Production Aluminium Sulphate [($Al_2(SO_4)_3$] from Kaolin Jaboi Sabang by Crystallization Step Using a Dry Process

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Abstract

One of the main chemicals used in water treatment process are aluminum sulphate used as coagulant thus forming clean water. Aluminum sulfate [$Al_2(SO_4)_3$] or alum is one of the chemicals that are required both in industry and water treatment companies. This research objective was to study the operating conditions of the process of making solid aluminum sulfate of kaolin and sulfuric acid to see the effect of temperature, time, ratio of sulfuric acid and kaolin, sulfuric acid concentration, the rotation speed of the stirrer and the particle size of solid aluminum sulfate to be generated in order to obtain optimum operating variables process and optimal conversion value. In this research, the process of mixing the sulfuric acid and kaolin, aluminum sulfate paste subsequently extracted with distilled water that has been heated to obtain aluminum sulfate. Fixed variables in this study was the weight and particle size kaolin each 25 grams and 250µm, the condition of the extraction process at a temperature of 100 ° C, the ratio of sediment and hot water 3:1, while stirring time is 1 hour by the number of washing as much as three times as well as conditions bone-dry drying. While controlled variable are the operating time for 20, 50, 90 and 110 minutes, the ratio of sulfuric acid and kaolin 1: 2; 2: 2; 3: 1 and a sulfuric acid concentration of 30%; 50%; and 70%. X-ray diffraction test showhighest composition of SiO2 as much as 96.9%, whereas only 1.26% is alumina. Optimum yield is 84.63% obtained at concentration of 70% sulfuric acid and reaction time 90 minutes

Keywords: *Water treatment, aluminum sulfate, kaolin Jaboi, dry processes, extraction*

1. Introduction

Aceh has five locations of active volcanoes, one of which is a volcano located in the village of Jaboi Sabang. The results of thealteration process of volcano known as clay minerals. According Saliban (2001) in his article explains that hydrothermal clay minerals are minerals alumina silicate-hydrate (hydrated alumino-silicate) formed through a process of alteration of ferromagnesium minerals. In general, this mineral can be grouped into six types, kaolin, pyrophyllite, mica, illite, smectite and chlorite. Identification of clay minerals by XRD method is the most effective and accurate method to date. However, compared with the petrographic method they are relatively expensive, so the combination of the two methods can be very useful and efficient.

Kaolin is a rock mass composed of clay material with a low iron content. Classified as non-metallic mineral, kaolin andprimer clay soil types that has a coarse-grained soils, fragile, is plastic when moist, harden when dry and heated. In general, the color is grayish white, but sometime can be found as yellow, orange and reddish gray color. Kaolin chemically formulated $Al_2O_3.2SiO_2.2H_2O$ as minerals, usually mixed with other oxides such as calcium oxide, magnesium oxide, sodium oxide, iron oxide and sometimes also mixed with titanium oxide (Othmer 1993).

Its presence is quite abundant in Indonesia, especially in Aceh province. It is mainly containing silica (45%) and alumina (38.5%). Other content is ferry oxide (0.98%), calcium oxide (0.49%), sodium oxide (0.48%), as well as other materials that are discharged by burning (13.78%). It is referred by the public as white clay which is residual sludge or brittle rocks that occur as a result of hydrothermal processes.

Based on research conducted by Wicaksono (2013), in the production of aluminum sulphate using bauxite as raw materials that containing Al_2O_3(alumina) 57.5%, stage of the process was done by modifying the Bayer and Gaulini process. The first stage is digestion process that operates at a temperature of 160^oC, pressure 1 atm with the addition of 55% of NaOH solution. The second stage is the precipitation process which operates at a temperature of 70^oC, 1 atm to produce $Al(OH)_3$. Furthermore, the addition of 66% sulfuric acid solution into the reactor at a temperature of 17^oC and 5 atm pressure to produce liquid aluminum sulfate. The third stage is the crystallization of molten aluminum sulfate in crystalizer belt to obtain crystals of aluminum sulphate.

Utilization of kaolin as raw material for production alum was also studied by Ismayanda (2011) with the best conversion of dissolved aluminum in the reaction between kaolin and sulfuric acid was obtained by 82%, namely under reaction conditions with a temperature of 180^oC, 90 minutes, and 350 rpm stirrer rotation. The degree of acidity (pH) of aluminum sulfate products produced in this study was 3.15 to 3.2.The high use of alum in the water treatment industry, this study sought to obtain optimal results using a variety of research and explore the potential of natural resources in Indonesia, especially in province of Aceh.

2. Materials And Method

Kaolin used in this study was from Sabang.It is yellowish white and mashed until passing 250 micron. Kaolin which is still in the form of chunks was dried until its water content decreases, then crushedusing ball mill until the its particle size passing 250 micron sieve. Kaolin and sulfuric acid was poured into beaker glasss with ratio of 1:2 ; 2:2 and 3:1 while simultaneously stirred to reach perfect mixing and the solution temperature was kept constant. Stirring speed and temperature variation used were 150 ; 200; 250 rpm and 130; 160; 190; 200and 210 ^{o}C, respectively. While sulfuric acid concentration used was 30% ; 50% ; 70%. The result from the reaction was a pasta and the length of reaction time that varied is 20; 50; 70 ; 90 and 110 minutes. Pasta extracted with hot water to dissolve aluminum sulfate. Dissolve aluminium further analyzed with complexiometric titration method. At last the performance of the alum product against sedimentation velocity of impurities was observed.

