Identification of Magnetite Material (Fe$_3$O$_4$) Based on Natural Materials as Catalyst for Industrial Raw Material Application

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Abstract. Identification of magnetite nanoparticles synthesized from natural iron sand with a chemical treatment that is by using the coprecipitation method on temperature and heated spaces, using a pair of acids and bases, i.e. HCL as a solvent NH$_4$OH and as its precipitation. The Crystal structure, the percentage of elements, the particle size and properties of the magnetism material characterization by XRD, XRF identification testing, and permagraph. From the results obtained in the Analysis that the value of the percentage purity of Fe$_3$O$_4$ are derived from Natural Sands before Extraction is of 81.42%, and once on extract 86.73% increase to its purity. From the results of the analysis of properties of ferrite magnet to Fe$_3$O$_4$ from sand iron retrieved the value of Saturation Magnetization (Ms) produced amounted to 0.29 T, or residual magnetization Remanence (Br) of 0081 T, and Coercivityy (Hc) amounted to 1.82 kA/m expected data analysis results may explain the comparison characteristics in structure and magnetic properties of material with a natural sand Fe$_3$O$_4$ Aldrich so it can be an additional related information value added (added value) the local SDA.

1. Introduction

Aceh is one of the provinces in Indonesia that have natural resources (SDA). As for the abundant natural resources and is a natural ingredient important in Aceh include gold, coal, iron ore, iron sand, and so on. But generally the SDA is still in the form of raw and mostly undiscovered and unknown deposit. Along with the development of the industry, it is automatically causes the demand for industrial raw materials against certain products be increased

The synthesis of magnetite Fe3O4 by using coprecipitation method. The same method has also been developed by [1]. Among the synthesis method, coprecipitation method is the simplest method in the process because it is more easy to do and requires a low reaction temperature (100°C <).

The coprecipitation method is one of the methods of the synthesis of organic compounds based on the deposition of more than one substance together after passing the point of saturation. The basic concept iscoprecipitation which is dissolved into the solvent, after it was added to the solution as precipitation so that the final result is obtained in the form of deposits. Coprecipitation is a method that is easy to use and has some advantages, namely the process using low temperature, the time required is relatively short, high purity as well as a relatively inexpensive cost. This coprecipitation process is
done to get a Fe₃O₄ particles have a purity higher than the powder which is not through coprecipitation Fe₃O₄[2].

This research is examined in depth of the structure and magnetic properties of iron sand on the coast of Syiah Kuala, Banda Aceh and then compared with synthetic materials Fe₃O₄ Aldrich in the hope that the natural material-based sand iron magnetic properties and structure similar to that of synthetic materials that can be utilized and enhanced its economic value as well as for the additional information data base for the local area.

2. Methodology

The materials on the research consists of iron oxide Fe₂O₃ powder that comes from the iron sand coast of Syiah Kuala that have previously undergone the extraction well with magnetic separation, and chemical treatment by using coprecipitation method.

Data retrieval for analysis XRF Laboratory performed on Mineral PT. Semen Andalas Lhoknga, Aceh Besar. The data is obtained in the form of percent weight (wt%) indicate percentage of the mineral content in the sand iron. To find out the composition of the present phase, the qualitative identification is performed by using x-ray diffraction (XRD) (Philips PW 3710 diffractometer, Co-Kα radiation (\(\lambda = 1.78896 \text{ Å}\)), the measurement of the magnetic properties is done in the laboratory, Department of Materials Physics of engineering of The University of Indonesia, Depok. The equipment used is Permagraph (Magnet Physics, Germany) with an external magnetic field 2 tesla.

![Flow Chart of Iron Sand Extraction](image)

**Figure 1.** Flow Chart of Iron Sand Extraction

3. Results and Discussion

1. Analysis of x-ray Fluorescence data (XRF) Fe₃O₄ samples

Identification and characterization of the elements contained within the magnetite Fe₃O₄ powders using x-ray Fluorescence (XRF). The identification of these elements needs to be done to find out
what are the elements of the elements contained in the pollen magnetite Fe3O4. And also to know the level of purity of powder Fe3O4. This is very important as the materials used are natural ingredients that have already been extracted and separation before. The results obtained can be seen from the test in the following table that indicated XRF 1.

| No  | Magnetic separation | Coprecipitation Method |
|-----|---------------------|------------------------|
| Name of Compound | Percentage (%) | Name of Compound | Percentage (%) |
| 1    | Fe3O4            | 81.42 ± 1.23          | Fe3O4            | 86.73 ± 0.35  |
| 2    | SiO2             | 4.4 ± 0.2             | SiO2             | 2.5 ± 0.02    |
| 3    | Al2O3            | 3 ± 0.9               | Al2O3            | 0             |
| 4    | P2O5             | 0.41 ± 0.05           | P2O5             | 0.34 ± 0.08   |
| 5    | K2O              | 0.11 ± 0.005          | K2O              | 0.075 ± 0.004 |
| 6    | CaO              | 1.04 ± 0.0095         | CaO              | 0.72 ± 0.01   |
| 7    | TiO2             | 7.61 ± 0.100          | TiO2             | 8.93 ± 0.02   |
| 8    | V3O5             | 0.57 ± 0.004          | V3O5             | 0.57 ± 0.007  |
| 9    | Cr2O3            | 0.19 ± 0.005          | Cr2O3            | 0.22 ± 0.006  |
| 10   | ZnO              | 0.06 ± 0.003          | ZnO              | 0.06 ± 0.003  |
| 11   | Bi2O3            | 0.61 ± 0.01           | Bi2O3            | 0.23 ± 0.0003 |
| 12   | Re2O7            | 0.3 ± 0.02            | Re2O7            | 0.2 ± 0.01    |
| 13   | Eu2O3            | 0.55 ± 0.03           | Eu2O3            | 0.60 ± 0.05   |

