A herbal extract for the synthesis of magnetite nanoparticles

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Abstract

In this work, we present a novel green and cost-efficient method for synthesis of superparamagnetic magnetite nanoparticles with an average diameter of 30-46 nm by coprecipitation method and using Acanthophyllum Bracteatum extract as surfactant. We used soxhlet extractor as extraction technique. The sample was characterized by vibrating sample magnetization (VSM), scanning electron microscopy (SEM), X-ray diffraction (XRD) and fourier-transform infrared spectroscopy (FTIR).

Keywords: Green Synthesis, Herbal Extract, Magnetite, Nano particles

1. Introduction

Recently, great efforts were made to use green and environmentally friendly methods for the synthesis of nano size materials. These efforts involve the use of plant or fruit extracts as surfactants [1,2]. Plant parts such as leaf, root, latex, seed, and stem are being used for metal nanoparticles synthesis [3]. The greener environmentally friendly processes in chemistry and chemical technology are becoming increasingly popular. The techniques for obtaining nanoparticles using naturally occurring reagents such as plant extracts, could be considered attractive for nanotechnology.

Magnetic nanoparticles have attracted a great attention due to their unique physical, chemical and structural properties when the particle sizes approach to nanoscale. It is these unique features that endow magnetic nanoparticles with wide applications, such as magnetic storage, catalysis, microwave absorption, magnetic resonance contrast, cancer hyperthermia, cell separation and drug delivery [4]. Therefore, more and more efforts have been devoted to the synthesis of magnetic nanoparticles recently. Many preparation routes, including coprecipitation, sonochemistry, colloidal method, combustion synthesis, solvothermal synthesis, hydrothermal method, microemulsion method and thermal decomposition have been reported [5]. Iron oxides exist in many forms in nature, with magnetite (Fe_3O_4), maghemite (γ-Fe_2O_3), and hematite (α-Fe_2O_3) being probably the most common [6]. In this study, nanosize particles of iron oxide were synthesized by coprecipitation method and using Acanthophyllum Bracteatum extract as surfactant. Such a novel method for the synthesis of magnetite nanoparticles has not yet been reported.

2. Experimental

All the reagents were of analytical purity, and were used without further purification. 0.1 M solutions of $FeCl_2.4H_2O$, $FeCl_3.H_2O$ and NaOH were prepared. To synthesize Fe_3O_4 nanoparticles, we loaded $FeCl_2.4H_2O$ and $FeCl_3.H_2O$ with the ratio of 1:2 into a 500 mL three-neck flask which was magnetically stirred under a flow of nitrogen gas. Afterwards, Acanthophyllum Bracteatum extract was added and the obtained mixture was stirred and heated for 15 min. under ambient conditions, 200 mL of NaOH solution was added into the vessel. After the reaction mixture was adequately mixed under magnetic stirring for 45 min, the black solution was cooled to room temperature. Magnetite nanoparticles were washed with water and ethanol for many times, then dried for characterization.

3. Results and discussion

The XRD patterns of prepared products are shown in Fig. 1. Six characteristic peaks can be indexed as the cubic structure of Fe_3O_4. The peaks correspond to the crystal planes (220), (311), (400), (422), (511), (440) of crystalline Fe_3O_4. The average crystallite sizes are calculated using Scherrer's equation ($D= K \lambda / B \cos\Theta$), which gives 9.8 nm for (311) peak.

Table 1

X-ray diffraction data

hkl	**(220)**	**(311)**	**(400)**	**(422)**	**(511)**	**(440)**
2Θ (deg)	30.091	35.444	43.076	53.439	56.966	62.554
d (A°)	2.96737	2.53058	2.9825	1.71321	1.61523	1.48369

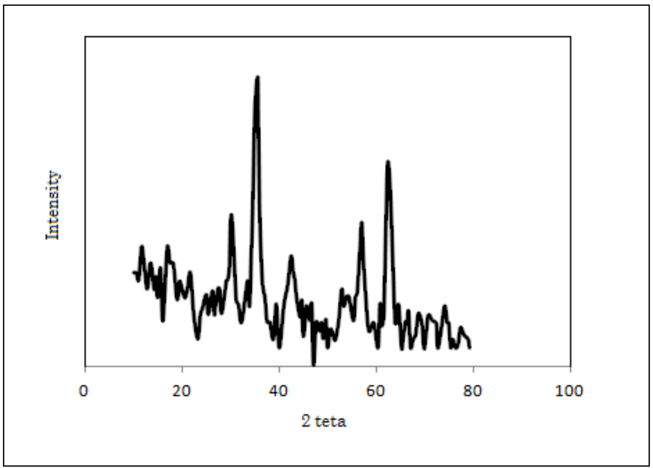

Fig. 1. XRD pattern of the product.

