FERRIC ALUMINUM SULFATE PRODUCTION FOR WATER TREATMENT PURPOSES

by

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ICHTISAR

Untuk memenuhi kebutuhan akan aluminium sulfat untuk pendjernihan air telah diselidiki pembuatannja dari tailing bauksit, suatu bahan bauksit inferieur jang merupakan zat buangan pada pertambangan bauksit.

Tailing bauksit dihaluskan mendjadi —100 mesh dan kemudian direaksikan dengan asam sulfat 45° Bé selama 3 djam pada 105-110° C. Sebagai hasil diperoleh suatu „cake" dengan 15,5% oksida² logam jang dapat melarut, jang terdiri dari oksida aluminium dan besi III (aluminium sulfat teknik mengandung 15-17% Al_2O_3).

Zat² jang tidak melarut sebanjak 8,1%. (a.l. mengandung silika) tidak dipisahkan.

„Cake" jang dihasilkan mempunjai sifat² jang baik, jakni agak mudah dihantjurkan dan melarut dalam air.

Dari pertjobaan² koagulasi dengan beberapa djenis air permukaan ternjata, bahwa "ferric aluminum cake" ini dapat dipakai sebagai pengganti aluminium sulfat.

Zat² jang tidak melarut terpisah dari airnja ber-sama² dengan kotoran² koloidal jang di koagulasikan.

INTRODUCTION

Aluminum sulfate which is much used in water treatment and other processes, is still an import product in Indonesia.

Demand for this chemical is increasing steadily, especially with the construction and planning of water treatment schemes all over the archipelago. Present and future needs are estimated as follows, for which foreign currency to the amount of $ 45 per ton of alum is required.

1963	7000 ton	1967	12000 ton
1964	9000 ton	1968	14000 ton
1965	9000 ton	1969	15000 ton
1966	11000 ton	1970	17000 ton [1]).

Raw materials, needed for the production of aluminum sulfate are available locally, such as bauxite and kaolin as the alumina source, and sulfur deposits for the sulfuric acid production. Several conditions however, have to be fulfilled before production of alum in Indonesia can be realized, most important of which is the availability of high grade sulfur and/or sulfuric acid on the local market [2]).

Before World War II broke out in the Pacific, experiments were made to produce alum locally. Laboratory experiments were carried out at the Central Bureau for Technical Investigations of the Department of Industries using bauxite and spent sulfuric acid from the alkylation plant of the STANVAC oil refinery in Sungai Gerong [3]). Further experiments were carried out by the oil company in Sungai Gerong on a larger scale. The aluminum sulfate produced, however, contained a large amount of tar like substances which gave a dark color to the product. These rendered the product unsuitable for water treatment by giving a taste to the water which made it unpalatable. Since then another experiment was carried out by A.J. van Bergen and C.A.A. van der Woude to produce alum from kaolin and technical sulfuric acid at the Laboratory for Testing Materials in Bandung [4]). It must be regretted that the pilot plant stage could not be carried out due to lack of funds.

During the Japanese occupation, aluminum sulfate was produced in Sepandjang at the sulfuric acid plant, and in Sungai Gerong at the oil refinery. Both plants stopped their alum production however, after the war came to an end.

PURPOSE OF INVESTIGATION

Due to the rising demand for aluminum sulfate for water treatment purposes, it is considered necessary that Indonesia become self-supporting in the supply of this commodity.

Although Indonesian bauxite deposits are large, the amount of high grade bauxite is limited, and it is being exported for the production of aluminum or will in the future be consumed in the national aluminum industry.

