Synthesis and characterization of Barium Hexaferrite particles by sol–gel auto combustion method

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Abstract- M type Barium hexagonal ferrite ($BaFe_{12}O_{19}$) has been synthesized by Sol-gel auto combustion route. The effect of sintering temperature on structural and magnetic properties is investigated in detail. The prepared precursors calcined at temperatures in the range of 250 ^oC – 950 ^oC and characterized by FTIR, XRD and VSM. Result revealed that increasing the annealing temperature leads to decrease the intermediate phase such as γ-Fe_2O_3, α – Fe_2O_3 and $BaFe_2O_4$ whereas the $BaFe_{12}O_{19}$ increases and appears as a major phase at 950^{o}C. Magnetic measurement shows that particle formed is single domain with no nonmagnetic impurities.

Introduction

In recent years, nanoparticles of ferromagnetic metals such as Fe, Co, and Ni attract more and more interests in terms of their special physical properties and potential application in catalysts, high density magnetic recording media, medical diagnostics [5], ferrofluids and biomedical fields. In this paper we report the formation of Barium hexaferrite nanoparticles directly from a citrate precursor by a self ignition reaction and its annealing studies [1, 2].

Experimental procedure

Analytical grade Barium nitrate, iron nitrate, citric acid and Ammonia were used as raw material to prepare BaFe12O19 hexaferrite. Nitrates were dissolved in a minimum amount of distilled water .Citric acid in the ratio of 1:1 to total moles of nitrate ions was then added into the prepared aqueous solution to chelate Ba^{2+} and Fe^{3+} in the solution. The mixed solution was neutralized to pH 7 by adding liquor ammonia. The neutralized solution was evaporated to dryness by heating at 80^{o}C on a hot plate with continuous stirring. As water evaporated the solution became viscous and finally formed a very viscous brown gel. Increasing the temperature led to the ignition of the gel. The dried gel burnt in a self propagation combustion manner until all gels are completely burnt out to form a loose powder. The fine powders thus obtained were calcined in air at 250 ^oC, 500 ^oC and 950 ^oC to achieve ordered ferrite nano particles. Synthesized powders were characterized by FTIR, XRD, SEM and VSM.

Result and Discussion

FTIR spectra of the self ignited and annealed samples were recorded to confirm the formation of Barium ferrite phase and to understand the nature of the residual carbon in the samples. The strong absorption between 580 cm^{-1} and 440 cm^{-1} which confirm formation of ferrite. There are some weak and broad absorption corresponding to the presence of small amount of residual carbon in the samples as usually observed in citrate precursor method. Heat treatment leads to disappearance of this absorption indicating complete removal of residual carbon from the samples. XRD pattern of as-burnt powder, which indicates the presence of γ-Fe_2O_3 as a major phase and some small reflections of minor phase such as $BaCO_3$ and $BaFe_{12}O_{19}$. By increasing the annealing temperature to 950^{o}C, $BaFe_{12}O_{19}$ appears as a major phase and α-Fe_2O_3 and $BaFe_2O_4$ as minor phases are detected. During annealing $BaCo_3$ decomposes and Ba^{2+} librated reacts with γ or α-Fe_2O_3 to form a small amount of barium monoferrite ($BaFe_2O_4$).The reaction between barium

monoferrite and iron oxide leads to formation of barium hexaferrite. The sample heated at 500 °C followed by 950 °C shows pure phase of barium hexaferrite. Magnetic measurement shows that the barium ferrite samples annealed at 950 °C has the maximal coercive field of 4625 Oe corresponding to the maximal remnant magnetization of 30.0 emu/g

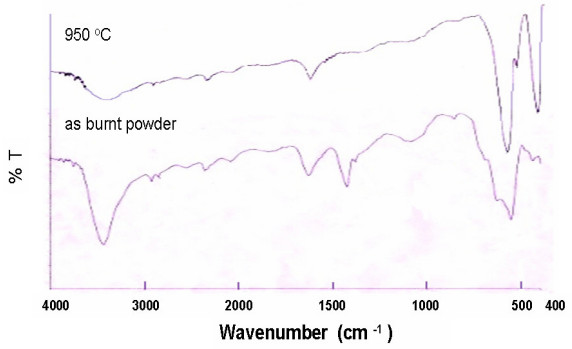

Fig. 1- FTIR spectra of samples

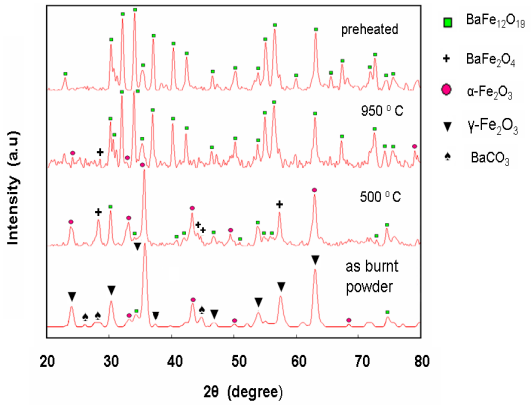

Fig. 2- XRD for the samples heated at different temperature.

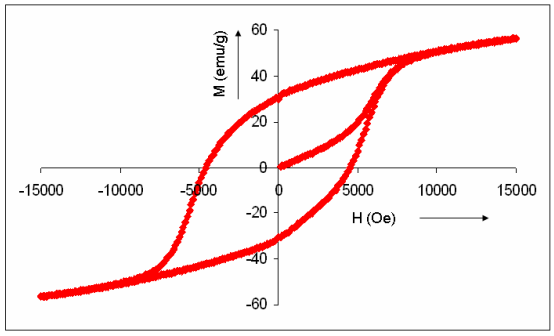

Fig. 3- Hysteresis loop for the sample at 950 °C.

Conclusion

The single phase $BaFe_{12}O_{19}$ nano-powders have been successfully synthesized via sol–gel auto-combustion technique. The obtained particles are 50 to100 nm in diameter and containing single magnetic Domains. Annealing improves the structural and magnetic properties of the samples synthesized with our method.

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