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Synthesis of Strontium Based on Natural Iron Sand North Lombok Coastal Club Doping Co and Cu Metal Ions As Power Generating Materials

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Abstract: The $SrCl_2$ with natural iron sand is the basic material for making Strontontium M-Hexaferrite (SrM) as a generator of electricity in the form of permanent magnets samples which are doped to make the utilization of SrM more effective by adding metal ions that have almost the same size as cobalt (Co) and cupper (Cu) using the coprecipitation method. The synthesis process was carried out in the chemical laboratory of the FKIP, the Highway Engineering Laboratory, the Faculty of Engineering and the advanced Biology Laboratory of the FMIPA UNRAM. In this study, concentration variations and temperature variations were used during the calcination process, namely (x = 0.0; 0.4; 0.8 and 1.0) (T = 800; 1000 and 1100 ^{0}C). These variations greatly affect the sample, where the greater the concentration and calcination temperature, the darker the resulting color in the sample and this is in accordance with the purpose of the calcination process, namely the greater the temperature at the time of calcination, the higher the water content in the sample reduced because the solvent in the sample evaporates. In addition to these materials, the solvent used also plays an important role in the process of making samples, namely using 25% HCl to dissolve, 37% NaOH so that the precipitation process is faster and distilled water as a neutralizer.

Keywords: Coprecipitation; Co and Cu; Doping; Generator; Natural iron sand; SrM; Synthesis

Introduction

Technological developments are increasingly innovative to make it easier for humans to do work. However, technological developments cannot be separated from the energy sources used. Energy sources are increasingly depleting, so other energy is needed as an alternative to new energy sources to reduce the energy crisis which will ultimately improve human welfare. Alternative energy as the energy used aims to stop the use of natural resources or damage to the environment. There are lots of primary natural resources that are renewable and can be used to produce energy, one of which is electricity (Syahbana, 2022). Both natural sources such as light, wind and water as well as those that are material physics such as permanent magnets. The integration of technologies that use renewable energy is very helpful for human activities besides saving the earth, because it is environmentally friendly and can reduce global warming.

Permanent magnets are a material with wide applications in various industries in Indonesia and are very strategic materials (Hindasyah et al., 2002; Susilawati, Doyan, et al., 2023; Wijaya et al., 2016). Energy efficiency such as in electric generator systems, electric drive systems/electric motors, industrial automation and others is largely determined by the nature and quality of the magnetic material. Even in the application of electronic automation systems, industrial automation and the like require a large number of magnets and specifications of different magnetic properties for each component. In developing permanent magnets, natural resources can be utilized,

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namely natural iron sand containing Fe (ferrite) magnets (Susilawati, Doyan, & Muliyadi, 2020; Susilawati et al., 2022).

Ferrite (Fe) is a magnetic material that has been widely used (Fatari et al., 2022; Tahanian et al., 2020; Tolani et al., 2022). Ferrite-based magnets can easily be found in various electronic equipment, sensors and power generators. Ferrite has a relatively low price, good physical and chemical stability and a fairly easy raw material that can be obtained as a basic material for making permanent magnets (Fatimah et al., 2022).

In general, the magnets commonly developed are M-type hexaferrite magnets, ($MFe_{12}O19$; M = Sr, Pb, Ba). Strontium ferrite (SrM) (Elansary et al., 2020; Mangai K et al., 2020) is a magnet whose composition consists of iron (Fe) as a synthetic material. These magnets have excellent chemical stability, corrosion resistance, good thermal resistance and have good electrical and magnetic properties as well. The element iron can be obtained from abundant natural materials, namely iron sand which is located along the coastline and is dark in color.

The materials used in synthesizing M-type hexaferrite magnets are hematite (Fe_2O_3) (Elinda et al., 2022; Susilawati et al., 2021) and magnetite (Fe_3O_4) (Daud et al., 2016), as raw materials added with an additive, namely $SrFe_{12}O_{19}$. In the synthesis of SrM to determine its effect on the magnetic properties of the material as a basic material for electricity generators in the form of permanent magnets which have high quality and are varied by using Co (Miessler et al., 2014), Cu (Hambali et al., 2021), Mn-Ni (Susilawati et al., 2021), Zn-Mn (Doyan et al., 2020), Co-Ni (Susilawati et al., 2020), Co-Zn (Susilawati et al., 2023) metal ion doping. Doping was carried out to reduce the anisotropic properties of the Strontium M-Hexaferrite (SrM) species without changing the original structure. The synthesis process has various methods, such as the powder maturation method (Winatapura et al., 2019), sol gel (Muliyadi et al., 2019; Wardiyati et al., 2017), and coprecipitation method (Kurniawan et al., 2017; Winatapura et al., 2019).

