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Synthesis and Characterization of Electromagnetic Material Based On Composite of *Barium M-Ferrite* and *Zinc Oxide*

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ABSTRACT

The making of composites $BaFe_{12}O_{19}$/ZnO has been done with Wet Milling method used media toluene. Barium M-Ferrit as a matrix and Zinc Oxide as a filler used as the main raw material for composite manufacturing. The milling process of Barium M-Ferrit was done for 12 hours using the High Energy Milling (HEM). Furthermore, the calcination process used furnace at 900 ° C for 4 hours. While Zinc Oxide is milled for 3 hours and calcined at a temperature of 500 °C for 3 hours. The results of Barium M-Ferrit and zinc Oxide mixed using wet milling touluene media for 15 minutes and dried for 1 hour at 200 °C. X-ray diffraction (XRD) showed that $BaFe_{12}O_{19}$ as a matrix and ZnO as filler with hexagonal crystal structure was formed and the peak showed a single phase, where each $BaFe_{12}O_{19}$ lattice parameter a = 5.8930 Å, c = 23.1940 Å and ZnO lattice parameter a = 3.2533 Å, c = 5.2073 Å. Characterization Vibrating Sample Magnetometer (VSM) obtained the value of magnetic properties $BaFe_{12}O_{19}$ powder (matrix) obtained (Ms) magnetic saturation 54.03 emu/g, (Mr) magnet remanent 33.06 emu/g, (Hcj) coercivity 2943 Oe and (BHmax) product energy 190 kGOe and Zinc Oxide as filler values (Ms) magnet saturation 7.84 emu / g, (Mr) magnet remanent 1.27 emu/g, (Hcj) coercivity 152.4 Oe and (BHmax) energy products 10 kGOe. The results of XRD on 50% mass of composites ZnO additions using match software have two phases, namely the presence of ZnO and $BaFe_{12}O_{19}$ phases which indicate that heterogeneous structures with hexagonal crystal structures. Composite magnetic properties obtained by adding 50% mass of ZnO were (Mr) magnet 39.40 emu/ g, coercivity 2728 Oe, (BHmax) product energy 110 kGOe and for composites 75% mass addition ZnO remanent 39.36 emu/g with coefficient of 1365 Oe and (BHmax) product energy was 60 kGOe.

Keywords : *Barium M-Ferrit, Zinc Oxide*, Composite, Coercivity, Remanence.

I. INTRODUCTION

$BaFe_{12}O_{19}$ (hexagonal M-type feritte) material with *space group* P 63 / mmc[1] It is currently interesting for researchers that *Barium M-hexaferrite is* widely used in magnetic recording media, *microwave* devices, communication devices, such as mobile phones, local area network systems, and radar systems.[2] *Barium hexaferrite* has a temperature *curie* relatively high, high coercivity value of high magnetic anisotropy fields, has excellent chemical stability and corrosion resistivity

It can be prepared into hard magnets and soft magnets depending on the arrangement of variations in the composition of $BaFe_{12}O_{19}$ and ZnO, making the crystal structure has a low degree of anisotropy with low coercivity. Ferrite-based soft magnets have high electrical resistivity to minimize energy losses due to *Eddy current* [3].

Barium M-hexaferrite has a high saturation magnetic polarization (78 emu / g), which consists of strong uniaxial anisotropy crystals, high Curie temperature (450 ° C) and large coercive field (6700 Oe), associated very well in chemical stability and corrosion resistance. Because it has a very large coercive field, the anisotropic properties of the material increase so that the nature of its absorption becomes increasingly weak. So as the main potential to be used as raw material in making composites.

Zinc Oxide (ZnO) is a hexagonal structured semiconductor with band gap width (˜ 3.3 - 3.7 eV) and exciton energy tied to ˜ 60 MeV at room temperature. ZnO also hosts inexpensive and environmentally materials that can be treated with different metal ions, including transition metal elements (Cr, Mn, Fe, Ni, Co, etc.)[4]. which has a density of 5.67 g / cm^3 and a high melting point[5].

II. METHODOLOGY

Material $BaFe_{12}O_{19}$ powders and ZnO, first as a matrix, Barium Ferrite powder reduce particle size using *High Energy Milling* (HEM) for 12 hours, then calcined for 4 hours at 900 °C. The second ingredient of *Zinc Oxide* as filler to reduce particle size using *High Energy Milling* (HEM) for 3 hours, then the milling powder is dried on the *Oven* for 4 hours, then calcined for 3 hours at 900 °C. Mixing raw materials in making $BaFe_{12}O_{19}$/ ZnO using High Energy Milling (HEM) includes several stages, Matrix, filler and composite samples were characterized using *X-Ray Diffraction* (XRD) to determine the phase and crystal structure, Picnometer to test powder density, *Vibrating Sample Magnetometer* (VSM) to determine the magnetic properties and Scanning Electron Magnetic (SEM) for know the morphology of $BaFe_{12}O_{19}$/ ZnO samples.

