

OPTIMIZATION OF ALUMINA FLOTATION FROM GIBBSITE BEARING-SHALE OF SOUTH WESTERN SINAI, EGYPT BY USING SODIUM OLEATE AS A COLLECTOR

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The effect of sodium oleate on the flotation of alumina was studied using samples of gibbsite bearing-shale of south western Sinai, Egypt. The assays of the samples are 18.98% Al_2O_3 , 15.45% SiO_2 , 12.83% Fe_2O_3 , 14.87% CaO , 5.74% P_2O_5 , 5.34% MnO , 0.86% K_2O , 0.76% Na_2O , 1.50% trace elements and 23.65% loss on ignition. The aim of this research is to upgrade alumina in the concentrate to be suitable for the industrial applications. Various operating variables (i. e. pH, pulp density, collector dosage, and particle size) affecting the flotation process of gibbsite were studied. Sodium oleate used as an anionic collector; as well as, sodium hydroxide was used as a pH modifier.

The optimum conditions obtained were as follows: pH = 11, collector dosage = 2000 g/t, pulp density = 250 g/l and particle size = (-100+80) μm . At these conditions, a concentrate having a grade of 40.1% alumina with component recovery of 96.1% was obtained. The grades of the other ore constituents in final concentrate were as follows: SiO_2 was decreased from 14.2% to 5.9%, CaO was decreased from 14.1% to 4.8%, Fe_2O_3 was decreased from 13.1% to 5.4%, P_2O_5 was decreased from 4.3% to 3.2%, MnO was decreased from 4.2% to 3.5%, while K_2O was increased from 0.89% to 1.3%, Na_2O was also increased from 0.69% to 1.2%, traces were increased from 1.6% to 2.7%, and loss on ignition was increased from 25.4% to 31.9%. The component recoveries of SiO_2 , CaO , Fe_2O_3 , P_2O_5 , MnO , K_2O , Na_2O , and traces of the final concentrate were 21.4%, 17.5%, 21.2%, 38.4%, 42.9%, 75.3%, 89.6%, and 86.9%, respectively. The mass recovery of final concentrate was 51.5%.

KEYWORDS: Gibbsite, alumina flotation, collectors, isoelectric point, pH, pulp density, particle size

NOMENCLATURE

c	assay of constituent in concentrate, %	$R_c(t)$	component recovery of constituent in tailings, %
C	mass of concentrate, gm	$R_m(c)$	mass recovery of concentrate, %
f	assay of constituent in feed, %	$R_m(t)$	mass recovery of tailings, %
F	mass of feed, gm	t	assay of constituent in tailings, %
$R_c(c)$	component recovery of constituent in concentrate, %	T	mass of tailings, gm

1. INTRODUCTION

Gibbsite $\text{Al}(\text{OH})_3$ is a crystalline aluminum trihydroxide which is used in the manufacture of refractory products [1]. The most abundant structural element in the earth's crust is aluminium. It composes eight per cent of the earth's mineable layer and is most abundant as aluminium oxide or combined oxides in a wide variety of minerals [2,3]. Due to their high corrosion resistance and mechanical strength to mass ratio, aluminum alloys are used as major structural material in aircraft, buildings, machinery parts, beverage cans and food warps [4,5]. In nature, aluminum occurs only in combination with other elements and is a part of the crystal structure of many rock forming minerals. Bauxite is the most important commercial ore of aluminum [5]. Bauxite consists of several hydrous aluminium oxide phases [boehmite ($\gamma\text{AlO.OH}$), gibbsite ($\text{Al}(\text{OH})_3$), and diaspore ($\alpha\text{AlO.OH}$)] [2]. Besides of its main use as an aluminum ore, bauxite is used also to manufacture refractory products, aluminous chemicals, abrasives, and miscellaneous applications. These applications include β -alumina solid state electrolytes and first-class refractories [4].

The major impurities of gibbsite of south western Sinai are quartz, hematite and kaolinite. Other impurities such as, rare earths and alkali occur in small percentages. Gravity, magnetic, or electrostatic separation methods are not suitable for the concentration of gibbsite ore. This may be due to the very small significant differences in the physical properties (density, magnetic and electrostatic susceptibility, etc.) between the mineral phases (gibbsite, kaolinite and quartz), which are considered the major constituents of the ore. Flotation process was then selected as a suitable and effective method for the concentration and upgrading of alumina from gibbsite bearing-shale of south western Sinai to make it suitable for the Bayer process.

Many researchers [4-13] have studied the flotation of alumina using different types of collectors. Their results are summarized and explained below.

Flotation was selected as the most suitable method for the recovery of a high purity gibbsite concentrate from the Brazilian bauxite ore using alkyl sulfates as collectors. The results were good at pH value of 2, where the component recovery of alumina was 97.4% and the grade of alumina was 93% at a particle size of $(-177+3)$ μm and a pulp density of 20% solids [4].