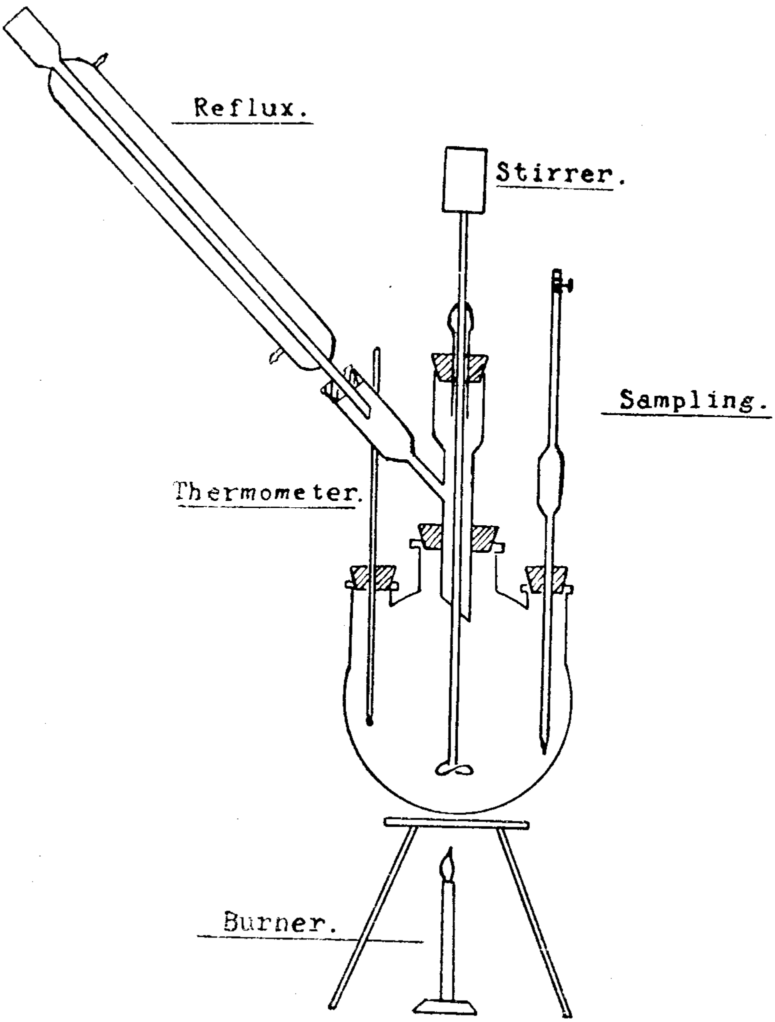
Bauxite tailing, however, is available in great quantities and is being discarded as a waste product of the bauxite mines [5]). It contains a substantial amount of iron, so that digestion with acid will give a product, containing both aluminum and iron sulfates, each of which is known to have coagulating properties.

Purpose of this investigation will be to find out:
Whether from bauxite tailing and sulfuric acid, ferric-aluminum sulfate can be produced which is suitable as a coagulant in water treatment processes.

PREPARATION OF FERRIC ALUMINUM CAKE.

Bauxite tailing was made available through the courtesy of P.N. Tambang Bauksit Indonesia, Kidjang, with the following analysis:

Free moisture		1.81%
Dry basis:	Al_2O_3	34.94%
	Fe_2O_3	19.45%
	TiO_2	1.43%
	SiO_2	22.71%
	bound water	21.56%



Laboratory equipment for the production of ferric aluminum cake.

Bauxite tailing (2% excess) was ground to a fineness of minus 100 mesh, and digested with 2.37 parts of 45° Bé sulfuric acid in a three neck flask under controlled heating.
As soon as the exothermic reaction set in, the initial heating was decreased, leaving the reacting mixture at reflux temperatures of 105 — 110°C. A stirrer was provided for getting a smooth reaction throughout the mixture. Samples were taken every half hour after the boiling temperature was reached. After three hours of reaction the mixture was poured into a disk, in which the mass solidified after cooling.

Analysis.

Sample No.	Reaction Time, hours	Slurry			Yield of soluble oxides % total oxides in tailing
		Total soluble oxides	soluble Fe_2O_3	soluble Al_2O_3	
1	0.5	10.61%	4.40%	6.21%	66.2%
2	1	11.56	4.57	6.99	72.2
3	1.5	12.58	4.81	7.77	78.5
4	2	14.45	4.79	9.66	90.3
5	2.5	14.30	4.78	9.52	89.3
6	3	14.80	5.03	9.77	92.3

Note: i the percentages of Al_2O_3 were obtained by subtracting % Fe_2O_3 from % total oxides, and thus actually include any minor quantity of TiO_2

ii During the cooling (solidification) period some evaporation of water took place, yielding a cake somewhat less than the amount of slurry (95.4%). For obtaining the analysis of the cake, above percentages, which were based on the amount of slurry, should therefore be divided by 0.954. Total soluble oxides in the final cake then becomes

$$\frac{1}{0.954} \times 14.80\% = 15.51\%$$

JAR TESTS

The ferric aluminum cake obtained was compared with imported aluminum sulfate, commonly used for water treatment in Indonesia, and which contained at least 17% Al_2O_3.
These comparisons were carried out by jar tests using different surface waters

The following jar test procedure was used:

1 minute of rapid mixing with a speed of 100 rpm

10 minutes of slow mixing with a speed of 60 rpm

15 minutes of settling followed by decantation and filtration.

After flocculation was finished, every jar was given a Floc Index and the time needed for settling of the flocs was indicated in minutes.
The turbidity of the samples was measured after decantation as well as after filtration.

In the filtered water were also determined: specific electrical conductivity at 20° C (K_{20}), total iron content, color and pH.

