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Mixing Analysis of Bamboo and Natural Iron Sand as a Magnetic Material

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Abstract

This study aims to determine the magnetic properties of Fe3O4 synthesized from rope bamboo and natural iron sand. In this study, natural magnetic bio-char of bamboo and iron sand was synthesized by the co-precipitation method at a calcination temperature of 500oC. Then it was characterized through several tests, namely XRD and VSM. The results of the XRD test showed that the synthesis of natural bamboo + iron sand produced HKL peaks that were identical to Fe3O4 where these peaks were the peaks of magnetite and hematite. Magnetic properties were tested using VSM through a hysteresis curve with samples classified as soft magnets.

Keywords: magnetic, XRD, VSM

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INTRODUCTION

Bamboo is a natural resource whose existence is very close and cannot be separated from the life of the Indonesian people, its existence is very much found in several places, both those planted intentionally and those that grow wild. Bamboo is a non-timber forest product that has not received optimal attention in its utilization. Economically, the use of bamboo in Indonesia is generally still in a simple form in terms of processing such as for fences, roof supports, walls, scafholding, stakes and other uses that still have low added value with traditional processing and only for fulfillment local needs (KLHK, 2019).

Bamboo stems mostly contain fiber consisting of cellulose, hemi-cellulose and lignin, one of the advantages of lignocellulosic fiber in bamboo fiber is its ability to fuse with magnetic materials which are very useful in making magnets. Magnets derived from bamboo not only have important engineering value but are also useful in the world of technology such as electronics, optics, energy and so on as has been done in China by combining traditional bamboo recombination technology and in-situ co-precipitation to make magnetic reconstitution bamboo boards which useful for increasing the loading capacity of nanomagnetic materials in composites from 2D surfaces to 3D surfaces (Yang et al., 2020).

As a result of nature, the CN-ABF porous magnet was successfully made from activated bamboo fiber and organic metal alloy CoNi - MOF with a simple chemical activation method showing excellent electromagnetic wave absorbing properties (Zhao et al., 2021). Previous research also explained that bamboo grains synthesized with Ni-Mn-Ga microwires by melting extraction technique at a high temperature of 1323 K for 3 hours under Argon pressure showed that microwires have a very large magnetic field which causes strain on the wire (Qian et al., 2020).

In making magnets, bamboo waste needs to be mixed with raw material for magnets in the form of iron oxide which is widely available in Indonesia, namely natural iron sand. Natural iron sand is a type of sand with a high concentration of iron, the main content of iron sand is magnetite Fe3O4 and also contains small amounts of titanium, silica, manganese, calcium and vanadium (Templeton, 2013). By synthesizing Fe3O4/PEG/PPy magnetic nanoparticles and natural iron sand with the co-precipitation method and ultrasonic treatment where the nanoparticles were synthesized with two different treatments at 700oC, the magnetic properties of the nanoparticles were produced (Simamora et al., 2018). In line with this (Rianna et al., 2019) reported that $BaFe_{11.6}Mg_{0.2}Al_{0.2}O_{19}$ which was synthesized from natural iron sand by the calcination method has magnetic properties.

Research result of (Rianna et al., 2018) showing natural iron sand from Kata Beach, West Sumatra Indonesia extracted using a permanent magnet showing results on Scanning Electron Microscopy with Energy Dispersive X-ray (SEM-EDX) that iron sand contains Fe and O elements originating from the Fe_3O_4 magnetite phase.

Bamboo fiber contains lignocellulosic which has the property of being able to combine with magnetic materials which is very useful in making magnets. Natural iron sand contains magnetic materials such as magnetite (Fe_3O_4), hematite (α-Fe_2O_3), and maghemite (γ-Fe_2O) (Heryanto & Tahir, 2021). Magnetite Fe_3O_4 is a very interesting material mixed with natural fibers because it has several very interesting properties such as having coercive field properties, being superparamagnetic, and being easily attracted to magnetic field sources (Calvo et al., 2012). This study aims to utilize bamboo waste and natural iron sand in the manufacture of magnetic materials.

METHODS

Raw Material Preparation

The raw materials used in this study were bamboo rope waste from Doloksanggul sub-district, Humbang Hasundutan Regency, North Sumatra and natural iron sand from Lumajang, West Java.

Magnetite Synthesis Process (Fe_3O_4)

Bamboo stalks were cut into 10 cm diameters and then dried in an oven at 105oC for 20 hours. The dried bamboo is then heated in a furnace at 400^{o}C for 4 hours to produce bamboo charcoal. The bamboo charcoal is then ground and then sieved using a 100 mesh sieve to produce bamboo powder. The bamboo powder was then soaked in 30% H_3PO_4 for 20 hours. The samples were then dried at 105^{o}C for 5 hours. Then the dried samples went through a heating process at 500^{o}C for 2 hours before being neutralized with NaOH and washed with distilled water until the pH was neutral. Calcination with a temperature of 500^{o}C produces a relatively high crystallinity of bamboo at high temperatures which can also completely convert cellulose in bamboo into activated carbon. The last step is the sample is dried in an oven at 105^{o}C for 20 hours and is ready to be characterized into **Sample 1**.