III. RESULTS AND DISCUSSION

1. Crystal Structure

Analysis of BaM crystal structure is done by using XRD at an angle between 15-65° which aims to identify the phases formed in the BaM. Figure 1 shows the XRD pattern of the BaM sample as a matrix and ZnO as a filler. For BaM powder (matrix) samples that have been milled with wet *miling* and *mixing* 12 hours and which are calcined at a temperature of 900 °C for 4 hours and ZnO powder (filler) *wet milling* and *mixing* 3 hours and calcined 500 °C for 3 hours. In Figure 2 and ZnO show the formation of a single phase and hexagonal crystal structure space group (P 63 / mmc) lattice parameters $BaFe_{12}O_{19}$ a = 5.8930 Å, c = 23.1940 Å and ZnO hexagonal space group crystal structure (P 63 / mc) lattice parameter a = 3.2533 Å, c = 5.2073 Å. The three highest peak intensity of $BaFe_{12}O_{19}$ is found in the field d (110), (017) and (114) with angles 2θ around (30.33), (32.21) and (37.10). It can be seen that the three highest ZnO peaks are in the plane (101, 002, 100) with an angle of 2θ in the amount of (36.25°, 34.42°, 31.80°).

Characterization of VSM (*Vibrating Sample Magnetometer*) obtained the value of magnetic properties $BaFe_{12}O_{19}$ (matrix) obtained (Ms) magnetic saturation 54.03 emu / g, (Mr) magnet remanent 33.06 emu / g, (Hcj) coercivity 2943 Oe and (BHmax) product energy 190 kGOe and *Zinc Oxide* as filler values (Ms) magnet saturation 7.84 emu/g, (Mr) magnet remanent 1.27 emu/g, (Hcj) coercivity 152.4 Oe and (BHmax) energy products 10 kGOe.

2. Magnetic Properties Analysis

Samples A (black), B (purple), C (light blue), D (blue) and E (red). In Figure 4. The hysteresis curve of the $BaFe_{12}O_{19}$/ ZnO 0%, 25%, 50%, 75% and 100% (wt%) prepared with a solid state reaction method. This study used Vibrating Sample Magnetometer (VSM) to analyze the magnetic properties of sample A; B; C; D and E. Measurements are made at room temperature in the atmosphere. The results of the VSM analysis on the hysteresis curve above can be seen that the saturation magnetic value (Mr), (Hcj) is getting smaller, the effect of the addition of BaFe $Composition_{12}O_{19}$. The composite saturation magnetic value (Ms) obtained from sample A; B; C; D; and E; in a row of 54.03, 45.74, 39.40, 39.36 and 7.84 emu / g. In addition, the coercivity value (Hcj) increases with the size of the composition of $BaFe_{12}O_{19}$. The amount of coercivity value generated from each sample A; B; C; D; and respectively 2943, 2821, 2728, 1365 and 152.3 Oe. The results show that the less $BaFe_{12}O_{19}$ is mixed with ZnO, decreasing

magnetic properties due to the magnetic properties of ZnO much smaller than the magnetic properties of $BaFe_{12}O_{19}$. While the remanent magnetic values (Mr) are generated from each sample A; B; C; D; and E; respectively 33.06, 24.60, 1720, 14.69 and 1.27 emu / g. the greater the remanent magnetic value (Mr), the greater the magnetic properties.

The addition of ZnO which is diamagnetic as a disturbance in magnet oxide ferrite, with a lower magnetic moment will reduce the magnetic properties of BaM. The addition of ZnO composition has reduced *hard magnetic* of BaM, so that BaM obtained *soft magnet*.

The coercivity and remanence magnetization of BaM particles (matrices) are different when compared to the addition of the ZnO composition which produces the opposite tendency. This difference is quite interesting, so it requires a more in-depth study. However, it is clear that the magnetic strength of the particles is influenced by the addition of the ZnO composition carried out.

