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Preparation, characterization and magnetic properties of the $BaFe_{12}O_{19}$ @ chitosan composites

Lei Li [a], Zunju Zhang [b], Yu Xie [c, *], Jie Zhao [c, **]

[a] Qinhuangdao Branch School, Northeast Petroleum University, Qinhuangdao 066004, PR China
[b] Environmental Management College of China, Qinhuangdao 066004, PR China
[c] College of Environment and Chemical Engineering, Nanchang Hangkong University, Nanchang 330063, PR China

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ABSTRACT

The $BaFe_{12}O_{19}$ @ chitosan composites are synthesized by the crosslinking reaction through chitosan and glutaraldehyde onto the surface of $BaFe_{12}O_{19}$. The structures of the samples were characterized by Fourier transform infrared spectroscopy and X-ray diffraction. The shape and size were observed by scanning electron microscopy and transmission electron microscopy. These results showed that chitosan has been decorated onto the surface of $BaFe_{12}O_{19}$, and the chitosan-glutaraldehyde Schiff-base composites have also been formed within the chitosan layers. Then, the magnetic properties of the samples were tested with the vibrating sample magnetometer. The magnetic saturation (M_S), residual magnetization (M_r) and coercive force (H_c) values of the $BaFe_{12}O_{19}$ @ chitosan Schiff-base composite have achieved 44.94 emu/g, 27.82 emu/g and 3580.7 Oe, respectively. Compared with single $BaFe_{12}O_{19}$, the M_S, and M_r of the $BaFe_{12}O_{19}$ @ chitosan composites decreases 12.31 emu/g and 8.58 emu/g, respectively. Finally, based on the experimental results, the probable formation mechanism of this composite has been investigated.

1. Introduction

Recent years, studies of the magnetic properties of ferrite materials have drawn more and more attentions [1–3]. Among the magnetic materials, $BaFe_{12}O_{19}$ has become a research hotspot [4–7]. Some studies have indicated that $BaFe_{12}O_{19}$ can be widely applied to magnetic fluids [8], electromagnetic microwave absorber [9,10], high frequency devices [11,12] and density perpendicular recording media [13]. These applications benefit from the high curie temperature, large M_s, magneto-crystalline anisotropy, good corrosion resistivity and excellent chemical stability of $BaFe_{12}O_{19}$ [14,15]. However, the application of $BaFe_{12}O_{19}$ in microwave absorption has been limited due to its high-density, lower dielectric loss, narrow absorption bands and so on [16].

In electromagnetic fields, Schiff-base has been attracted widely interests [21–23] due to its lower density, easier processing, wider absorption bands as well as excellent microwave absorbing properties [24–29]. Chitosan, as the most abundant natural amino polysaccharide, possesses significantly cost-effectiveness, environmentally friendly and inherent chirality, and has become an important material to synthesize Schiff-base [17–20]. As an additive of electromagnetic composites, chitosan Schiff-base can adjust the permittivity and permeability of composites, and enhance the composites' electromagnetic loss. In this work, we firstly design and synthesize the $BaFe_{12}O_{19}$ @ chitosan composites. The preparation, characterization and magnetic property analysis of the $BaFe_{12}O_{19}$ @ chitosan composites are as follows.

2. Experimental

2.1. Materials

$BaFe_{12}O_{19}$ was synthesized by the sol-gel method [30]. Chitosan (with a degree of deacetylation > 90.0%) was purchased from Sinopharm Chemical Reagent Co. Ltd., and other chemicals were all analytical grade.

2.2. Synthesis of the $BaFe_{12}O_{19}$ @ chitosan composites

2.0 gr chitosan was dissolved into 50 mL diluted acetic acid

* Corresponding author.
** Corresponding author.
E-mail addresses: yu_xie1234@163.com (Y. Xie), jiezhaoyjs@163.com (J. Zhao).

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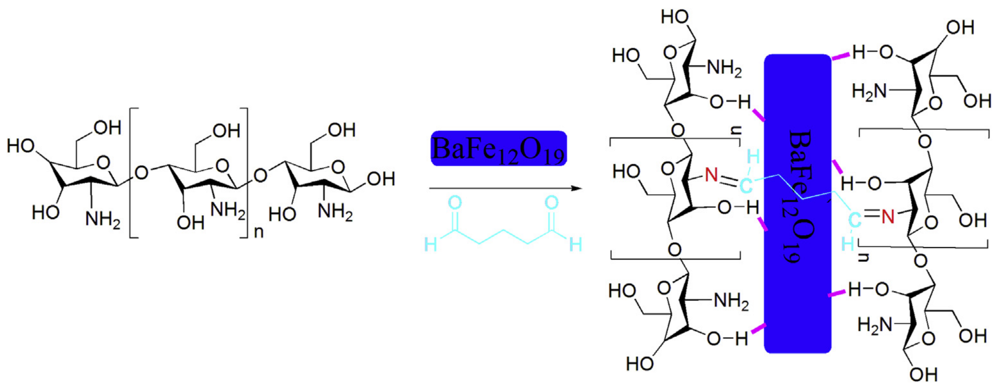

Fig. 1. The proposed preparation scheme of the $BaFe_{12}O_{19}$ @ chitosan composites.

