IMPROVEMENT OF THE MAGNETIZATION OF BARIUM FERRITE NANORODS

Hartono[12*], Bambang S Purwasasmita[2], Nugraha[2], Budi Hartono Setiamarga[2]

[1]Department of Electrical Engineering, Sultan Ageng Tirtayasa University, Jl. Jenderal Sudirman Km 3, Cilegon, Indonesia

[2]RCNN Bandung Institute of Technology, Jl.Ganesa 10 Bandung, Indonesia

Email: sallam.hartono@yahoo.com , purwa@tf.itb.ac.id , nugraha@tf.itb.ac.id, setiamarga@gmail.com

Abstract. Barium ferrite is a permanent magnet that is frequently used in electronic devices such as data storage media, signal absorbers or radar, because of its magnetic properties. In certain uses, it is desirable to have a rod structure to take advantage of the barium ferrite anisotropic properties. In this research, barium ferrite powder with rod structure was made using the sol-gel method using nanocellulose template. Barium ferrite powder was synthesized from a solution of barium nitrate and iron nitrate using the sol-gel method with nanocellulose crystal template with variations in template mass. The structure and properties of barium ferrite were observed using Vibrating Sample Magnetometer (VSM). VSM observations showed the single phase of barium ferrite produces saturation magnetization of 54.6 emu/g, remanence magnetization of 28.6 emu/g.

Keywords— Magnetization, Nanocellulose, Nanorod Barium Ferrite.

1. Introduction

Barium ferrite is a commercial permanent magnet of ceramic type. the magnetic material has very strong mechanical properties and is not easy to corrosion. as a permanent magnet, barium ferrite has magnetic properties with a high level of stability to the effect of the outside magnetic field at temperatures above 3000oc [1].

Barium ferrite is often the option for researching magnetic materials because this material can be made into permanent magnets that have good material magnetic properties and many applications for various needs. besides that, barium ferrite is, even more, economic and easy to manufacture.

Various methods are used in manufacturing barium ferrite magnets to produce better magnets.

The axial desired form for barium ferrite is nanorods or what is called nanorods.

The shape is of this rod easy to direct the magnetic moment of a magnetic particle. The appropriate or flat order of the nanorods affects the magnetic properties of the particles. Hysteresis that "fat" and produced from straight arrangements, more suitable for use in magnetic recording because it has a large storage density than flat. While the “thin” hysteresis that is produced from a flat order will be more suitable for magnetic reading. To shape the particles into the desired shape a template is required.

Cellulose is the most abundant natural polymer and is easily biodegradable. Cellulose is produced from plants, marine animals, and bacteria. Cellulose or fiber can be divided into nanoscale materials called nanocrystalline cellulose, nanofibrils, and others. Based on their size and shape, this nanocrystalline cellulose can be an ideal template for nanorod materials.

In this research, a study was conducted on the effect of the cellulose template of Luffa Acutangula in the synthesis of barium ferrite magnet particles [2].

Anitostrophic shapes such as rods or nanorods, with size $a < c$. To form an anisotropic structure, a template from a synthetic nanocellulose material is generally required which is a natural material. The purpose of this study was to produce barium ferrite with better magnetic properties than the synthesis of barium ferrite without a nanocellulose template.

2. Research Method

2.1 Research Procedures

After the literature study, the design of process parameters, preparation of tools and materials, nanocellulose synthesis experiments, barium hexaferrite synthesis experiments, and characterization will be carried out.