Floc Index: 4 Pin Point
6 Fair
8 Good
10 Excellent

Sample I: *Surface water from Hydraulic Laboratory, ITB Campus*

	Coagulant *ppm aluminumsulfate/ppm ferric aluminum cake*					
	20/20	40/40	45/45	50/50	55/55	60/60
Floc index	4/4	8/8	8/8	10/10	10/10	10/10
Settling time (minutes)	15/15	6.2/12.2	6.1/6.0	6.5/3.4	8.1/7.0	6.1/7.4
Turbidity after decantation	6.8/8.5	2.4/2.9	2.2/2.5	3.1/3.2	3.2/2.9	2.2/2.4
Turbidity after filtration	6.1/6.5	0.9/1.2	0.7/0.5	0.5/0.7	0.6/0.5	0.8/0.6
K_{20} ($10^{-6}ohm^{-1}cm^{-1}$)	118/119	125/122	128/128	129/129	128/127	127/126
ppm Fe (total)	0.05/0.07	0/Traces	0/0	0/0	0/Traces	0/0
Color (Pt-Co scale)	15/20	10/15	7.5/10	7.5/7.5	7.5/7.5	7.5/7.5
pH	6.7/6.8	6.6/6.6	6.5/6.6	6.5/6.5	6.4/6.4	6.4/6.4

Sample II: *Tjikapundung river water* (from the dam near Djalan Siliwangi)

	Coagulant ppm aluminumsulfate/ppm ferric aluminum cake					
	20/20	40/40	45/45	50/50	55/55	60/60
Floc index	4/4	6/6	8⁻/8	10⁻/10	10/10	10⁻/10
Settling time (minutes)	15/15	13.3/13.4	9.3/13.4	9.3/9.2	9.0/9.0	9.4/9.0
Turbidity after decantation	3.1/3.7	1.4/1.3	1.1/1.1	1.0/1.0	1.0/1.1	1.8/1.3
Turbidity after filtration	1.2/1.5	0.6/0.6	0.2/0.1	0.1/0.1	0.2/0.1	0.2/0.2
K_{20} ($10^{-6}ohm^{-1}cm^{-1}$)	115/111	118/119	118/118	119/118	120/120	125/121
ppm Fe (total)	Traces/0.1	0/0	0/0	0/0	0/0	0/0
Color (Pt-Co scale)	20/15	15/10	5/5	5/5	5/5	5/5
pH	7.3/7.3	7.0/7.0	6.9/7.0	6.8/6.9	6.8/6.8	6.8/6.9

Sample III: *Tjikapundung river water* (from Kebon Bibit)

	Coagulant ppm aluminumsulfate/ppm ferric aluminum Cake					
	20/20	40/40	45/45	50/50	55/55	60/60
Floc index	4/4	8/6	6/8	8/10	10/10	10/10
Settling time (minutes)	10.5/10.6	8.1/10.0	8.2/7.4	10/5/8.1	9.2/8.5	7.1/7.1
Turbidity after decantation	5.4/5.8	0.7/1.7	1.5/1.2	1.4/1.0	1.2/1.2	0.9/1.0
Turbidity after filtration	3.1/2.4	0.4/0.7	0.2/0.2	0.5/0.2	0.2/0.2	0.2/0.2
K_{20} ($10^{-6}ohm^{-1}cm^{-1}$)	108/107	111/110	109/110	110/110	111/111	116/111
ppm Fe (total)	Traces/0.06	0/Traces	0/0	Traces/0	Traces/0	0/0
Color (Pt-Co scale)	20/30	10/15	5/10	5/10	10/10	5/5
pH	7.2/7.2	7.0/7.0	6.8/6.7	6.7/6.7	6.7/6.7	6.7/6.7
$KMnO_4$ number	6.8/7.1	4.6/4.7	1.9/2.5	3.5/2.6	3.3/3.0	2.6/3.3

RESULTS OF JAR TESTS

Almost identical results were obtained with the produced ferric aluminum cake as compared with aluminum sulfate, commonly used in Indonesia. Only slight differences occur, which, however, can be neglected.

The high iron content in ferric aluminum sulfate did not influence the quality of the filtered water, if the right dose for coagulation was applied.

SUMMARY:

Three hours digestion of ground bauxite tailing with 45° Bé sulfuric acid easily yields a product with a total soluble oxide content of 15,5% (compare 15-17% alumina content in commercial aluminum sulfate).
By not separating the insolubles (8,1% of silica and undissolved oxides) from the soluble sulfates, a cake was obtained which is comparatively easy to break and to dissolve.

As a coagulant in water treatment, ferric aluminum cake compares favorably to imported aluminum sulfate, the insoluble matter in the first being removed together with precipitated colloidal matter from the clarified waters.

ACKNOWLEDGEMENT

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