20 grams of extracted natural iron sand was dissolved in 30 mL of 37% HCl and then stirred at 350 pm at 70^{o}C for 1 hour using a magnetic stirrer. Based on research (Elda Swastika et al. 2021) showed that natural iron sand extraction using 37% HCl showed a better degree of crystallinity with the resulting sample purity level of 72% Fe and 28% O. The solution was then filtered and precipitated using NH_4OH. The results of the brown/black precipitation were filtered and then washed using distilled water and dried in an oven at 105^{o}C for 5 hours. Then the samples were heated at 500^{o}C for 2 hours and were ready to be characterized into **sample 2.**

Then 100 mL of distilled water is put into a glass beaker. Mix 10 grams of natural iron sand which has been activated using HCl with 10 grams of bamboo powder which has been activated in H_3PO_4 solution into a glass beaker and then stirred at 700 rpm until the solution is homogeneous. Into the solution, add 45 mL of 1M NaOH and stir at 350 rpm for 1 hour.

Then wait for the solution to settle. The precipitate was washed using distilled water and ethanol 10 times and then dried in an oven at 105oC for 5 hours and finally the sample was heated at 500^{o}C for 2 hours to become **sample 3**.

RESULTS AND DISCUSSION

Sample identification was analyzed using X-ray diffraction (XRD). Through the XRD test obtained information on the phases formed, crystal structure and composition of the phases present in each sample synthesized by the coprecipitation method. Data analysis and crystal structure were analyzed using X'pert High Score Plus, Origin and Microsoft excel software. The following is Figure 3.1 of the resulting XRD spectrum:

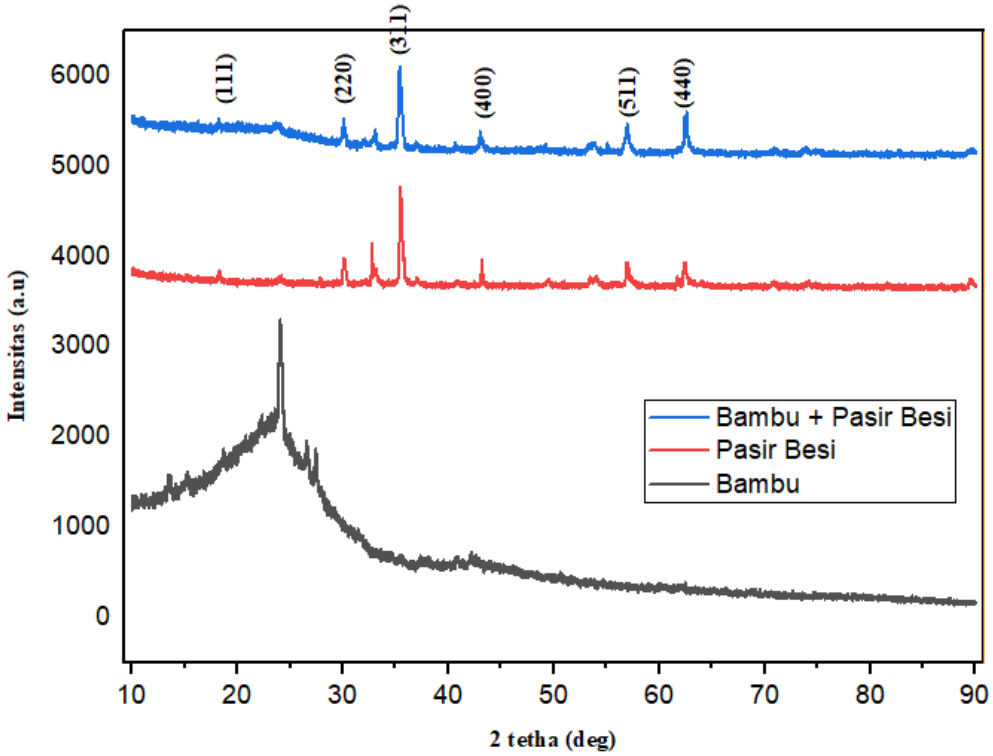

Figure 1. Diffraction pattern of bamboo XRD; natural iron sand; bamboo + natural iron sand