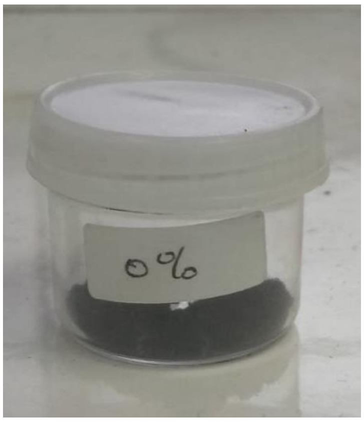
2.2 Preparation of Luffa Acutangula

Figure 1. Luffa acutangula fiber that has been cut

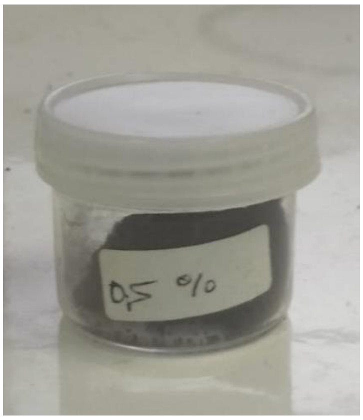
2.3 Manufacture of Nanocellulose

Figure 2. Cellulose powder

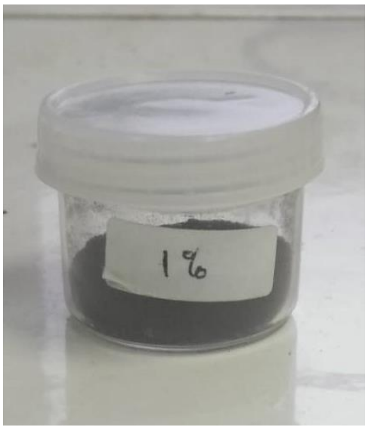
2.4 Manufacturing of Barium Ferrite Magnets



a



b



c

d

Figure 3. Calcined Barium Ferrite Powder with concentration:
a. 0% (w/v), b. 0,5% (w/v), c. 1% (w/v), d. 1,5% (w/v).

3. Result and Discussion

3.1 Nanocellulose Isolation Procedures

Isolation of nanocellulose from gambas was carried out using the strong acid hydrolysis method. Acid hydrolysis is the most effective process because it requires very low energy. This process is carried out by adding a strong acid H2SO4 45%. the amorphous part of the cellulose has been removed and the nanocellulose is ready for use.

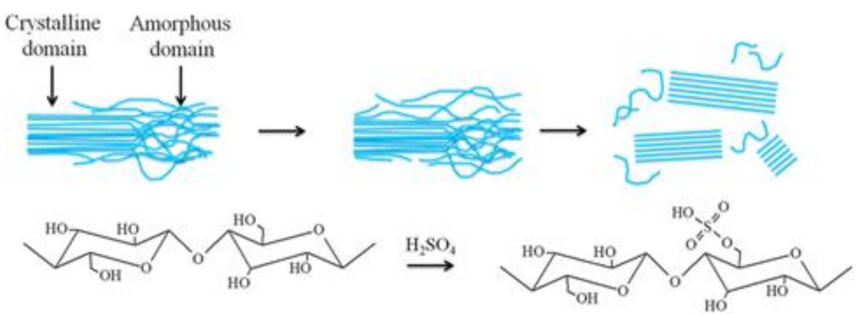


Figure 4 Acid Hydrolysis Mechanism

3.2 Fourier Transform Infra-Red (FTIR)

The results of the FTIR spectrum of the synthesized nanocellulose sample can be seen in Figure 5.