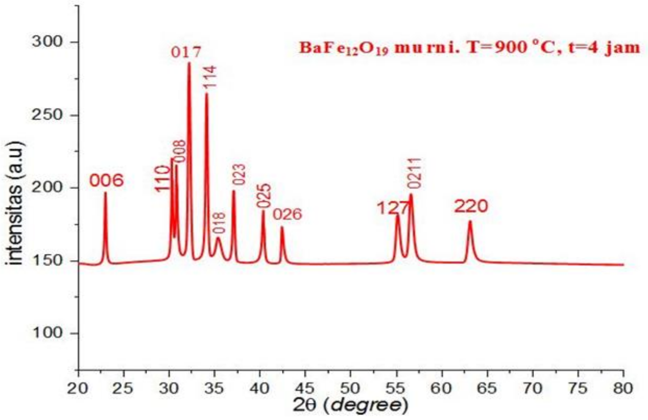

Figure 1. XRD pattern of $BaFe_{12}O_{19}$ (matrix)

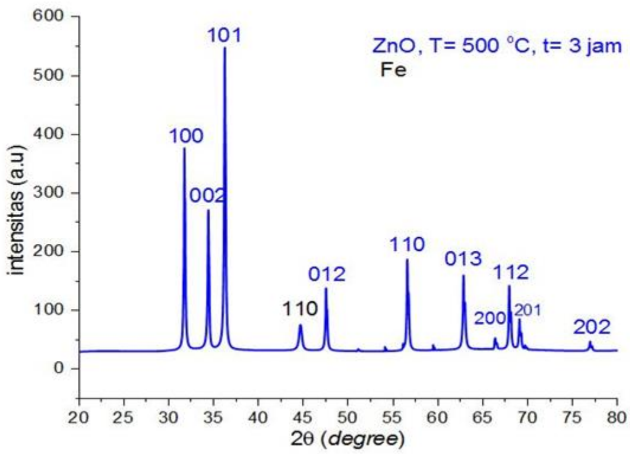

Figure 2. XRD pattern of ZnO (filler)

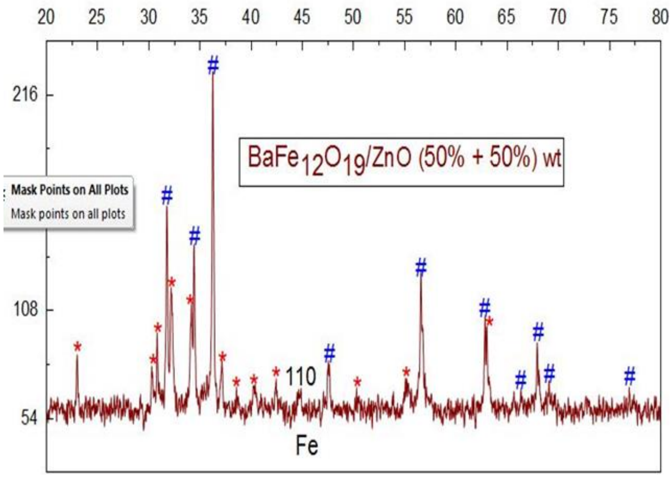

Figure 3. XRD pattern of BaFe12O19/ ZnO composite

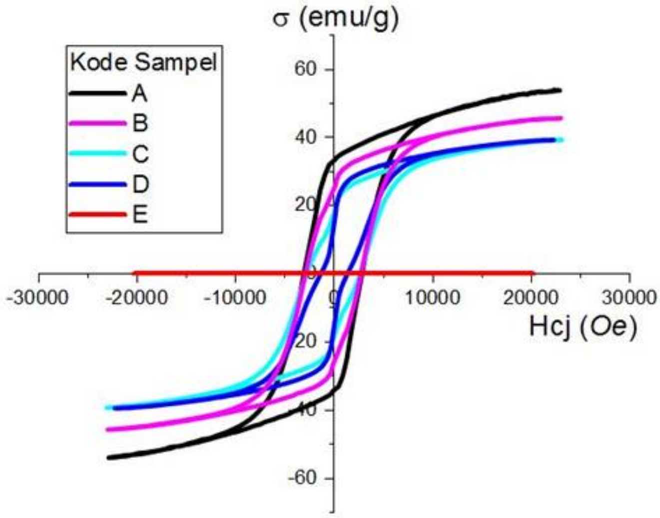

Figure 4. The magnetic field hysteresis curve (Ms), (Mr), (Hcj) influences the addition of % ZnO to $BaFe_{12}O_{19}$.

Scanning Electron Microscope

SEM analysis of $BaFe_{12}O_{19}$ images (a) and (c) are the forms of $BaFe_{12}O_{19}$ sample particles that have been grilled for 12 hours using High Energy Milling (HEM) with *wet milling* on tolouene media, shows the hexagonal crystal structure of most small grains, particle size of 3 μm, which has relatively smooth surface particles. For images (b) and (d) showing the micro and surface structure of $BaFe_{12}O_{19}$/ ZnO, almost all particles show hexagonal crystal structures and for average particle sizes below 0.5 μm. It appears that the greater the composition of ZnO, the surface morphology of $BaFe_{12}O_{19}$/ ZnO composites looks smoother and smaller. This is very closely related to the distribution of ZnO in $BaFe_{12}O_{19}$/ ZnO composites. Barium hexaferrite has quite high magnetic properties, so that between$BaFe_{12}O_{19}$ and ZnO particles tend to form aggregates. The higher ZnO composition, the aggregation between Barium hexaferrite grains will decrease, so that the surface morphology of $BaFe_{12}O_{19}$/ ZnO composites will appear smoother.