3. Results and Discussion

In the water treatment industry, alum can be used as a water purifier such as in sedimentation process because alum is dissolved in water, thus able to bind impurities and precipitate impurities in the water in result making the water becomes clear. In this research alum was made from kaolin. Kaolin is referred as white clay, a residual sludge or brittle rocks that occur as a result of hydrothermal processes. Kaolin is mainly containing silica (45%) and alumina (38.5%). Other content is ferry oxide (0.98%), calcium oxide (0.49%), sodium oxide (0.48%), as well as other materials that are discharged by burning (13.78%). Based on analysis of the composition of kaolin originated from Sabang precisely in the village Jaboi presented in Table 1.

Table 1. Analysis results of kaolin Jaboi

Composition	Percent (%)
SiO_2	96,9
Al_2O_3	1,26
Fe_2O_3	0,15
CaO	0,83
MgO	0,22
SO_3	0,13
K_2O	0,1
Na_2O	0,08
TiO_2	1,124

The results showed the highest composition is SiO_2 as much as 96.9% whereas only 1.26% alumina. This is consistent with an overview of the initial theory that the main constituent of kaolin is silica. Geologically, kaolin are form as a result of alteration trough weathering and hydrothermal process in igneous rocks *felspatik*. Aluminum potash minerals, silica and feldspar transformed into kaolin. Kaolinisation process takes place in certain conditions, so elements other than silica, aluminum, oxygen, and hydrogen will experience exchange as seen in the equation as follows:

$$2KAlSi_3O_8 + 2H_2O \rightarrow Al_2(OH)_4(SiO_5) + K_2O + 4SiO_2 \textit{(Kaolinit Felspar)}.$$

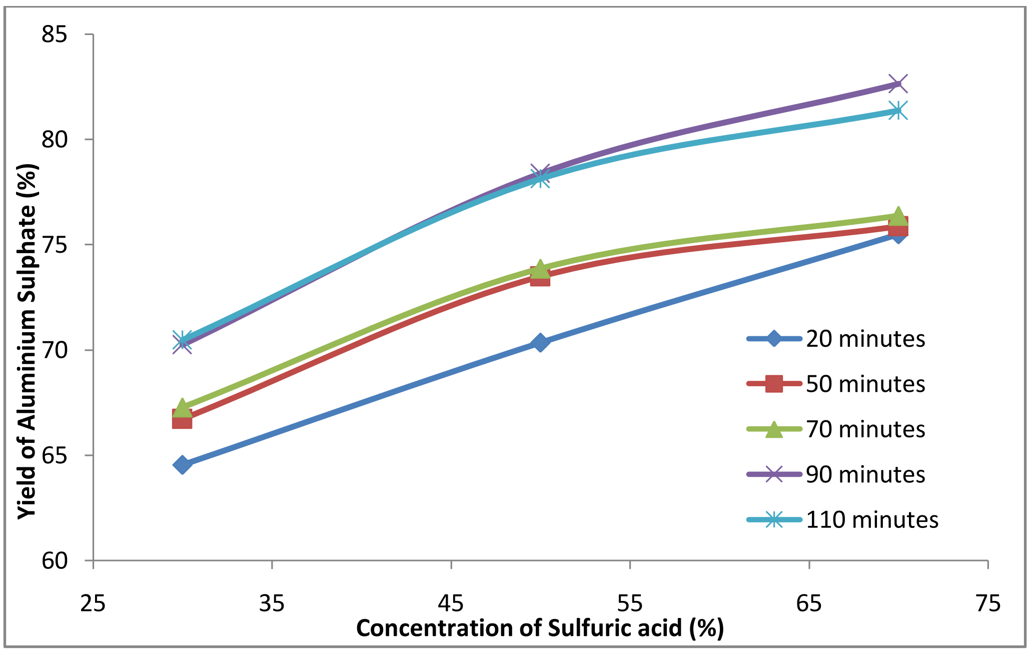

Figure 1. Effect relationship of sulfuric acid concentration vs time at stirring speed of 200 rpm, T:200 °C (sulfuric acid and kaolin ratio of 3: 1)

Based on Figure 1 can be seen in 30% sulfuric acid concentration at variation in time 20, 50, 70, 90 and 110 minutes respectively obtained yield 64.53%; 66.72%; 67.27%; 70.24%; and 70.46%. It showproduct increased significantly over the time, the same results were also obtained in sulfuric acid concentration of 50% to yield 70.35 % respectively; 73.48 %; 73.85%; 78.37 and 78.12%. At maximum points, concentration of sulfuric acid 70% and the operating time of 90 minutes, obtained a yield of 84.63% and start to decline in yield to 81.37% at 110 minutes stirring time, The length of contact time causes saturate reaction between sulfuric acid and alumina which induced optimal results. Conversion of aluminum sulphate increases with the increasing of sulfuric acid concentration and duration of reaction where can lead to increased conversion of aluminum sulfate. However, when the concentration of sulfuric acid increased by 70% and reaction time of 110 minutes, results is decline. According Ismayanda (2011) it is influenced by the low volume of fluid that is not capable to dissolve the entire surface of the kaolin powder so that the mixing is disrupted. This due to cavities in kaolin arecovered bylarge quantities of sulfuric acid, while on the rest don't reach kaolin surface.

4. Conclusion

Producing good quality alum from kaolin tookimportant variables,such as sulfuric acid concentration and ratio of kaolin and sulfuric acid. Furthermore, the expected results of alum is able to work very well as a coagulant in water treatment processes. The optimum condition to produce Aluminium Sulphate is at sulfuric acid concentration of 70% and reaction time of 90 minutes with a yield of 84.63%.

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