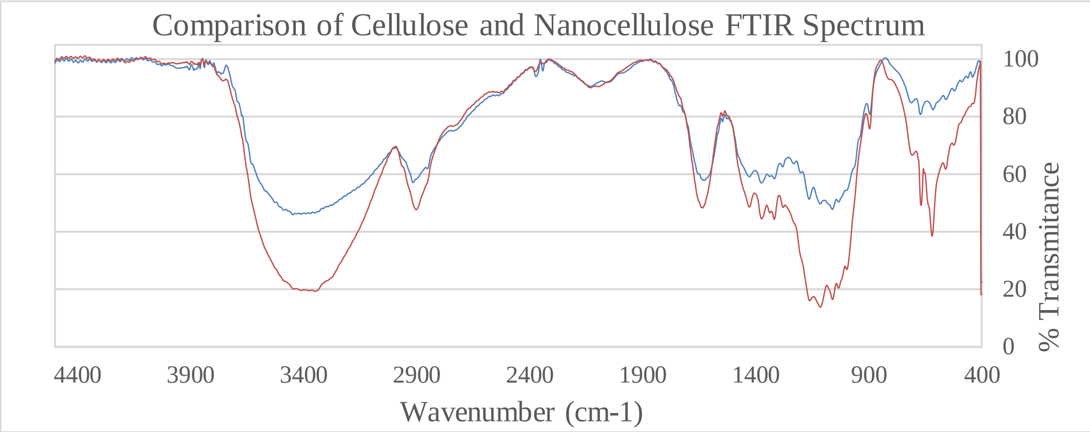


Figure 5 Comparison of Cellulose – Nanocellulose FTIR Spectrum

3.3 Vibrating Sample Magnetometer (VSM) Characterization Results

The magnetic properties of the resulting barium ferrite sample can be determined from the sample hysteresis curve in the VSM characterization results. Comparison of hysteresis curves on variations in the use of templates can be seen in Figure 6 below.

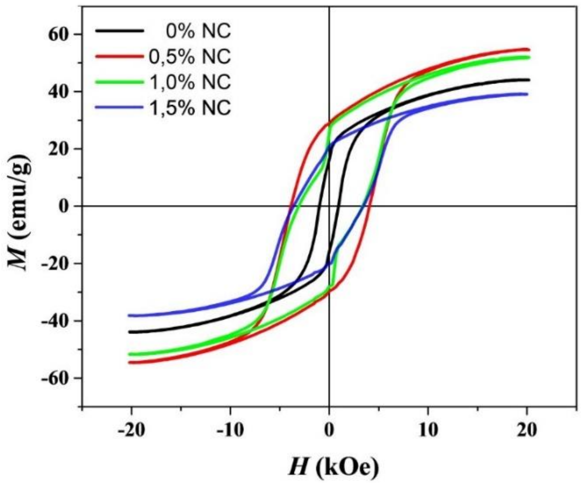


Figure 6 Comparison of Hysteresis Curves on Variations in the Use of Nanocellulose Templates

while the hysteresis curve for each barium ferrite sample can be seen in Figures: 4.4, 4.5, 4.6, and 4.7 following:

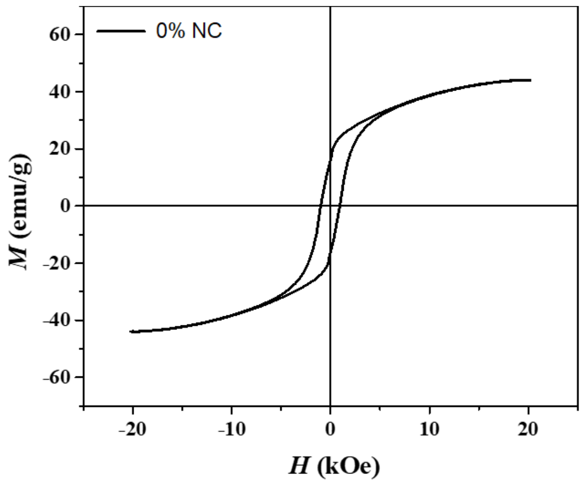


Figure 7 Sample Hysteresis Curve BaFe12O19 with Templates 0%(w/v) Nanocellulose

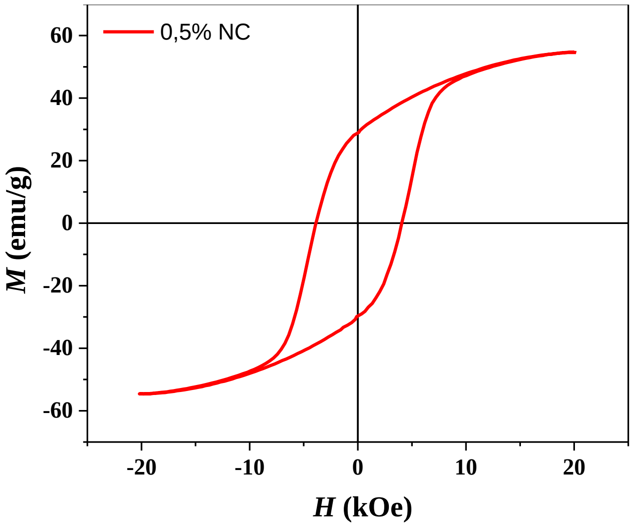


Figure 8 Sample Hysteresis Curve BaFe12O19 with Templates 0.5%(w/v) Nanocellulose