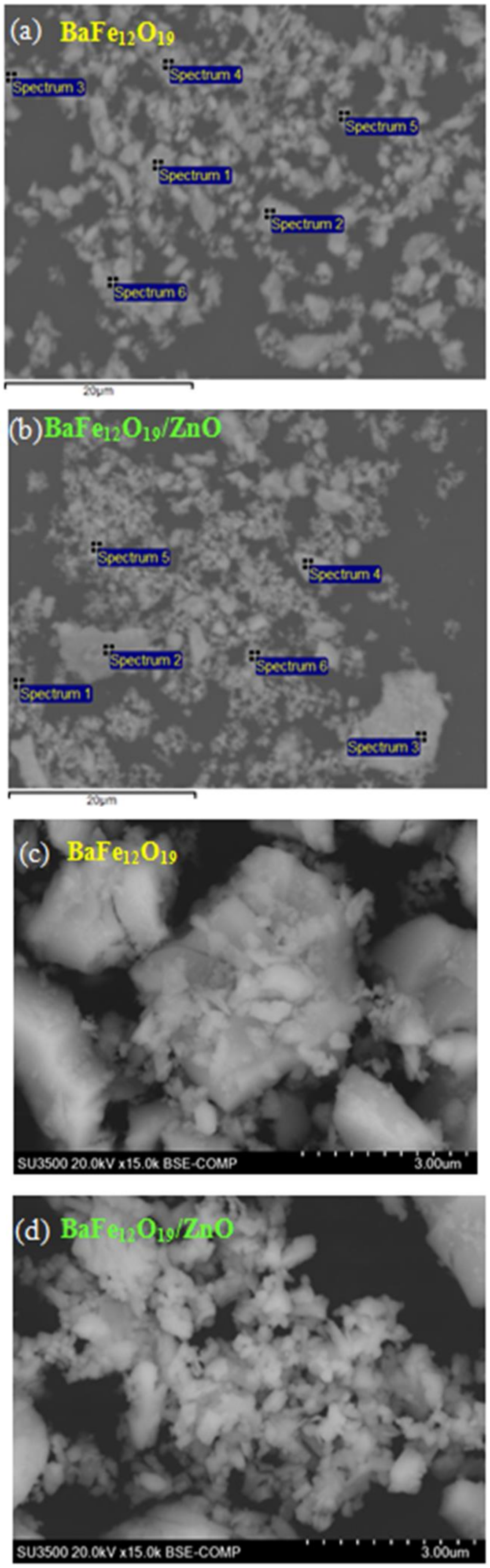

Figure 5. Scanning Electron Microscope results of $BaFe_{12}O_{19}$ and $BaFe_{12}O_{19}$/ ZnO

IV. CONCLUSION

Based on the research that has been done, the conclusions are:

1. It has been successfully made $BaFe_{12}O_{19}$/ ZnO using High Energy Milling (HEM) with wet milling in toluene media.
2. From the results of the *X-Ray Diffraction* (XRD) on $BaFe_{12}O_{19}$ as a *matrix* shows that the phase formed single face and hexagonal crystal structure has lattice parameters a = 5.9290 Å and c = 23.4130 Å *space group* (P 63 / mmc). The three highest peak intensities are in the fields (017), (114) and (110) with an angle of 2θ around (32.21), (37.10) and (30.33).
3. ZnO powder as *filler* shows that the single face phase and the hexagonal crystal structure have lattice parameters a = 3.2533 Å, c = 5.2073 Å *space group* (P 63 / mc). The three highest peak ZnO intensities are found in the field$_{dkl}$ (101, 002 and 100) with an angle of 2θ of (36.25^{o},and 34.4231.80).
4. $BaFe_{12}O_{19}$ Hexagonal / ZnO (file JCPDS No. 39-1433). So from each peak and field on $BaFe_{12}O_{19}$/ ZnO according to the diffraction peak pattern of the composite base material that is $BaFe_{12}O_{19}$ as the *matrix* and ZnO as the *filler*. In the analysis using software match has two phases namely $BaFe_{12}O_{19}$ and ZnO which shows the existence of $BaFe_{12}O_{19}$ and ZnO which states that the crystal structure is heterogeneous.
5. From the results of VSM Characterization, increasing addition of ZnO, will increase magnetic properties of remanence and coercivity will decrease. This shows that the sample (D) is soft magnetic.
6. The results of surface analysis using Scanning Electron Magnetic (SEM) showed that the composition of *barium ferrit* 25% + 75% *zinc oxide* had the smallest and smallest particle size, because of the greater mass addition of ZnO.

V. REFERENCES

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