performances (reflection loss < -20 dB) were obtained in the frequency ranges of 4.3–8.2 GHz due to the low anisotropy field. Liu et al. [7] also fabricated the core–shell material of ZnO coated iron by the arc-discharge method. However, the arc-discharge method is not only expensive but also waste of energy. Compared with the arc-discharge method, the electroless plating method is an easy way and convenient method to prepare core–shell structure. Han et al. [8] used Si coated iron to form core–shell material and attributed the good absorbing properties to the insulating shell which could efficiently reduce the permittivity and improve the impedance matching degree and thus have good absorbing properties. Furthermore, another way to enhance the absorbing properties of CI is increasing the magnetic loss by electroless plating magnetic layer on CI particles. At the same time, using the magnetic layer (Ni, Co) can protect the particles from oxidation which has been proven. Previously, Jia et al. [9] through electroless plating prepared Ni coated CI particles, and the reflection below −10 dB could be obtained in the whole X band, which shows good absorbing properties compared with raw CI particles. Compared with Ni, Co is also a good candidate as magnetic layer to protect the CI from oxidation and also accompanied by good magnetic properties. However, there was seldom report about using Co coated CI to prepare core shell structure as absorbent.

In this paper, a core shell structure Co(CI) particles are fabricated through electroless plating method, and the effect of core shell structure on the electromagnetic and microwave absorbing properties is investigated. Furthermore, the influence of Co layer on the heat resistance of Co(CI) particles is also studied and compared.

2. Experimental

2.1. Sample preparation

CI particles with average diameter of 1–5 μm were obtained from Xinghua Chemical CO. Ltd, Shaanxi Province, China, which

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Table 1
The chemical composition of the electroless plating Co.

$CoSO_4 \cdot 7H_2O$ (g/L)	$NaH_2PO_2 \cdot H_2O$ (g/L)	$C_6H_5Na_3O_7 \cdot 2H_2O$ (g/L)	NH_4Cl (g/L)	pH	Temperature (°C)
20	20	50	40	9.2	90

were produced by decomposition of $Fe(CO)_5$, the content of α-iron > 99.5 wt%, and polycrystalline microstructure. The