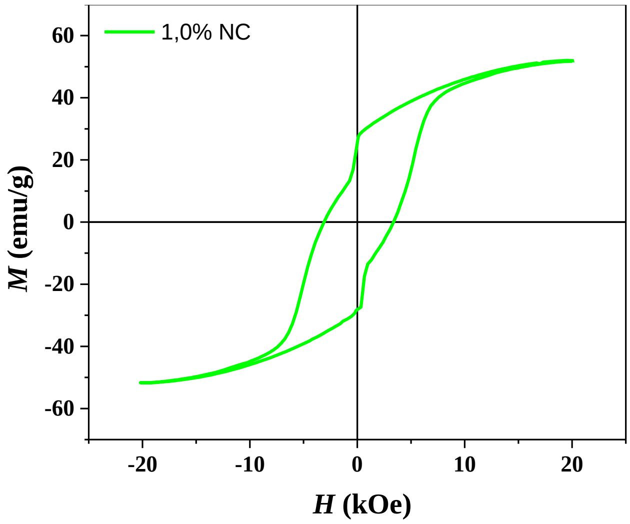


Figure 9 Sample Hysteresis Curve BaFe12O19 with Templates 1%(w/v) Nanocellulose

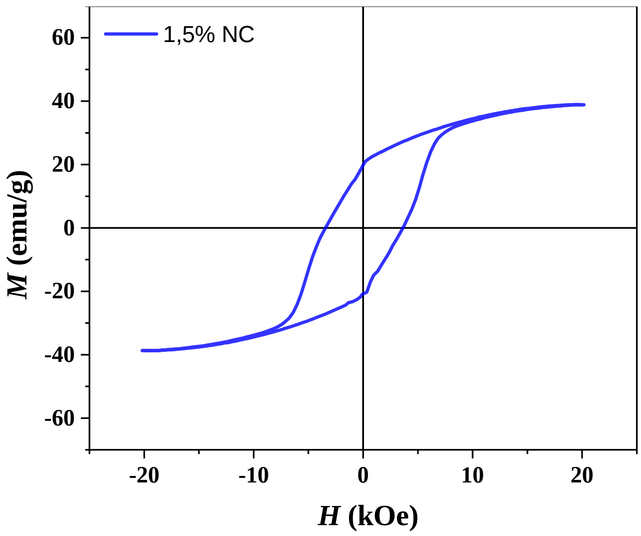


Figure 10 Sample Hysteresis Curve BaFe12O19 with Templates 1.5%(w/v) Nanocellulose

The hysteresis curve in the use of 0% and 0.5% templates did not have a fracture indicating the formation of a single phase of barium ferrite. Meanwhile, in the use of 1% and 1.5% templates, some fractures indicate the presence of other phases besides barium ferrite in the sample. From the hysteresis curve above, the saturation magnetic moment (Ms) sample BaFe12O19 is 38,85-54,56 emu/g, remanence magnetic moment (Mr) is 15,85-28,63 emu/g, and coercivity is 304,51-1006 Oe. Magnetic properties of the whole sample BaFe12O19 can be seen in detail in Table 1 below

Table 1 Magnetic properties of sample $BaFe_{12}O_{19}$

No	Nanocellulose (%w/v)	Saturation Ms (emu/g)	Remanence Mr (emu/g)	Coercivity		Mr/Ms
				(kA/m)	(Oe)	
1	0	44,03	15,85	76,9	966,58	0,36
2	0,5	54,56	28,63	303	3808	0,525
3	1	51,94	24,63	244,3	3070	0,474
4	1,5	38,85	19,25	267,9	3367	0,495

The value of the saturation magnetic moment and the remanence magnetic moment can be compared with the graph in Figure 11.