Method

This study used a pure experimental method, namely the coprecipitation method, which consisted of three stages: the separation of natural iron sand obtained at Tebing Beach, North Lombok, the separation of Fe_3O_4 compounds from magnetic materials and the synthesis of SrM with Co and Cu metal ions doped. The three stages used the coprecipitation method using HCl 25% solvent, distilled water and to form a precipitate using NaOH 37% solution. The steps in the coprecipitation method are as shown in Figure 1.

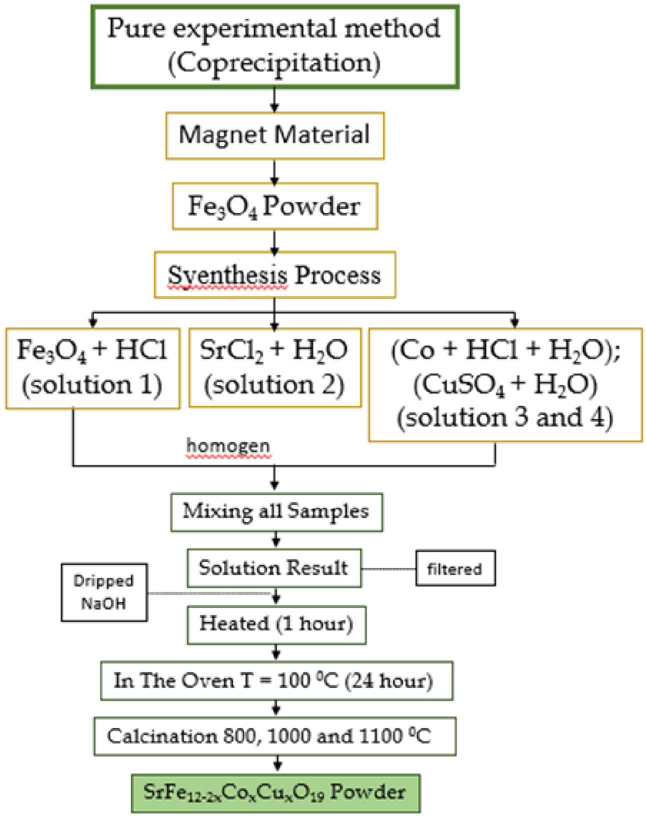

Figure 1. Synthesis process with coprecipitation method

Result and Discussion

The synthesis of $SrFe_{12-2x}Co_xCu_xO_{19}$ was carried out using the coprecipitation method where the basic material used was natural iron sand obtained from one of the beaches in West Lombok, namely the Tebing beach of North Lombok and $SrCl_2$ and doped with Co and Cu metal ions. These materials are then weighed according to the composition obtained in the chemical reaction equation below (Munib et al., 2016):

Dopant chemical reaction equation x = 0
$4FeC^{l2} + 8FeCl_3 + SrCl_2 + H_2CO_3 + 34NH_4OH \rightarrow SrFe_{12}O_{19} + 34NHCl + 32H_2O + 2H_2 + CO_2$

The chemical equation for the dopant is x (12-2x)
$(12-2x)FeCl_2 + FeCl_3 + SrCl_2 + H_2CO_3 + 0{,}2CoCl_2 + H_2 + 0{,}2CuCl_2 + H_2SO_4 + 33{,}2NaOH \rightarrow SrFe_{12x}Co_xCu_xO_{19} + 33{,}2NaCl + H_2O + 2H_2 + CO_2$

Based on the reaction equation above, it can be determined the amount of elemental/compound composition needed to manufacture $SrFe_{12-2x}Co_xCu_xO_{19}$ powder. After knowing the amount of element/compound composition needed, then the $SrFe_{12-2x}Co_xCu_xO_{19}$ synthesis process is carried out by following the steps as shown in Figure 1. The first step in making $SrFe_{12-2x}Co_xCu_xO_{19}$ is to make a solution which is stirred with a magnetic stirrer on a hot plate at room temperature until the solution is be homogeneous. The homogeneous solution is then heated and dripped with NaOH 37% until the desired precipitate is formed, as shown in Figure 2. After obtaining the desired precipitate, then filtered to obtain a neutral pH, as shown in Figure 3. The neutral precipitate is then heated in the oven for 24 hours at 100 ^{0}C, as shown in Figure 4. The final product from the oven, then crushed and calcined at predetermined temperatures, namely 800, 1000 and 1100 ^{0}C, as shown in Figure 5.