In other research, sodium oleate was used to float gibbsite from a mixture of quartz, kaolinite, iron and titanium oxides (Guyana bauxite ore) at pH values between 10 and 11. At the optimum conditions a component recovery of more than 90% gibbsite was obtained [6]. The maximum floatability of gibbsite, chamosite and boehmite was achieved at a pH of 8 during the adsorption of laurylamine on all minerals. The adsorption of laurylamine occurred at a pH value ranged between 4 and 8 [7].

However, the flotation of gibbsite by using amines as collectors can not be applied for the south western Sinai gibbsite ore because a significant amount of quartz is present. Bulut and Yurtsever [8] found that, sodium dodecyl sulfate, as an alkyl sulfate collector, is effective in the acidic pH range during the flotation of alumina from kyanite ore using different collectors. Dodecylamine hydrochloride (DAH), as a cationic collector, is effective in the basic pH range and potassium oleate (KOL), as an anionic collector, floats kyanite at pH value ranges from 6 to 9. Doss [9] reported that, anionic surfactants such as the alkyl sulfates and alkyl sulfonates are adsorbed on

alumina by means of electrostatic and hydrophobic bonding. Consequently, when the alumina surface becomes negatively charged above pH 9, sulphonate adsorption ceases, but at pH values below 9, sulphonate ions is adsorbed to the positive alumina surface by electrostatic attraction.

Aluminum silicates such as pyrophyllite, illite and kaolinite are impurity minerals in diasporic-bauxite, it being necessary to remove these silicate minerals to improve the mass ratio of $\text{Al}_2\text{O}_3/\text{SiO}_2$ for the Bayer process. Quaternary ammonium salt (DTAL) was used to float diaspore at a pH values ranged from 6 to 7 [10]. The surface charges of gibbsite particles were probed by potentiometric titration and subsequently were analyzed to estimate intrinsic proton affinity constants of OH surface groups. It was found that the point of zero charge could be achieved at a pH value ranged from 8.1 to 9.6 [11]. The electron spin resonance (ESR) was used to study the adsorption of spin probe analogs of stearic acid on amorphous alumina [12].

The point of zero charge (ZPC) of gibbsite is at a pH value of 9.1. The electrokinetic potential and contact angle measurements were used to show the adsorption mechanism of sodium dodecyl sulfate and dodecylamine chloride on the alumina surface. From these results, it was found that, sodium dodecyl sulfate and dodecylamine chloride converted the alumina surface to a hydrophobic one at a pH less than ZPC and a pH more than ZPC, respectively [13]. Zhenghe et al. [5] have used the reverse flotation technology to float alumina from aluminosilicates using a cationic collector. The purpose of the presented work is to upgrade the alumina in gibbsite ore to be suitable for industrial applications by using of sodium oleate as a flotation collector. These industrial applications include aluminous chemicals, abrasives, building stones, alumina refractories and aluminium extraction [4].

2. MINERALOGY

Based on petrography and EDX technique, several minerals were identified in the studied samples as follows:

Gibbsite is turbid cryptocrystalline heavily stained black, orange and brown colors. It occurs as radial aggregate embedded in marly matrix. The matrix is mainly composed of equal amounts of fine-grained quartz and carbonate. It contains minute grains of Fe and Mn oxy-hydroxides. The BSE of gibbsite is shown in Fig. 1.

Quartz is monocrystalline, medium-grained, well sorted and subround to well round. The cryptocrystalline quartz occurs as filling pore spaces between grains and as overgrowths. The BSE of quartz is shown in Fig. 2.

Kaolin occurs as amorphous dusts and patches with aggregate polarization in crossed nicols. It mostly resulted from acidic ground water, whereas the unstable minerals dissolve releasing Si, Al to the pore waters that can be produced by flushing of the gibbsite by fresh water. The BSE of kaolin is shown in Fig. 3.

Halite appears as disseminated small cubic crystals encountered in gibbsite. Calcite occurs as rhombohedral crystals, anhedral grains and aggregates radiating fibrous. It exhibits twinning and perfect rhombohedral cleavages.

Hematite occurs either as disseminated anhedral crystals or occasionally as minutes. It is steel-black with metallic luster in reflected light with a tendency to a marginal red. Generally, the iron associated with manganese forming Mn-Fe minerals.