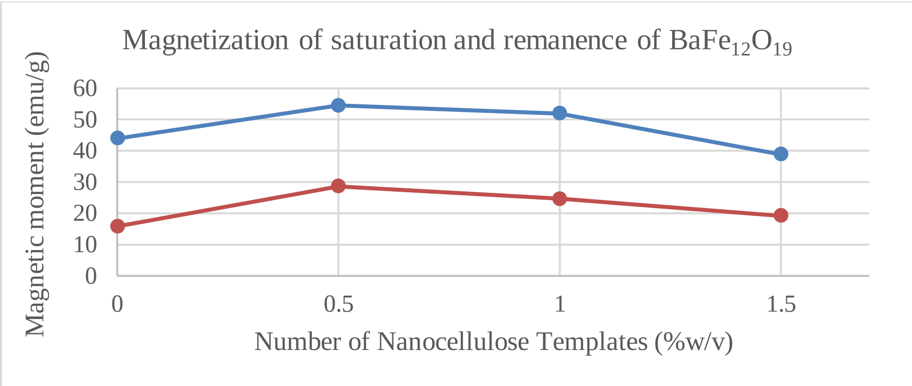


Figure 11 Sample Saturation and Remanence Graph $BaFe_{12}O_{19}$ with Different Number of Nanocellulose Templates

While the coercivity of each sample BaFe12O19 can be compared with the graph in Figure 12.

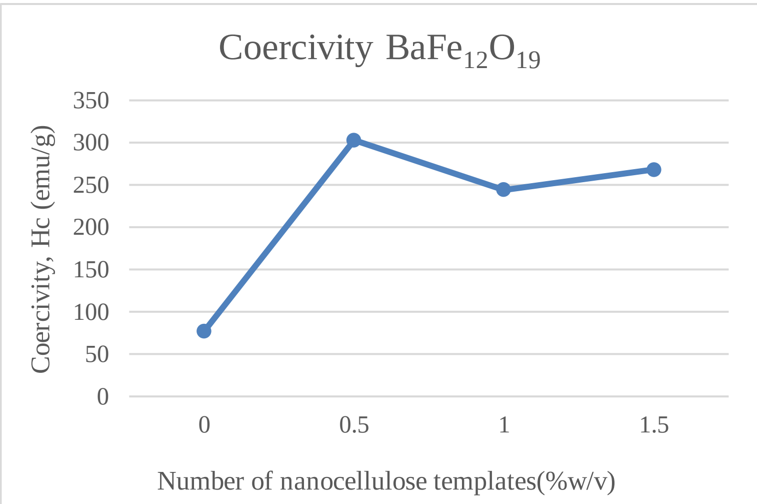


Figure 12 Sample Coercivity Graph BaFe12O19 with Different Number of Nanocellulose Templates

As explained in the previous chapter, a magnet is categorized as a hard magnet if it has the above coercivity of 104 A/m or 125.6637 Oe so that the four samples BaFe12O19 including the type of hard magnet because of the value of Hc> 125.6637 Oe.

Based on the VSM results above, the use of templates affects the magnetic properties of the BaFe12O19. The saturation and remanence magnetic moment values increased for the use of nanocellulose templates 0,5% and 1% but down for the use of nanocellulose templates 1,5%. In addition, the coercivity value increases with the use of nanocellulose templates 0,5% but down on usage 1% and 1,5%. Based on the comparison in Table 4.3 the sample with the best magnetic properties is the sample BaFe12O19 with templates 0,5% nanocellulose based on comparison value Ms/Mr and Hc the highest.

4. Conclusion

After the experiment, the following are the conclusions:

1. Barium ferrite in the form of nanorods was successfully synthesized with the best magnetic properties using 0,5% (w/v) nanocellulose.
   - Saturation magnetization, Ms = 54,56 emu/g
   - Remanence magnetization, Mr = 28,63 emu/g
   - Coercive field, Hc = 3,83 kOe
2. Barium ferrite with nanocellulose template 0,5% (w/v) has better magnetic properties than barium ferrite without template (Ms = 44,03 emu/g, Mr = 15,85 emu/g, Hc = 0,97 kOe).