Figure 2. Form a precipitate by dropping NaOH 37%

Figure 3. Filtered and washed to obtain a neutral pH

Figure 4. Oven process

Figure 5. Calcination process

The calcination process greatly affects the color of the sample, as shown below in Table 1.

Table 1. Effect of Calcination Temperature on Powder Color Change $SrFe_{12-2x}Co_xCu_xO_{19}$

Concentration Variation (x)	Calcination Temperature 800 ^{0}C	1000 ^{0}C	1100 ^{0}C
0			
0.4			
0.8			
1.0			

As seen in the table above, the calcination process is suitable for its purpose, namely to purify the sample by removing the water content (Fatimah et al., 2022). The powder that is used in the calcination process is of course already in the oven so that the texture of the powder can be easily crushed to get the desired sample powder results.

Very visible color difference in the sample. This change occurred due to the presence of doping which played a role in the dissolution process which was dripped with NaOH as a solvent to get precipitate in the sample (Khaerunnisa et al., 2018). The higher the mole fraction of metal used as doping, namely Co and Cu and the volume of NaOH, the darker the color of the sample produced (Susilawati et al., 2020). Apart from doping, temperature in the calcination process also plays an important role. This can be proven in the table above, where the greater the temperature at the time of calcination, the water content in the sample will decrease because the solvent in the sample evaporates (Susilawati et al., 2022).

In this study, the solvents used had a good effect, namely HCl and NaOH because these solvents were easily removed from the results of the synthesis (an integration of two or more existing elements that produced a new result) (Wulandari et al., 2021) and easily removed by using distilled water by means of washed until it gets a neutral pH so that during the final process, the sample to be tested will be as desired. So in this study, it can be concluded that the doping used in the natural sand-based Sr synthesis process using doping ions is very influential in the process of making samples using the coprecipitation method in the formation of SrM powder with the higher the temperature, the darker the resulting color.

Conclusion

Based on the results and discussion above, it can be concluded that Strontontium M-Hexaferrite ($SrFe_{12}O_{19}$) is based on natural iron sand on the cliffs of North Lombok using cobalt (Co) and Cuuper (Cu) metal ions as doping using the coprecipitation method which can dissolve using hydrochloric acid (HCl). which produces darker colors with higher calcination temperatures, namely from 800, 1000 and 1100 ^{0}C. The darker the color of the sample is also influenced by the doping used, as well as the solvent which plays a very important role in the precipitate process, namely NaOH and neutralization of the sample using distilled water. So that in the process of making the $SrFe_{12-2x}Co_xCu_xO_{19}$ sample it can be said to be successful by looking at the color of the resulting powder according to the calcination temperature from low to high and the amount of doping applied.

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Author Contributions

Conceptualization: Susilawati, Aris Doyan, and Saprizal Hadisaputra: formal analysis, Susilawati, Aris Doyan and Saprizal Hadisaputra; investigation: Susilawati and Aris Doyan; editing: Susilawati and Lalu Muliyadi.

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Conflicts of Interest

The authors of this article declare no conflict of interest.

References

Daud, N., Azis, R. S., Hashim, M., Matori, K. A., Jumiah, H., Saiden, N. M., & Mohd Shahrani, N. M. (2016). Preparation and Characterization of $Sr_{1-x}Nd_xFe_{12}O_{19}$ Derived from Steel-Waste Product via Mechanical Alloying. *Materials Science Forum*, *846*, 403–409. https://doi.org/10.4028/www.scientific.net/MSF.846.403

Doyan, A., Susilawati, Taufik, M., & Wahyudi. (2020). Electrical properties of M-type barium hexaferrites (BaFe12ZnMnO19). *AIP Conference Proceedings*, *2251*(1), 40043. https://doi.org/10.1063/5.0015695