The formation of diffraction peaks at the diffraction angle (2Θ) indicates the presence of crystalline phases in all samples while the height and width of the peaks indicate the size of the phase crystals in the sample, using software origin, Microsoft Excel and the Scherrer equation the average size of crystals formed for each -each bamboo sample; natural iron sand and bamboo + natural iron sand 0.69, 13.83, 7.63 nm. The resulting peak is amorphous. The resulting low intensity occurs because the heating temperature is below 250^{o}C to avoid the oxidation of Fe_3O_4 to Fe_2O_3 at a higher temperature. Based on the standards issued by the Joint Committee on Powder Difraction (JCPDS) it can be stated that the samples analyzed in this study had typical peaks for iron oxide (Fe_3O_4) with hkl (111), (220), (311), (400), (511) and (440) with a cubic crystal structure which is a material in the Fd-3m and Fe_3O_4 groups.
Based on the obtained hkl values, two crystalline phases were formed in the bamboo bio-char, namely magnetite and hematite. Magnetite is a crystalline oxide while hematite is a solid oxide with a hexagonal structure. Peaks with hkl (220) (311) and (400) belong to the basal plane of crystalline magnetite of bamboo bio-char. Furthermore, there is a peak of 33.3o which is identical to the basal plane of crystalline hematite, which is in accordance with previous studies (Yin et al., 2018)

VSM identification is one type of identification to determine the magnetic properties of Fe_3O_4 powder from the synthesis of the three samples. From the test results, a hysteresis curve is produced which is the relationship between the external magnet and magnetization.

From this curve we are able to determine the quantities which are very important to determine the magnetic properties of a material, namely saturation magnetization (Ms), coercivity field (Hc), and magnetic remanence (Mr).

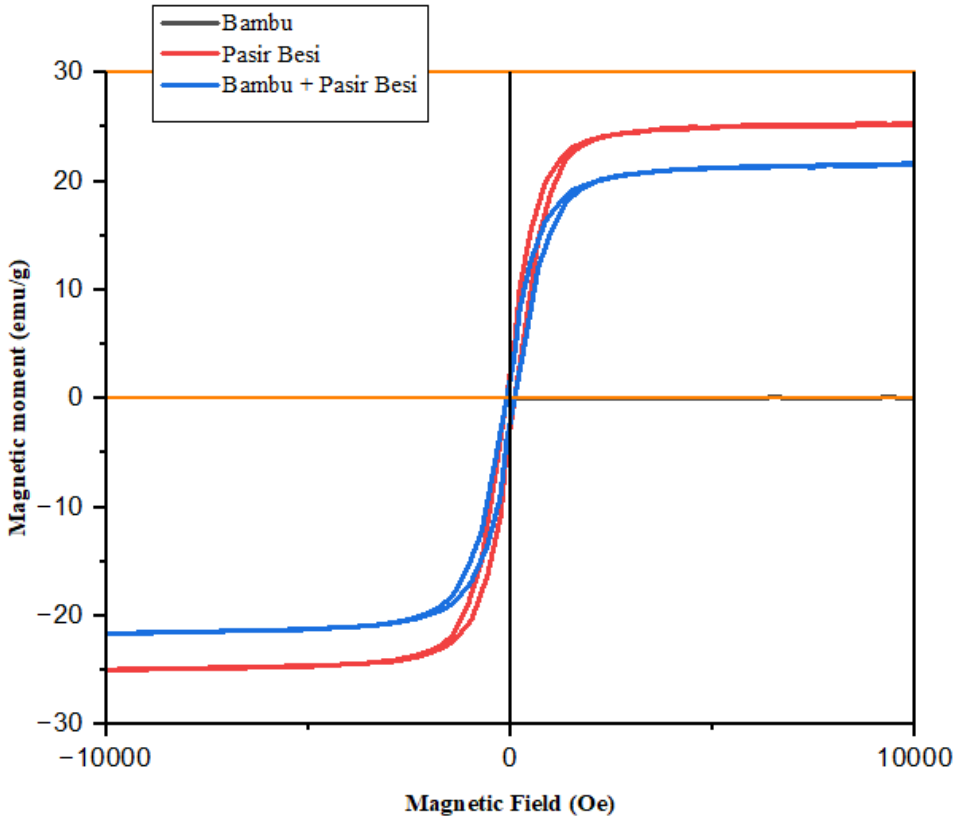

Figure 2. Hysteresis Loop of bamboo; natural iron sand; bamboo + natural iron sand

Based on the VSM analysis, bamboo powder that has been activated with a phosphoric acid solution is a diagenetic material. The synthesis of Fe3O4 from natural iron sand shows a magnetization value (Ms) = 25 emu/g with a coercivity (Hc) 134 Oe with a narrow hysteresis curve area so that this material is classified as a soft magnetic. By synthesizing natural bamboo + iron sand, a hysteresis curve is produced with a magnetization value (Ms) = 21.83 emu/g and a coercivity (Hc) 97 Oe which is also classified as a soft magnet. The small area of the curve indicates the amount of energy required for magnetization. So that the magnetite material with soft magnetic properties requires little energy for magnetization.

CONCLUSION

The results of the XRD characterization showed that the phases formed were magnetite (Fe_3O_4) and hematite (Fe_2O_3). The results of the VSM characterization showed that bamboo powder which was only activated with phosphoric acid exhibited diamagnetic properties. After mixing with natural iron sand, it shows the formation of a hysteresis curve with a narrow area and a coercivity value of 97 Oe so that it is classified as a soft magnet.

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