Study of hematite mineral (Fe₂O₃) extracted from natural iron ore prepared by co-precipitation method

M Muhammad¹, A Fatmaliana¹, Z Jalil²*

¹Department of Marine Science, Syiah Kuala University, Banda Aceh, Indonesia
²Department of Physics, Syiah Kuala University, Banda Aceh, Indonesia

*Email: zjalil@unsyiah.ac.id

Abstract. The minerals content and its magnetic properties of iron ore from Lhoong mining area, Aceh province were studied. The iron ore was prepared by co-precipitation method. As the results, the main mineral and chemical compositions of samples which were investigated by XRD and XRF analysis tests, showed that the Lhoong iron ore contain Fe₂O₃ (93.88%) and some minor impurities, such as SiO₂, MnO, and Al₂O₃ in varying proportions. Compare to XRD results, it was consistent with XRF, the phase compositions of iron ore are mainly hematite (Fe₂O₃). The XRD revealed that hematite is the major mineral components in the Lhoong iron ores. The magnetic properties of the samples after milling showed there has been increased in the remanent (Br) and coercivity (Hc). The electron microscope identification inform that the particle were agglomerated.

1. Introduction

Some properties of oxide among other iron (II) oxide (natural occurring FeO) or iron oxide, powder black oxide, iron (III) oxide (Fe₂O₃) or also known as the iron ore hematite or maghemite [1, 2]. Iron ore is rock containing minerals iron and a number of mineral impurity such as silica, alumina, magnesia and nickel. The iron contained in the rocks can be extracted with the technology existing at the moment and have economic value. Extraction is the process of separation of a substance from a mixture.

Thus, the extraction of the metals can be meant as a separation of metals from its source, which is usually in the form of the ore. The process of extracting metal from the ore is usually done with some separation techniques, such as pyrometallurgy, hydrometallurgy, and precipitation [3,4]. The making process of precipitation affects some of the properties of the basic material such as iron oxide phase formed, impurities and agglomeration. Therefore, a lot of research on synthesis of iron oxide to produce its pure mineral. The precipitation technique is the most widespread attention because of its simple, easy and cheap process [5-9]. In this work, we introduce the co-precipitation method to extract the pure hematite from local iron ore.

2. Materials and Method

Iron ore was collected from Setia Mining Lhong Area, Aceh Besar and originally separated by manual (magnetic separation), namely by using the magnet rods. The results of the subsequent separation weighed as much as 50 grams. Furthermore, the ore dissolved in HCl as the reaction:
Fe₂O₃ + 6HCl → 2FeCl₃ + 3H₂O………………………………….(1)

Comparison with 50 grams of iron ore and 280 ml HCl while stirring and heated at a temperature of 145 degrees C above the hot plate magnetic stirrer at 145 ºc temperature with a speed of 350 rpm. Precipitation with ammonium hydroxide to shed done (NH₄OH) 25% into the solution until the pH reaches 6 and formed deposits of the reaction:

2FeCl₃ + 3H₂O + 6NH₄OH → 2Fe(OH)₃ + 6NH₄Cl + 3H₂O.............(2)

The sediment is washed and dried in an oven at a temperature of 150 º C for 19 hours, the reaction:

2Fe(OH)₃ + 6NH₄OH + 3H₂O → 2FeOOH + 6NH₄Cl + 5H₂O………(3)

Next calcination conducted at temperature 500 ºc during 2 hours using the furnace. The process of characterization is done by XRF (X-ray fluorescence) to see the composition of the compound contained in iron ore and characterization using XRD to see crystal structure as well as the grain size of the iron ore.

3. Results and Discussion

By using this method of analysis is conducted to sample iron ore magnetic separation process (magnetic separation) iron ore samples and conducted chemical separation process (method of precipitation). Results composition of iron ore using XRF is shown in Table 1.

|                         | Magnetic separation | Precipitation method |
|-------------------------|---------------------|----------------------|
| Compound                | Purity (%)          | Compound              | Purity (%)          |
| Fe₂O₃                   | 95,99               | Fe₂O₃                 | 96,58               |
| SiO₂                    | 2,1                 | SiO₂                  | 2,1                 |
| CuO                     | 0,55                | Br                    | 0,36                |
| Br                      | 0,37                | P₂O₅                  | 0,3                 |
| CaO                     | 0,24                | CaO                   | 0,19                |
| MnO                     | 0,19                | MnO                   | 0,18                |
| NiO                     | 0,1                 | Re₂O₇                 | 0,1                 |
| Re₂O₇                   | 0,1                 | Cr₂O₃                 | 0,1                 |
| Cr₂O₃                   | 0,1                 | NiO                   | 0,09                |
| P₂O₅                    | 0,03                | La₂O₃                 | 0,07                |
| La₂O₃                   | 0,06                | ZnO                   | 0,04                |
| ZnO                     | 0,03                | Yb₂O₃                 | 0,02                |

Compounds with the highest content in iron ore magnetic separation process (magnetic separation) is Fe₂O₃ with percentage composition of 95.99%. Then followed the SiO₂ has a compound percentage composition of 2.10%. Further samples of iron ore carried chemical separation process (method of
precipitation), quantitative analysis of results showed that the compound rose to 96.58% Fe₂O₃, SiO₂ compound while still have percentages of the same composition with the iron ore magnetic separation process is done.

Compound silicate (SiO₂) will be lost if the given substance Enhancer (flux) as CaCO₃. Next extraction done the process of blast furnace process is intended is the process of ore reduction at high temperatures, this process requires time as well as the amount of solvent that is large enough, but this method has the advantage that the result is more perfect [10]. XRD observations can be seen in Figure 1.

**Figure 1.** XRD pattern of iron ore with magnetic separation and precipitation method

The data results of the x-ray Diffraction (XRD) conducted an analysis of the identification phase was done by observing the angle 2θ, lattice distance factor (d), intensity (I/IO), the phase and the crystal structure. This identification was approached with the value of the angle 20 according to which certain minerals listed on JCPDS (Joint Committee for Powder Diffraction Standard). The analysis is performed with the experimental results matching techniques and JCPDS.

Analysis of the results of XRD looks that is the dominant phase of Fe₂O₃ and SiO₂ phase followed by a minor. If compared, the diffraction peak profiles XRD test results on the samples of iron ore magnetic separation process visible diffraction peaks are still sharp. Peak (peak) diffraction begins to widen/shrink after chemically (method of precipitation). This indicates that there has been reduction of grain size when the method of precipitation takes place [11].

**Table 2.** Sherrer calculation of crystallite size

| Sample                      | Parameter   |  |
|-----------------------------|-------------|---|
|                            | FWHM (°)    | θ (°) | Crystallite size (µm) |
| Fe₂O₃ (magnetic separation) | 0.15180     | 17.72285 | 58.009 |
| Fe₂O₃ (precipitation)       | 0.42040     | 17.7665 | 20.950 |

By doing the calculations in Table 2 showed the size of the crystallites Fe₂O₃ magnetic separation process size 58,009 µm and the method of precipitation 20,950 µm size. This case shows that the
method of precipitation (process chemically) have managed to reduce the size of the grains are more suitable [12].

4. Conclusion
From this study showed that mineral composition iron ore by magnetic separation contains Fe₂O₃ (hematite) of 95.99% and Fe₂O₃ (hematite) yielded by co-precipitation method was 96.58%. The results of the phase identification using XRD, the iron ore found in the Lhong, Aceh Besar district is dominated by the main phase as Fe₂O₃ compound and SiO₂ as a minor phase. The grain size was getting smaller after heavy precipitation.

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