The surface chemical structure of the magnetite nanocrystals was characterized by fourier transform infrared (FTIR) spectroscopy (Fig. 2). The broad band 3410 cm^{-1} is due to the O–H stretching vibration attributed for water molecules adsorbed to the nanoparticles surface. The peak at 1615 cm^{-1} can be ascribed to the CO_2 from the air. The strong absorption band at about 580 cm^{-1} is due to Fe–O stretching vibration for the Fe_3O_4 nanoparticles.

Fig. 2. FTIR spectra of the product.

The morphology of magnetite nanoparticles was revealed by SEM technique (Fig. 3), that shows the pseudo-spherical morphology for the product.

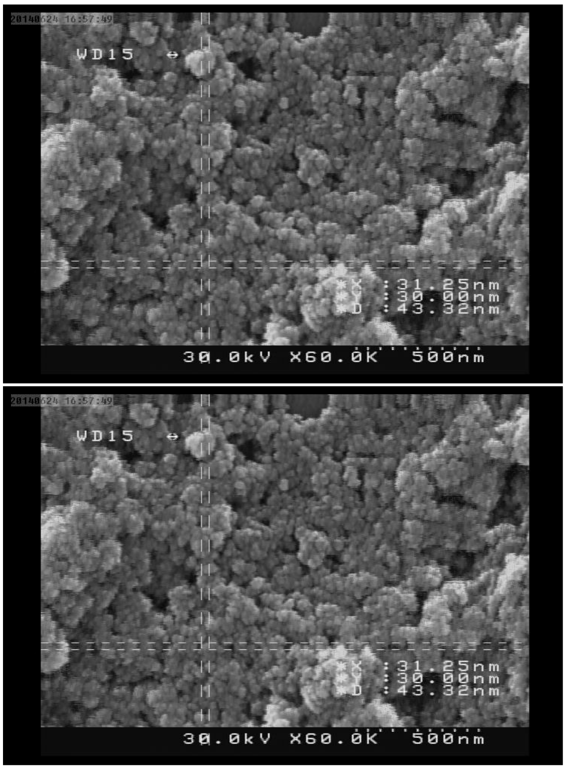

Fig. 3. SEM images of the product.

Fig. 4 shows the magnetization curve measured for the product. Zero coercivity and zero remanence on the magnetization curve indicate superparamagnetic behavior of the magnetite nanoparticles, and the saturation magnetization of the magnetite nanoparticles is 48.99808 emu/g.

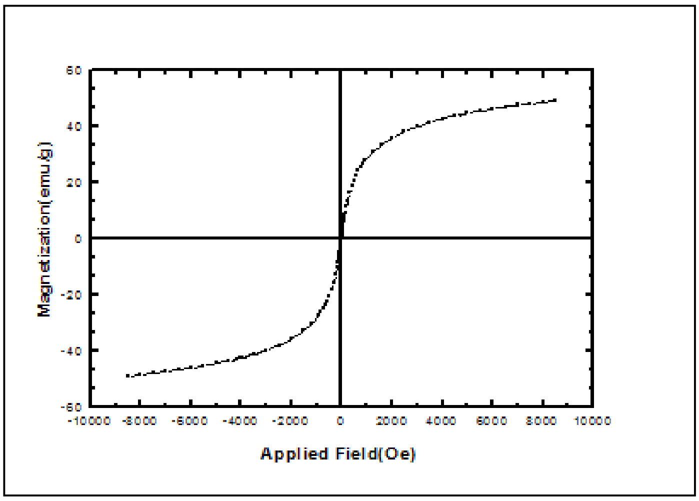

Fig. 4. M–H curve of the product.

4. Conclusion

This study presents a novel and environmentally friendly method that can be extended to prepare nanoparticles of other iron oxides. Magnetite nanoparticles have been successfully synthesized by coprecipitation method and use of Acanthophyllum Bracteatum plant extract as surfactant. The results show the pseudo-spherical morphology with an average diameter of 30-46 nm, and superparamagnetic behavior for the product.

5. References

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