

Synthesis of M-Hexaferrites Material Based on Natural Iron Sand with Metal Co Doping Using the Coprecipitation Method

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Abstract: The synthesis of M-hexaferrite with metal doping Co ($\text{BaFe}_{12-3x}\text{Co}_x\text{O}_{19}$) based on natural iron sand at Ketapang beach in Pringgabaya Subdistrict, East Lombok using the coprecipitation method has been successful. The basic ingredients used in this study were natural iron sand and Barium Carbonate (BaCO_3) powder, while the doping material used was Cobalt (II) Chloride Hexahydrate ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$) powder with a variety of mole fraction ($X = 0.0, 0.2, 0.4, 0.6, 0.8$ and 1.0). The solvent uses 37% hydrochloric acid (HCl), 25% NH_4OH solution, and distilled water. The sample formed was then calcined at 200 °C, 400 °C, 600 °C, 800 °C and 1000 °C. The resulting sample shows that there is an effect of Co doping and calcination temperature in the formation of barium M-hexaferrite. The higher the mole fraction of Co doping ions and the calcination temperature, the darker the color of the powder produced.

Keywords: Barium M-hexaferrite; cobalt (Co); coprecipitation.

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Introduction

The use of electromagnetic waves has been widespread in various fields such as electronics, telecommunications, and information. This results in increased pollution of electromagnetic waves in the form of microwave radiation which can interfere with the environment. Electromagnetic wave radiation that exceeds the limit can disrupt the environment, especially human health (Susilawati et al, 2015). In response to this problem, scientists have developed absorption technology for microwave radiation. Certain types of materials can be used for this technology. One of the materials that can be used as a microwave absorbent material is Barium M-Hexaferrite (Doyan et al, 2015).

Barium M-Hexaferrite (BaM) ($\text{BaFe}_{12}\text{O}_{19}$) has a hexagonal molecular structure, high saturation magnetization (78 emu/g), high coercivity field (6700 Oe) (Saidah et al, 2012). The high magnetic strength (coercivity field) causes the absorption property of BaM to be weak, making it less effective to use as a microwave absorbing material. To solve this problem, it is necessary to substitute or dop it to reduce the magnetic properties of BaM from a strong magnet to a weak magnet. BaM, which is weakly magnetic, has a wide application as an absorbent material for electromagnetic waves (Bhattacharya et al, 2014).

This research concentrates the formation of $\text{BaFe}_{12}\text{O}_{19}$ doped with metal Co with variations in doping and calcination temperature to produce $\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$ which can be used as a microwave absorber.

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This study aims to determine the characteristics of Co metal dopant administration and the temperature of barium M-hexaferrite ($\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$) on phase formation.

Several methods that can be used in the manufacture of barium M-hexaferrite include the mechanical method of milling, sol-gel, and coprecipitation (Khairunnisa et al, 2018). Among the three methods, the coprecipitation method is a method that has a high level of purity (Susilawati et al, 2013), so that in this study a synthesis was carried out using the coprecipitation method.

Method

Synthesis of M-hexaferrite with Co doping metal ($\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$) using the coprecipitation method (Susilawati et al, 2016). The basic ingredients in this study were natural iron sand (Ketapang Beach area, Pringabaya District, East Lombok), and Barium Carbonate (BaCO_3) powder, while the doping material used was Cobalt (II) Chloride Hexahydrate ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$) powder. The solvent uses 37% hydrochloric acid (HCl), 25% NH_4OH solution, and distilled water. The synthesis of $\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$ was carried out by varying the Co doping mole fraction ($x=0.0, 0.2, 0.4, 0.6, 0.8,$ and 1.0) and variations in calcination temperature ($T=200\text{ }^\circ\text{C}, 400\text{ }^\circ\text{C}, 600\text{ }^\circ\text{C}, 800\text{ }^\circ\text{C}$ and $1000\text{ }^\circ\text{C}$) (Susilawati et al, 2018)

Result and Discussion

Synthesis of M-hexaferrite with metal Co doping ($\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$) using the coprecipitation method includes material separation and synthesis processes. The iron sand separation process aims to separate magnetic material from natural iron sand (Susilawati et al, 2015). The natural iron sand separation process is shown in Figure 1.

Figure 1. The natural iron sand separation process.

This process is carried out by sieving natural iron sand first to separate the sand from the gravel so that a

fine texture is obtained and then separated by using a permanent magnet with a strength of 3.6 T to separate the magnetic material from natural sand then weighed and calculated the percentage of magnetic material obtained (Susilawati et al, 2018).

