Micro-structures and magnetic properties of Mg-Al substituted in barium hexa-ferrite prepared by co-precipitation method

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Abstract. In this study, Mg-Al substituted barium hexa-ferrite of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x=0-0.2) materials using co-precipitation method at a calcination temperature of 1200^{o}C for 2 hours were carried out. The precursor concentrations of the mixture were varied to identify the optimum sample. The final powder was characterized by using XRD, FE-SEM, and VSM. The XRD shows that the Mg-Al substitution was not change the micro-structures of barium hexa-ferrite. FE-SEM observation was carried out on the surface of hexagonal shape of barium hexa-ferrite. The magnetic properties shows that the decreases saturation (Ms), remanence (Mr) and coercivity (Hc). The optimum condition was obtained on x=0.2 with Ms= 29.28 emu/g, Mr= 15.33 emu/g, Hc= 1259 Oe.

1. Introduction

Barium hexa-ferrite ($BaFe_{12}O_{19}$) is one of hard magnetic materials with high magnetic saturation and coercivity, excellent corrosion resistance and chemical stability [1–4]. Many reports are available for the synthesis and characterization of the barium hexaferrite substituted with various cations such as: Mn, Al, Mg, Co, Ni, Ti, Zn for Fe [5-12].

Previous study on the barium hexa-ferrite doped Al and Mn (0.12, 0.24; and 0.42 wt%) sintered at 1000 and 1100 °C for 2 hours [13]. The results suggested that show decrease of the magnetic flux, saturation, and remanence values as the additive concentration increases. Shaayan et al. [14], reported that the synthesis of $BaFe_{12-x}Al_xO_{19}$ at a calcination temperature of 1100 °C for 9 h using a mechanical alloying method, resulted that the decrease of the saturation magnetization in addition of Al. Kumar et al. [15] reported that the synthesis of $BaMg_xFe_{(12-x)}O_{19}$ using the sol gel method with calcination temperature at 1100^{o}C for 2 hours. The results confirmed that, Mg has been substitution in $BaFe_{12}O_{19}$ with single phase hexagonal structure.

In this study, Mg-Al substituted barium hexa-ferrite of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x=0-0.2) materials using co-precipitation method at a calcination temperature of 1200^{o}C for 2 hours were carried out.

2. Experimental Method

Barium hexa-ferrite with doping materials of Mg-Al (x=0-0.2) were synthesized using a co-precipitation method where barium chloride ($BaCl_2$), iron chloride ($FeCl_3$), magnesium chloride ($MgCl_2$), and aluminium chloride ($AlCl_3$) were used as the raw materials. The materials were dissolved in 25 ml of HCl (37%) and magnetically stirred for 30 minutes at room temperature. The solution was then mixed with aquadest of 50 ml in a beaker glass and

was stirred using a magnetic stirrer at 500 rpm until homogeneous solution is obtained. The solution was washed 10 times using distilled water until a neutral pH of 7 is obtained and was dried in the oven for 15 hours at a temperature of 100 °C. Then, the powder was calcinated at a temperature of 1200°C for 2 hours and at a heating rate of 10 °C/minutes.

The final powder of barium hexa-ferrite material were analysed using X-ray Diffraction (Rigaku Smartlab), Field Emission Scanning Electron Microscopy (JEOL), Vibrating Sample Magnetometer (VSM250 Dexing Magnet Ltd).

3. Result and Discussion

Figure 1 shows the XRD pattern of Mg-Al substituted barium hexa-ferrite calcinated at a temperature of 1200ºC. The samples with substituted of Mg-Al have single phase of $BaFe_{12}O_{19}$ with hexagonal crystal structure. In addition, the additive is likely occur as the ions, where Mg-Al ions replace Fe ions [16].