From table 1. It can be seen that the highest content of compounds in iron sand after the separation of the manual is Fe3O4 with percentage composition of 81.42%. Then followed by the compound TiO2 which has the percentage composition of 7.61%. While compounds that have the lowest concentration is 0.06% of ZnO. The results of x-ray Fluorescence after the coprecipitation method using the extracted phase Fe3O4 shows an improvement where the most dominant element content compared to other identified elements is Fe3O4 with percentage 86.73 ± 0.35%. percentage of Fe3O4 is unidentified which almost 90%, it shows that natural materials from sand iron which was used contain magnetite is more dominant than other compounds. While the number of percentage of Fe3O4 Aldrich were used as a comparison is of 97%. Where a second later this sample each test will be performed with x-rays and Permagraph to be able to distinguish between characteristics of Fe3O4 Aldrich and Fe3O4 are derived from Natural sands

2. Observation Data analysis x-ray Diffraction (XRD)

The result is different between sand iron before and after in the extraction is seen in Figure 2. On the results of XRD sand iron before experiencing the acid solution base peak still looks sharp, the present phase of the most dominant and have the highest intensity is present on the compound in Fe3O4 2θ = 35.5020, 2θ = 30.0809, and 2θ = 56.9852. In addition the other phases are also still visible, namely TiO2 at an angle 2θ = 73.8103 and SiO2 phases at an angle 2θ = 43.1163. While on a sand iron that has been in the extraction of the Summit already looks wide and shows a straight line, widening the Summit identified the refinement that indicates that the size of the particles of Fe3O4 compounds have started are reduced. From the pictures also look there is a missing phase after the sand in the extract by using the kopresipitasi method. And emerging phase remains dominated by Fe3O4 compounds at an angle 2θ = 35.4853
3. The results of the analysis of Magnetic Properties of materials

The results of measurements of Fe3O4 is seen in Figure 3 below. Figure 3a shows the overall results of the curve hysteresis of Fe3O4 samples Aldrich. The hysteresis curve of known magnetic material properties such as saturation magnetization (Ms), residual magnetization (Mr), and the terrain coercivity (Hc). From the picture 3a can be known the value of Ms which is around 2.5 Tesla. As for the image 3b and 3 c can be shown change the shape of the curve hysteresis with shrink the scale on the x-axis i.e. outer magnetic field value (H). But from the second image is not yet determined the value of Mr and Hc. With more and shrink the scale on the x axis as in the 3d images can be known the value of Mr. amounting to about 0.75 Tesla and Hc 4.5 kA/m.

Based on Figure 3, the above shows that the curve of the sample hysteresis wide narrow curves. The existence of a narrowing of the width of the curve is caused on the sample not only contained Fe3O4 phase, but there are other exemplary phase dopants such as TiO2, SiO2 phase there, and other impurity. Impurity phase in samples appear can affect the value of the resulting saturation magnetization, the more phase pollutant contained in the sample of iron sand then sustaining more minor saturation magnetization of the resulting value. Because of the nature of magnetic phase...
pollutant contained in the sand iron is anti-ferromagnetic. Based on Figure 3. It appears that the curve that is formed is a type of soft magnetic (magnetic). The weak saturation magnetization caused by the lack of diversity of particle size and uneven disclosure happens i.e. clotting-clumping or agglomeration. The coercive field influenced by the large size of the particles and agglomeration that is the larger particle size will then be more coercive owned.

4. Conclusion
From the results obtained in the Analysis that the value of the percentage purity of Fe$_3$O$_4$ are derived from Natural Sands before Extraction is of 81.42%, and once on extract 86.73% increase to its purity. and the purity of the material is 97% Aldrich Fe$_3$O$_4$. While the analysis of properties of ferrite magnet to Fe$_3$O$_4$ from sand iron retrieved the value of Saturation Magnetization (Ms) produced amounted to 0.29 T, or residual magnetization Remanence (Br) of 0081 T, and Ccoercivity (Hc) amounted to 1.82 kA/m.

Advice
1. Need to know the comparison of particle size with the size of the Crystal.
2. Need to do repetitive extraction (continuous extraction) on extraction sand iron to get a higher purity level in the absence of the elements of the polluter. Need for accuracy and precision in the process of extraction so get maximum results.

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