



Degradation and removal of organic pollutants by BaFe_2O_4 nanostructures, synthesis and characterization

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ABSTRACT: BaFe_2O_4 nanostructures have been synthesized through a simple sonochemical reduction approach. X-ray diffraction characterization suggested that the product consists of cubic phase pure BaFe_2O_4 . The as-prepared products were also characterized by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). An X-ray energy dispersive spectroscopy (EDX) study further confirmed the composition and purity of the product. The synthesis procedure is simple and uses less toxic reagents than the previously reported methods. Other factors, such as the reaction time, temperature, different capping agent and the reductant type also have an influence on the morphology of the final products to some extent. The photocatalytic activity of the synthesized products has been compared for degradation and removal of organic pollutants.

Keywords: BaFe_2O_4 nanostructures; Degradation; Organic pollutants; Sonochemical ; SiO_2 ; TiO_2

INTRODUCTION

Over the last twenty years, a great deal of work has gone in to understanding the properties of matter at the nanometer scale. One class of mesoscopic system receiving a lot of attention is colloidal semiconductor quantum dots (QDs) or nanocrystals (NCs). Progress in this area has benefited from the dynamic interplay between advances in synthesis, optical characterization and theory. Despite this synergy, a major bottleneck in this field has traditionally been the availability of high quality, crystalline samples with narrow size distributions, high photoluminescence efficiencies and controlled surface chemistries. II–VI materials, in par-

ticular, have led to new opportunities for a better understanding and to utilize the size-dependent optical and electrical behavior of QDs as a result of the discovery in the early 90s by Murray and others that one could make high-quality QDs through the thermolysis of pyrophoric organometallic reagents.

The existing BaFe_2O_4 nanostructures syntheses that have been reported largely deal with solvothermal or solvent-based approaches for making these compounds. These approaches entail sonochemistry, microwave-assisted heating and the thermolysis of common mercury precursors. Other methods make use of metal ion impregnated Langmuir Blodgett films or other restricted environments such as vesicles or sol–gel net-

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works to grow BaFe_2O_4 nanostructures. Recently, the hydrothermal method has also been reported to prepare BaFe_2O_4 nanostructure materials, which has the potential advantages of relatively low cost, high purity and controlled morphology (Singh, *et al.*, 2007, Ding, *et al.*, 2003, Kristl and Drofenik, 2008). In this work, I report on BaFe_2O_4 nanostructures prepared by the simple sonochemical method, and compare the difference in then nanostructure of BaFe_2O_4 synthesized with a different reductant type.

MATERIALS AND METHOD

All of reagents and solvents were purchased from Merck (proanalysis) and were dried using molecular sieves (Linde 4 Å). XRD patterns were recorded by a Rigaku D-max C III, X-ray diffractometer using Ni-filtered Cu K α radiation. Scanning electron microscopy (SEM) images were obtained on a Philips XL-30ESEM equipped with an X-ray energy dispersive detector. Transmission electron microscopy (TEM) images were obtained on a Philips EM208 transmission electron microscope with an accelerating voltage of Paper Preparation.

RESULTS AND DISCUSSION

The composition of the as-prepared product was determined by XRD. All peaks in the patterns correspond to the reflections of cubic phase BaFe_2O_4 , with lattice constants $a = 6.0720$ Å (JCPDS 46-0113). No remarkable diffractions of other phases, such as barium, iron or their other compounds can be

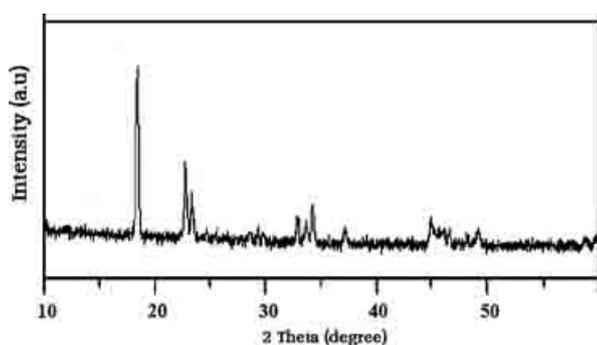


Fig. 1. XRD pattern of BaFe_2O_4 nanostructures

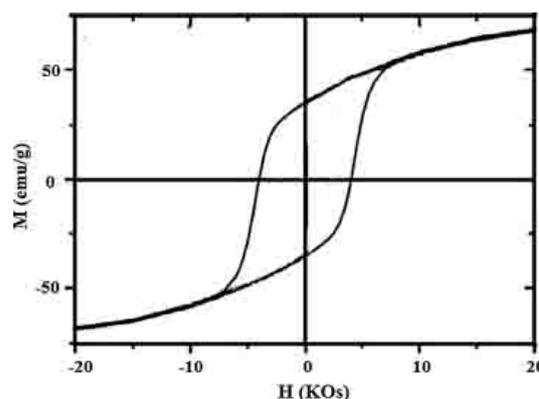


Fig. 2. Magnetization versus applied magnetic field at room temperature for the obtained BaFe_2O_4 nanostructures

found, indicating that a crystalline BaFe_2O_4 phase has been formed after the synthesis for all samples. The broadening of the diffraction peaks indicates that the samples are nanosized. The average particle size of the sample is about 25 nm, estimated through the Scherrer formula (Fig. 1).

The photocatalytic activity of the BaFe_2O_4 nanostructures was evaluated by monitoring the degradation of MB in an aqueous solution, under irradiation with visible light. Without light or nanostructures, nearly no MB was break down after 300 min, revealing that the contribution of self-degradation was insignificant. However, BaFe_2O_4 nanostructures exposed high photocatalytic activity. The heterogeneous photocatalytic processes include many steps, such as diffusion, adsorption and reaction, appropriate distribution of the pore is advantageous to diffusion of reactants and products, which prefer the photocatalytic reaction. In this research, the enhanced photocatalytic activity may be ascribed to suitable distribution of the pore, high hydroxyl content and high separation rate of photo induced charge carriers (Fig. 2).

CONCLUSIONS

In summary, this work has demonstrated a new approach for the controllable growth BaFe_2O_4 nanostructures via reductant exchange. This route to BaFe_2O_4 nanostructures is simple, convenient and effective, and holds potential for the large-scale synthesis needed for commercial applications. Most important of all, this new approach can yield a rod-like morphology of

BaFe₂O₄ nanostructures directly, without mechanical crushing and sieving as is need for a solidified melt, which may result in enhanced thermoelectric properties being exhibited. The synthesized BaFe₂O₄ nanostructures can be used in some analytical applications such as removal of methylene blue dye, since the %uptake was found to be >55% within 300 min.

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