Elansary, M., Belaiche, M., Ahmani Ferdi, C., Iffer, E., & Bsoul, I. (2020). New nanosized Gd–Ho–Sm doped M-type strontium hexaferrite for water treatment application: experimental and theoretical investigations. *RSC Advances*, *10*(42), 25239–25259. https://doi.org/10.1039/D0RA04722H

Elinda, B. U. P., Susilawati, Kosim, & Doyan, A. (2022). Synthesis BaFe12O19 Based on Natural Iron Sand with Cu and Ni Doping Using Coprecipitation Method. *Journal of Physics: Conference Series*, *2165*(1), 12008. https://doi.org/10.1088/1742-6596/2165/1/012008

Fatari, H. A., Doyan, A., Makhrus, M., Susilawati, & Taryana, Y. (2022). Synthesis of BaFe12-xCrxMnxO19 material based on Telindung beach iron sand using coprecipitation method. *Journal of Physics: Conference Series*, *2165*(1), 12006. https://doi.org/10.1088/1742-6596/2165/1/012006

Fatimah, Z., Susilawati, & Doyan, A. (2022). The process of making BaM (BaFe12O19) samples based on natural iron sand doped with metal (Co-Cu-Zn) using the coprecipitation method. *Journal of Physics: Conference Series*, *2165*(1), 12007. https://doi.org/10.1088/1742-6596/2165/1/012007

Hambali, S., & Doyan, A. (2021). Synthesis and Characterization Barium M-Hexaferrites ($BaFe_{12-2x}Co_xMn_xNi_xO_{19}$) as a Microwave Absorbent Material. *Solid State Phenomena*, *317*, 46–52. https://doi.org/10.4028/www.scientific.net/SSP.317.46

Hindasyah, A., & Yudho Pramono dan Agus Sunardi, E. (2002). Aplikasi Magnet Permanen pada Motor Dc Untuk Penggerak Alat Pengaduk Larutan. *Jurnal Sains Materi Indonesia Indonesian Journal of Materials Science*, 4(1), 1411–1098. https://doi.org/10.17146/jusami.2002.4.1.4891

Khaerunnisa, K., Susilawati, S., Savalas, L. R. T., Taufik, M., & Wahyudi, W. (2018). Sintesis Bahan M-

Hexaferrites Dengan Doping Logam Co Menggunakan Metode Kopresipitasi. *Jurnal Penelitian Pendidikan IPA*, *4*(1), 180–184. https://doi.org/10.29303/jppipa.v4i1.112

Kurniawan, C., Eko, A. S., Ayu, Y. S., Sihite, P. T. A., Ginting, M., Simamora, P., & Sebayang, P. (2017). Synthesis and Characterization of Magnetic Elastomer based PEG-Coated Fe3O4 from Natural Iron Sand. *IOP Conference Series: Materials Science and Engineering*, *202*(1), 12051. https://doi.org/10.1088/1757-899X/202/1/012051

Mangai K, A., Selvi, K. T., & Priya, M. (2020). Effect of Co and Sm Substitutions on the Magnetic Interactions of M-Type Strontium Hexaferrite Nanoparticles. *Journal of Superconductivity and Novel Magnetism*, *33*(3), 713–720. https://doi.org/10.1007/s10948-019-05227-0

Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2014). *Inorganic Chemistry Fifth Edition US*. Pearson Education, Inc.

Muliyadi, L., Doyan, A., Susilawati, S., & Hakim, S. (2019). Synthesis of SnO2 Thin Layer with a Doping Fluorine by Sol-Gel Spin Coating Method. *Jurnal Penelitian Pendidikan IPA*, *5*(2), 175–178. https://doi.org/10.29303/jppipa.v5i2.257

Munib, Susilawati, & Savalas, L. R. T. (2016). Sintesis Barium M-Hexaferritte (BaFe12-xNixO19) Doping Logam Nikel Dengan Metode Kopresipitasi. *Jurnal Penelitian Pendidikan IPA*, *2*(1). https://doi.org/10.29303/jppipa.v2i1.28

Susilawati, & Doyan, A. (2021a). Characteristics of Barium M-hexaferrite with Doping Mn and Ni in X-band Frequency for Microwave Absorption. *Materials Science Forum*, *1028 MSF*, 32–37. https://doi.org/10.4028/www.scientific.net/MSF.1028.32

Susilawati, & Doyan, A. (2021b). Synthesis and characterization barium m-hexaferrites (Bafe12-2xcoxmnxnixo19) as a microwave absorbent material. *Solid State Phenomena*, *317 SSP*, 46–52. https://doi.org/10.4028/www.scientific.net/SSP.317.46