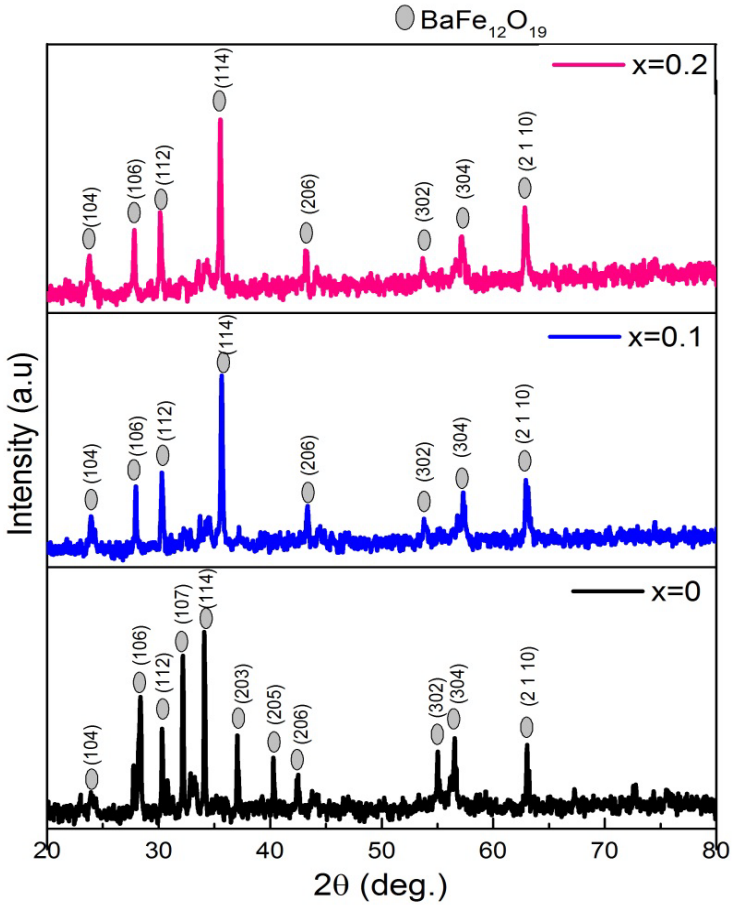
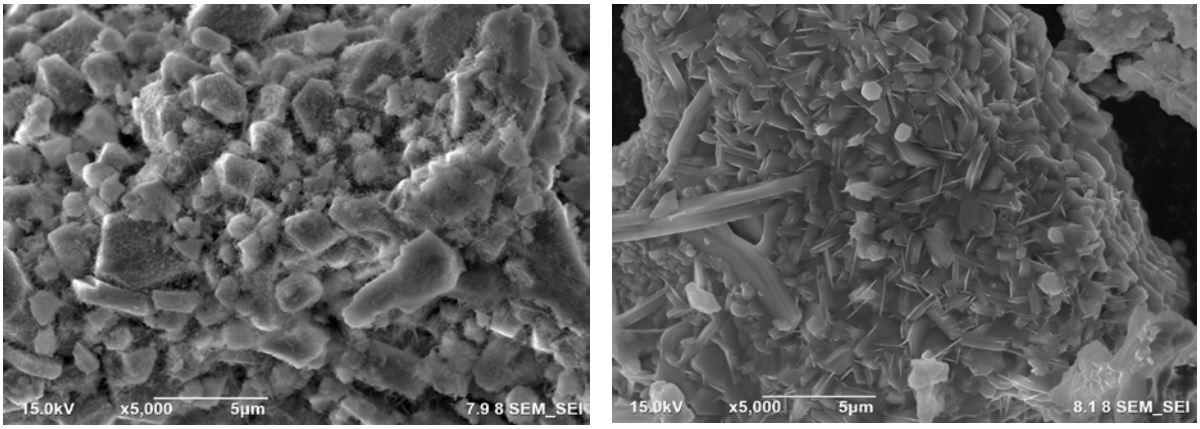


Figure 1. The XRD Patterns: $BaFe_{12-2x}Mg_xAl_xO_{19}$ powder samples (x=0-0.2)

Figure 2 shows that the FE-SEM images of $BaFe_{12-2x}Mg_xAl_xO_{19}$ powder samples (x=0-0.2) prepared by co-precipitation method after temperature calcination at 1200ºC for 2 hours in the air atmosphere. From Figures 2 for all FE-SEM images, it can be seen that the particle inside the sample was grown with relatively uniform shape. The particles were nearly hexagonal shape with average 5 µm.