References

[1] A. J. Moulson and J. M. Herbert, Electroceramics: Materials, Properties, Applications, Second Edition, Jhon Willey & Sons Ltd. ISBN:9780470867969; doi:10.1002/0470867965, 2003.

[2] A. G. Kolhatkar, A. C. Jamison, D. Litvinov, R. C. Wilson, and T. R. Lee, "Tuning the Magnetic Properties of Nanoparticles," *International Journal of Molecular Science,* vol. 14(8): 15977–16009., no. DOI: 10.3390/ijms140815977, p. 5, 2013.

[3] R. Hoadley, "Magnet Man," 1998-2017. [Online]. Available: http://www.coolmagnetman.com. [Accessed 3 December 2019].

[4] R. Hoadley, "Magnet Man," 1998-2017. [Online]. Available:http://www.coolmagnetman.com [Accessed 3 December 2019].

[5] Etapas de reacción y procesamiento en el proceso sol-gel," Nanova© by Homepro Systems LLC, 2019. [Online]. Available: https://nanova.org/fabricacion-de-nanoparticulas/attachment/etapas-de-reaccion-y-procesamiento-en-el-proceso-sol-gel/ . [Accessed 10 4 2019].

[6] G. Siqueira, j. Bras and a. Dufresne, "luffa cylindrical as a lignocellulosic source of fiber, micro fibrillated cellulose and cellulose nanocrystals," *bioresource 5(2) 727-740,* 2010.

[7] S. K. Y. R. and A. M. V., "Genus Luffa - an Ethnopharmacological and Phytochemical review," *International Journal of Pharma Sciences and Research (IJPSR) ISSN: 0975-9492,* vol. 7, no. 5 May 2016.

[8] "Science Clarified: Cellulose - Humans, Body, Used, Water, Process, Earth, Planets, Chemical, Form, Energy, Animals, Carbon, Oxygen, Cells, Primary, Substance, Plant, Basic, Surface.," Advameg, Inc., [Online]. Available: http://www.scienceclarified.com/Ca-Ch/Cellulose.html. [Accessed 14 12 2019]

[9] Summerscales, N. Dissanayake, A. S. Virk, and W. Hall, "A Review of Bast Fibres and Their Composites. Part 1-Fibres as Reinforcements," *Composites Part A Applied Science and Manufacturing,* vol. 41(10), pp. 1329-1335, 2010.

[10]R. P. Swatloski, S. K. Spear, J. D. Holbrey and R. D. Rogers, "Dissolution of Cellulose with Ionic Liquids," *Journal of the American Chemical Society*, vol. 124, no. 18, pp. 4974-4975, 2002.

[11]S. Kumar, "Analytical Instruments: Fourier Transform-Infrared Spectroscopy," 03 05 2013. [Online]. Available: http://analyticalprofessional.blogspot.com/2013/05/fourier-transform-infrared-spectroscopy.html. [Accessed 14 12 2019]

[12]N.Marturi, "Vision and Visual Servoing for Nanomanipulation and Nano characterization in Scanning Electron Microscope," *Micro and Nanotechnologies/Micro electric. Universite de Franche-Comte*, 2013.

[13]R. Nave, "HyperPhysics: Bragg's Law," [Online]. Available: http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/bragg.html. [Accessed 14 December 2019].

[14]UKEssays, "Vibrating Sample Magnetometer (VSM)," All Answer Ltd., November 2018. [Online]. Available: https://www.ukessays.com/essays/physics/vibrating-sample-magnetometer-vsm-6963.php?vref=1. [Accessed 14 December 2019].

[15]M. Rajinipriya, M. Nagalakshmaiah, M. Robert, and S. Elkoun, "Importance of Agricultural and Industrial Waste in the Field of Nanocellulose and Recent Industrial Developments of Wood-Based Nanocellulose: A Review," *ACS Sustainable Chemistry & Engineering*, vol. 6, no. 3, 2018.