Susilawati, Doyan, A., Al-Qoyyim, T. M., Ap'aludin, Maemum, P. J., Ristanti, C. I., & Ariani, B. I. (2023). Synthesis of Barium M-Hexaferrite Using Co-precipitation Method with Zn Doping Based on Natural Iron Sand at Tebing Beach, North Lombok as Microwave Absorbent Material. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 498–503. https://doi.org/10.29303/jppipa.v9i1.2935

Susilawati, Doyan, A., & Muliyadi, L. (2020). Synthesis of M-Hexaferrites Material Based on Natural Iron Sand with Metal Co Doping Using the Coprecipitation Method. *Jurnal Penelitian Pendidikan IPA*, *7*(1), 1. https://doi.org/10.29303/jppipa.v7i1.461

Susilawati, Doyan, A., Taufik, M., & Wahyudi. (2020). The Structure of Barium M-hexaferrite (BaFe12-2xCoxNixO19) Powders Using Co-precipitation Methods. *AIP Conference Proceedings*, *2251*(1), 40028. https://doi.org/10.1063/5.0015750

Susilawati, Pangga, D., Zainuri, M., Doyan, A., Prayogi, S., & Bilad, M. (2023). Synthesis and Characterization Of Barium Mhexaferrite BaFe12-2xCoxZnxO19 (0 ≤ X ≤ 1) Prepared from Co-Precipitation. *Rasayan J. Chem.*, *16*(2), 845–856. https://doi.org/10.31788/RJC.2023.1626810

Susilawati, S., Doyan, A., & Hadisaputra, S. (2022). Analysis Magnetic Mineral Content of Natural Iron Sand in Beach Island Lombok as Basic Materials of Micro Wave Absorbers. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2048–2052. https://doi.org/10.29303/jppipa.v8i4.2274

Syahbana, M. R. F. (2022). Penggunaan Magnet Permanen Pada Transformasi Generator 12 Volt. *Jurnal Ilmiah Mahasiswa Teknik (JIMT)*, *2*(2). Retrieved from https://jurnalmahasiswa.umsu.ac.id/index.php/jimt/article/view/1322

Tahanian, H., Aliahmadi, M., & Faiz, J. (2020). Ferrite Permanent Magnets in Electrical Machines: Opportunities and Challenges of a Non-Rare-Earth Alternative. *IEEE Transactions on Magnetics*, *56*(3), 1–20. https://doi.org/10.1109/TMAG.2019.2957468

Tolani, S., & Rewatkar, K. (2022). Synthesis and structural characterization of zinc substituted calcium W-type hexagonal ferrite. *Materials Today: Proceedings*, *66*(1), 1858–1861. https://doi.org/10.1016/j.matpr.2022.05.289

Wardiyati, S., Winatapura, D. S., & Sukirman, E. (2017). Pengaruh Penambahan Aditif Bi2O3 Terhadap Karakteristik Barium Heksaferit Hasil Sintesis dengan Metode Sol-Gel. *Jurnal Kimia Dan Kemasan*, *39*(2), 61–68. https://doi.org/10.24817/jkk.v39i2.2793

Wijaya, A. A., Syahrial, S., & Waluyo, W. (2016). Perancangan Generator Magnet Permanen dengan Arah Fluks Aksial untuk Aplikasi Pembangkit Listrik. *Reka Elkomika*, *4*(2). Retrieved from https://ejurnal.itenas.ac.id/index.php/rekaelkomika/article/view/1021

Winatapura, D. S., Sukirman, E., & Ridwan, R. (2019). Sintesis Nanopartikel Heksaferit MFe12O19 (M=Ba,Sr dengan Metode Kopresipitasi. *Jurnal Sains Materi Indonesia*, *13*(1), 39–43. https://doi.org/10.17146/jusami.2011.13.1.5397

Wulandari, I. O., Rahayu, L. B., Riva'i, I., Sulistyarti, H., & Sabarudin, A. (2021). Sintesis dan Karakterisasi Nanopartikel Fe3O4 termodifikasi Biokompatibel Polimer serta Potensinya sebagai Penghantar Obat. *The Indonesian Green Technology Journal*, *10*(1), 1–8. https://doi.org/10.21776/ub.igtj.2021.010.01.01