(a) (b)

Figure 2.FE-SEM image of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (a) x=0 (b) x=0.2

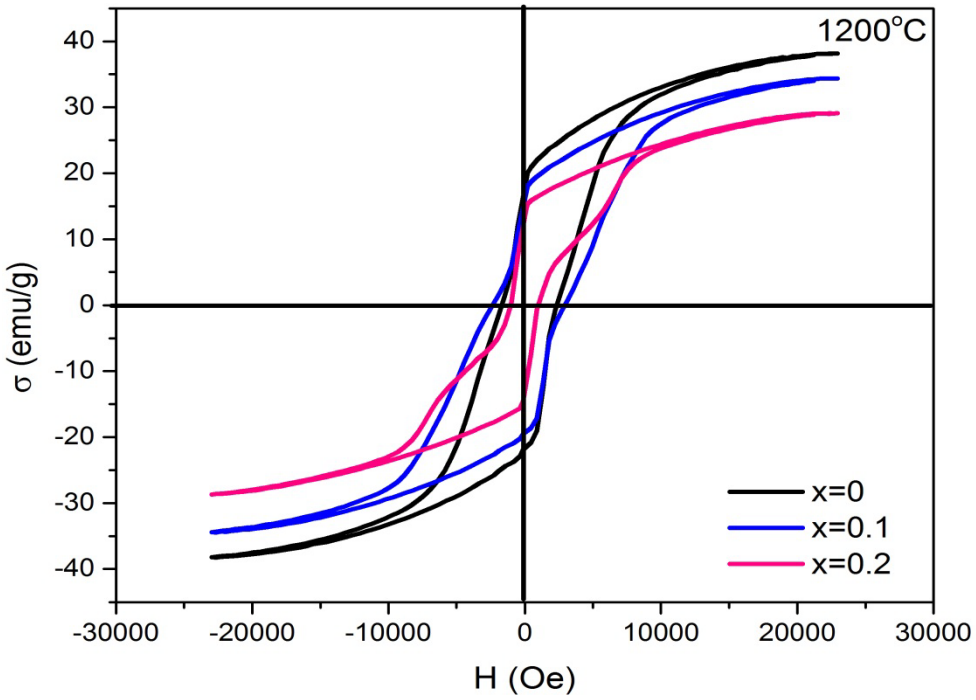


Figure 3.Hysteresis Curve of $BaFe_{12-2x}Mg_xAl_xO_{19}$ Powder (x= 0-0.2)

Table 1.Magnetic Properties of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x=0-0.2)

Sample	**Magnetic Properties**		
	Ms (emu g^{-1})	**Mr (emu g^{-1})**	**Hc (Oe)**
0	38.42	20.39	1736
0.1	34.25	18.07	2576
0.2	29.28	15.33	1259

Figure 3 represents that the hysteresis curves of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x=0-0.2). The characteristic magnetic parameters of $BaFe_{12-2x}Co_xNi_xO_{19}$ (x=0-0.2) are listed in Table 1. It can be seen that the substitution of the Mg-Al ions caused decrease the values of Saturation (M_s), Remanent (M_r), Coercivity (H_c). The decreases in magnetic parameters were due to the net alignment of grain magnetization. Considering the above results, Mg and Al have paramagnetic of magnetic properties, then Fe is ferromagnetic [16].

4. Conclusion

Mg-Al substituted barium hexa-ferrite of $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x=0-0.2) materials using co-precipitation method at a calcination temperature of 1200^{o}C for 2 hours were carried out. The XRD shows that the Mg-Al subtitution was not change the micro-structures of barium hexa-ferrite. FE-SEM observation was carried out on the surface of hexagonal shape of barium hexa-ferrite. The magnetic properties shows that the decreases saturation (Ms), remanence (Mr) and coercivity (Hc). The optimum condition was obtained on x=0.2 with Ms= 29.28 emu/g, Mr= 15.33 emu/g, Hc= 1259 Oe, and is suitable as an absorber of micro-wave material.

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