The synthesis of $\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$ made from natural iron sand was carried out with variations in the mole fraction of Co doping ion ($x=0.0, 0.2, 0.4, 0.6, 0.8,$ and 1.0) and variations in calcination temperature ($T=200\text{ }^\circ\text{C}, 400\text{ }^\circ\text{C}, 600\text{ }^\circ\text{C}, 800\text{ }^\circ\text{C}$ and $1000\text{ }^\circ\text{C}$). This process begins with dissolving the basic ingredients of natural iron sand with HCl then stirring with a magnetic stirrer on a hot plate with a temperature of $80\text{ }^\circ\text{C}$ for one hour and dissolving BaCO_3 with distilled water then stirring with a magnetic stirrer on a hot plate at room temperature for two hours. Then the natural iron sand solution is mixed with BaCO_3 so that it is brownish-black and added with the doping material. Furthermore, the mixture is dripped with NH_4OH to obtain a homogeneous precipitate (Figure 2).



Figure 2. $\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$ deposit.

The precipitate formed is filtered with filter paper then washed with distilled water until the pH is neutral (Susilawati et al, 2015). The neutral sample was then dried in an oven at $80\text{ }^\circ\text{C}$ and crushed until smooth. The next process is calcining the sample at a temperature of $200\text{ }^\circ\text{C}, 400\text{ }^\circ\text{C}, 600\text{ }^\circ\text{C}, 800\text{ }^\circ\text{C}$ and $1000\text{ }^\circ\text{C}$ for two hours (Figure 3).

Figure 3. The process of calcining the $\text{BaFe}_{12-x}\text{Co}_x\text{O}_{19}$ sample.

The calcined sample is then crushed again to form $BaFe_{12-x}Co_xO_{19}$ powder as shown in Figures 4 and 5.

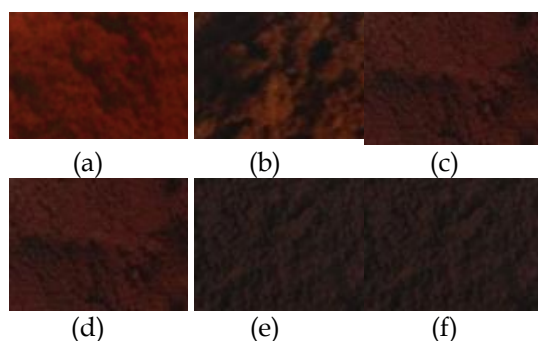


Figure 4. Sample $BaFe_{12-3x}Co_xO_{19}$ (200 °C) doping variation Co (a) $x=0.0$, (b) $x=0.2$, (c) $x=0.4$, (d) $x=0.6$, (e) $x=0.8$, (f) $x=1.0$.

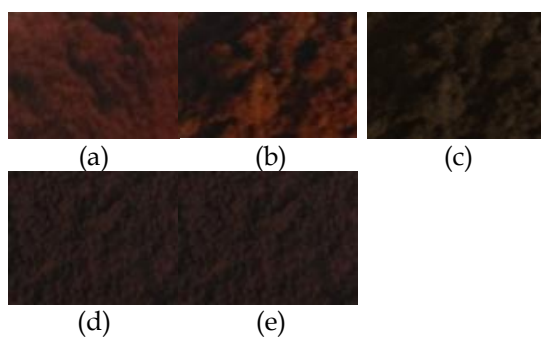


Figure 5. Sample $BaFe_{12-x}Co_xO_{19}$ ($x=0.8$) calcination temperature variation a) 200 °C, (b) 400 °C, (c) 600 °C, (d) 800 °C, (e) 1000 °C.

Figure 4 shows a sample of $BaFe_{12-3x}Co_x$ (200 °C) doping variation. In the figure, it is clear that there is a color difference in the sample caused by the doping of metal Co. The higher the mole fraction of metal Co doping, the darker the color of the resulting sample will be (Susilawati et al, 2015). This is due to the doping of metal Co, mixing the solution will produce a darker color and the volume of NH_4OH needed to precipitate the sample is higher along with the increase in the mole fraction of the doping ion (Susilawati et al, 2018).

Figure 5 shows the sample $BaFe_{12-x}Co_xO_{19}$ calcination temperature variations. The higher the calcination temperature, the darker the color of the resulting sample. This is because the solvent used has evaporated due to the calcination process (Susilawati et al, 2019). Calcination aims to remove water content, solvents, and impurities such as CO_2 from barium carbonate ($BaCO_3$) as it will affect the purity of the sample (Susilawati et al, 2017).

Conclusion

The synthesis of barium M-hexaferrite based on natural iron sand (Ketapang Beach area, Pringgabaya

District, East Lombok) was successfully carried out using the coprecipitation method. The results of the synthesis show that there is an effect of metal doping and calcination temperature in the formation of barium M-hexaferrite. The higher the mole fraction of Co doping ions and the calcination temperature, the darker the color of the powder produced.

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