(pH = 1). Then 2.0 gr $BaFe_{12}O_{19}$ was added into above the solution with ultrasonic treatment for 0.5 h. After that, 10 mol/L NaOH solution was slowly dropwise added into the above the solution with the pH value of 13. The mixture was heated to 60 °C. Then, 0.5 mL of the 25% glutaraldehyde were added into the mixture stirring for 2 h. Finally, the precipitate was filtrated and washed by deionized water, ethanol, acetone, respectively. The product was obtained under vacuum at 50 °C for 12 h.

2.3. Characterization

Fourier transform infrared (FTIR) spectra was obtained using Nicolet 5700 FTIR with KBr method. X-ray diffraction (XRD) patterns of the samples were characterized by using a philps-pw3040/60 diffractometer with Cu Kα radiation (λ = 0.15418 nm). The morphologies and the microstructure of the synthesized samples were observed by a scanning electron microscopy (SEM, Nova NanoSEM450) and a transmission electron microscope (TEM, JEOL JEM2010), respectively. A Lakeshore 7404 vibrating sample magnetometer was used to measure the magnetization of the samples in applied magnetic fields over the range of −10 to +10 kOe at room temperature.

3. Results and discussion

3.1. Proposed preparation scheme of the $BaFe_{12}O_{19}$ @ chitosan composites

Fig. 1 illustrates the preparation process of the $BaFe_{12}O_{19}$ @ chitosan Schiff-base composites. First, chitosan is deposited onto the surface of the $BaFe_{12}O_{19}$ through the $BaFe_{12}O_{19}$···H–O– interactions under the environment of glutaraldehyde at the pH of 13. Second, the $BaFe_{12}O_{19}$ @ chitosan composites are formed at 60 °C stirring for 2 h through the crosslinking reaction between chitosan and glutaraldehyde onto the surface of $BaFe_{12}O_{19}$. The characterization is discussed as follows.

3.2. FTIR analysis

Fig. 2 shows the FTIR spectra of $BaFe_{12}O_{19}$, the $BaFe_{12}O_{19}$ @ chitosan composites. In Fig. 2a, the characteristic peaks of $BaFe_{12}O_{19}$ are at 584 and 432 cm^{-1} with slightly shift compared with the literature [31]. The peaks at 584 and 432 cm^{-1} can be attributed to Fe(Ba)–O stretching vibration. From the insert pattern, Fig. 2b shows the characteristic peaks of the $BaFe_{12}O_{19}$ @ chitosan composites at 1719, 1547, 1152, 1072, 1026, 584 and

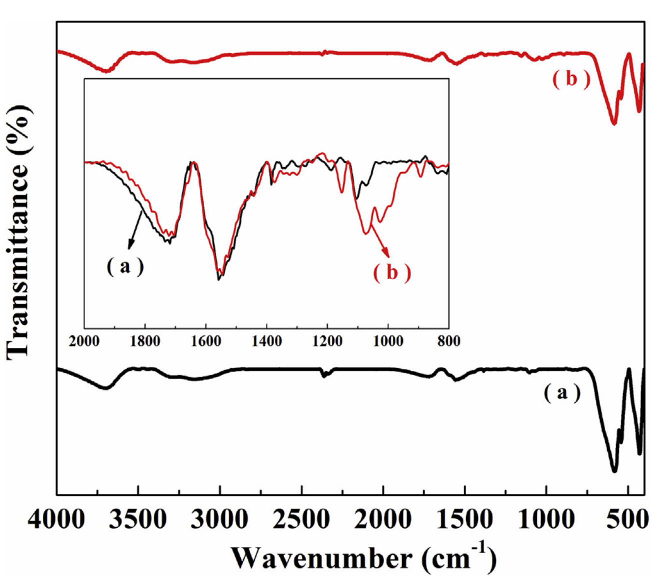

Fig. 2. FTIR spectra of (a) $BaFe_{12}O_{19}$ and (b) the $BaFe_{12}O_{19}$ @ chitosan composites.

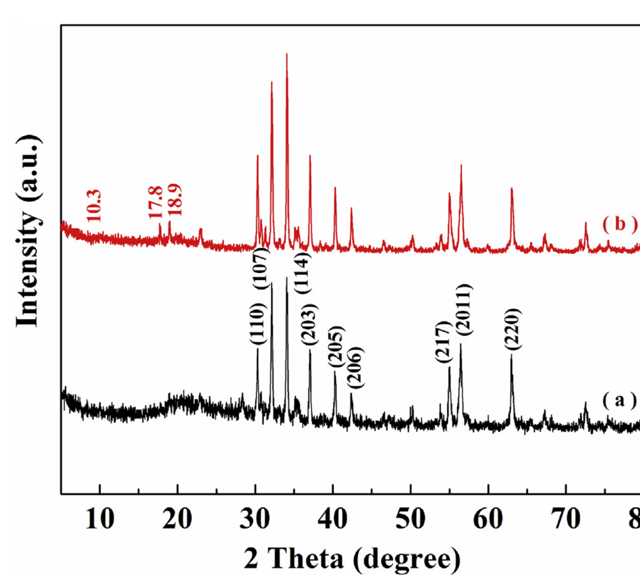

Fig. 3. XRD spectra of (a) $BaFe_{12}O_{19}$ and (b) the $BaFe_{12}O_{19}$ @ chitosan composites.