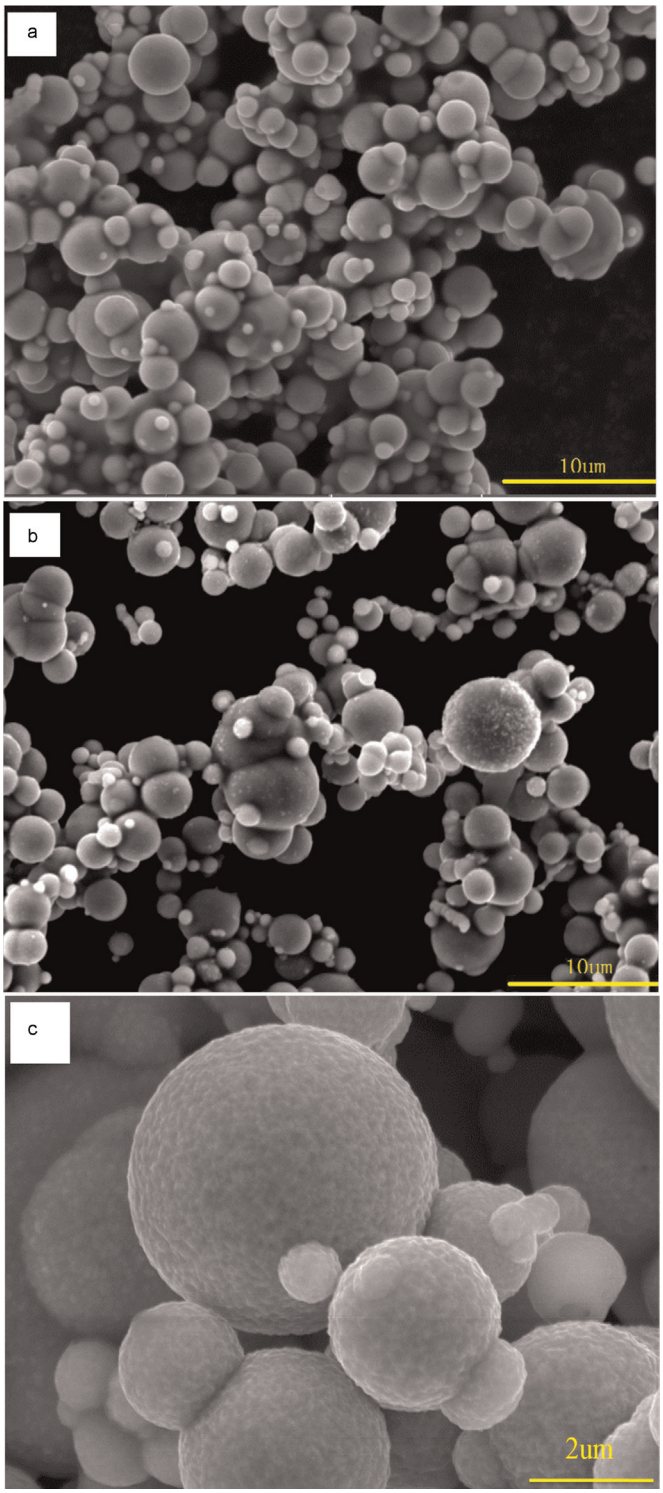

Fig. 1. The SEM of original CI particles (a), the low magnification of electroless plating Co(CI) particles (b) and (c) the high magnification of (b).

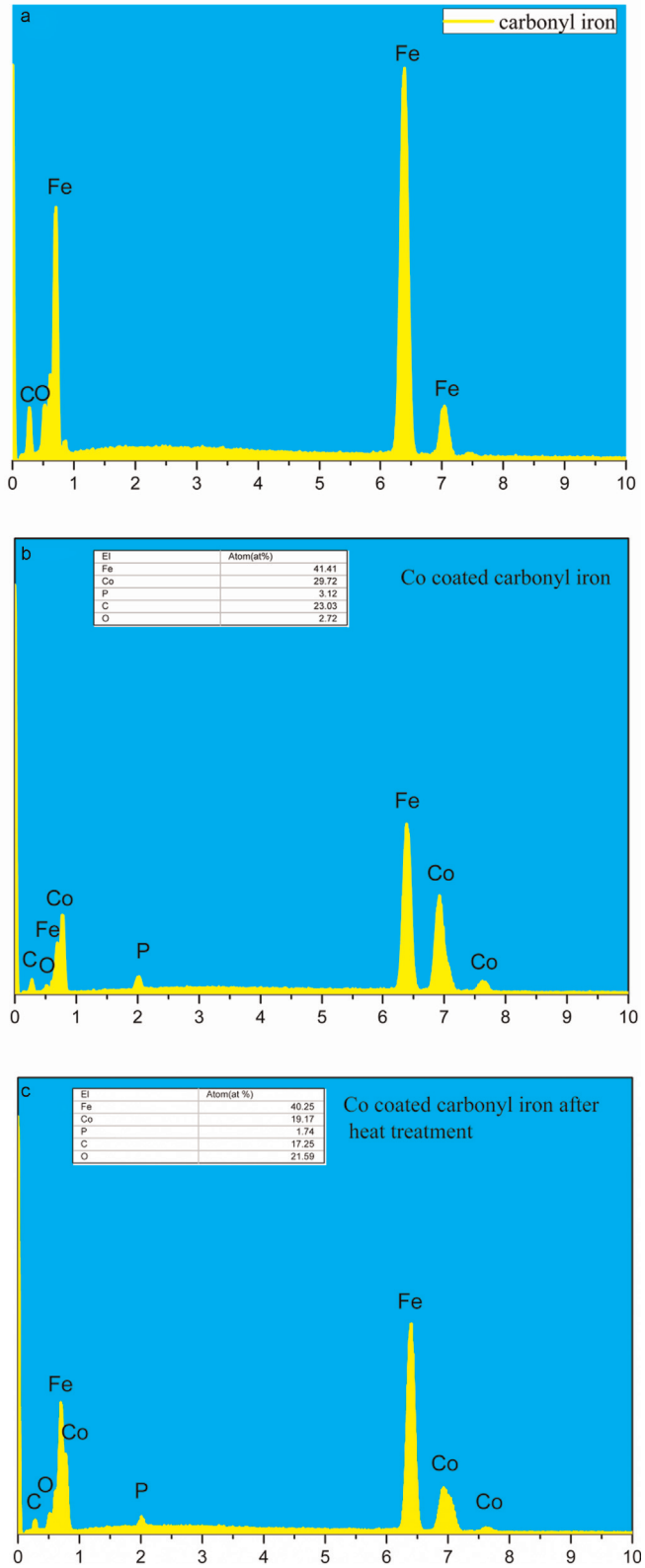

Fig. 2. The EDS spectra of original CI particles (a) and electroless plating Co(CI) particles before (b) and after (c) heat treatment.

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