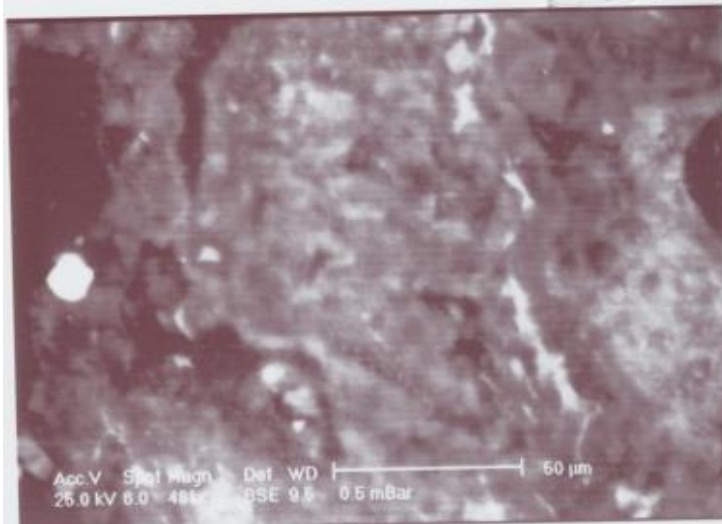


Fig. 1: The BSE image of gibbsite

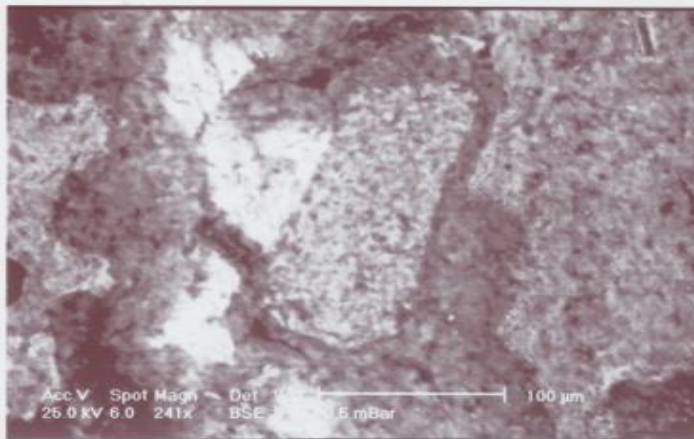


Fig. 2: The BSE image of quartz

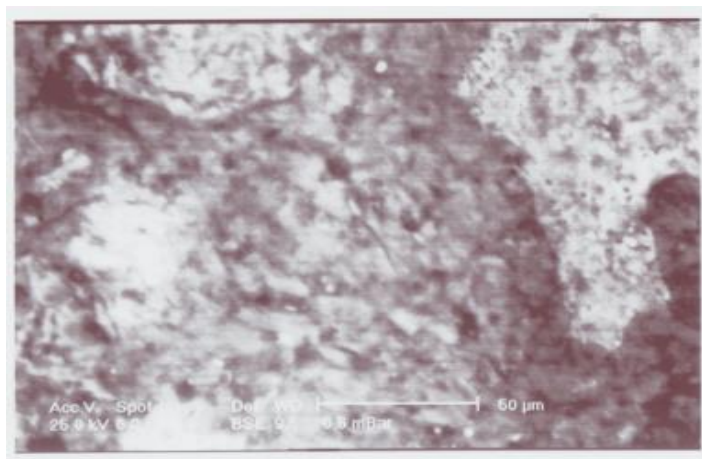


Fig. 3: The BSE image of kaolin

Gypsum exists as white massive and acicular prismatic crystals of different shape and sizes. They exhibit aggregates of subhedral to anhedral crystals having vitreous luster. Few crystals show the perfect cleavage of the growing crystals. The occurrence of gypsum in the studied gibbsite can be explained as due to upward movement of brine by capillary action and its evaporation at the surface.

3. EXPERIMENTAL WORK

3.1 Materials

The samples used in the present work were obtained from the Southwest of Sinai (Abu Thur). A batch representative sample of about 250 kg was taken from the gibbsite zone. The obtained sample was split to smaller ones and crushed to minus 10 mm in a laboratory jaw crusher. The crusher product was sieved on a screen of 200 μm size. The screen oversize (+200 μm) was ground in a closed ball mill to minus 200 μm . Grinding conditions were as follows: slope of mill = 0° , ball-to-ore ratio = 3:1, mill speed = 60 rpm, and grinding time = 20 minutes. The crushing and grinding flowsheet of the head sample is illustrated in Fig. 4.

A representative sample was taken and chemically analyzed for the determination of the different constituents. The chemical analysis of the studied head sample is given in Table 1

3.2 Reagents

All the flotation tests were carried out using sodium oleate as a collector. Sodium hydroxide was used as a pH modifier. Tap water was used for maintaining the flotation pulp at a constant level, as well as, all the other experimental purposes.

3.3 Apparatus

Laboratory flotation tests were carried out in a 3000 ml Wemco Fagergern cell. A hand skimming was used to skim the froth.

3.4 Experimental Procedures

The impeller speed, during all flotation tests, was fixed at 1250 rpm and an aeration rate of 6 L/min was used. The total conditioning time was 15 min. The studied operating parameters were the pH value, collector dosage, pulp density and feed particle size. The gibbsite sample was added slowly and then conditioned with water for 5 minutes.

The pH value was adjusted at the end of the initial conditioning period and allowed to condition for 5 minutes with the pulp. The collector dosage was added at the end of the second conditioning period and allowed to condition for 5 min with the pulp prior the aeration. The air supply valve was gradually opened. The required pulp level was maintained constant during the flotation experiments.

In each experiment, and after allowing 15 sec for the froth to form, one concentrate was collected during batch flotation tests. The collected products

(concentrate and tailings) were dried, weighed and chemically analyzed. The component recovery of alumina and other constituents in the concentrate and tailings were calculated.

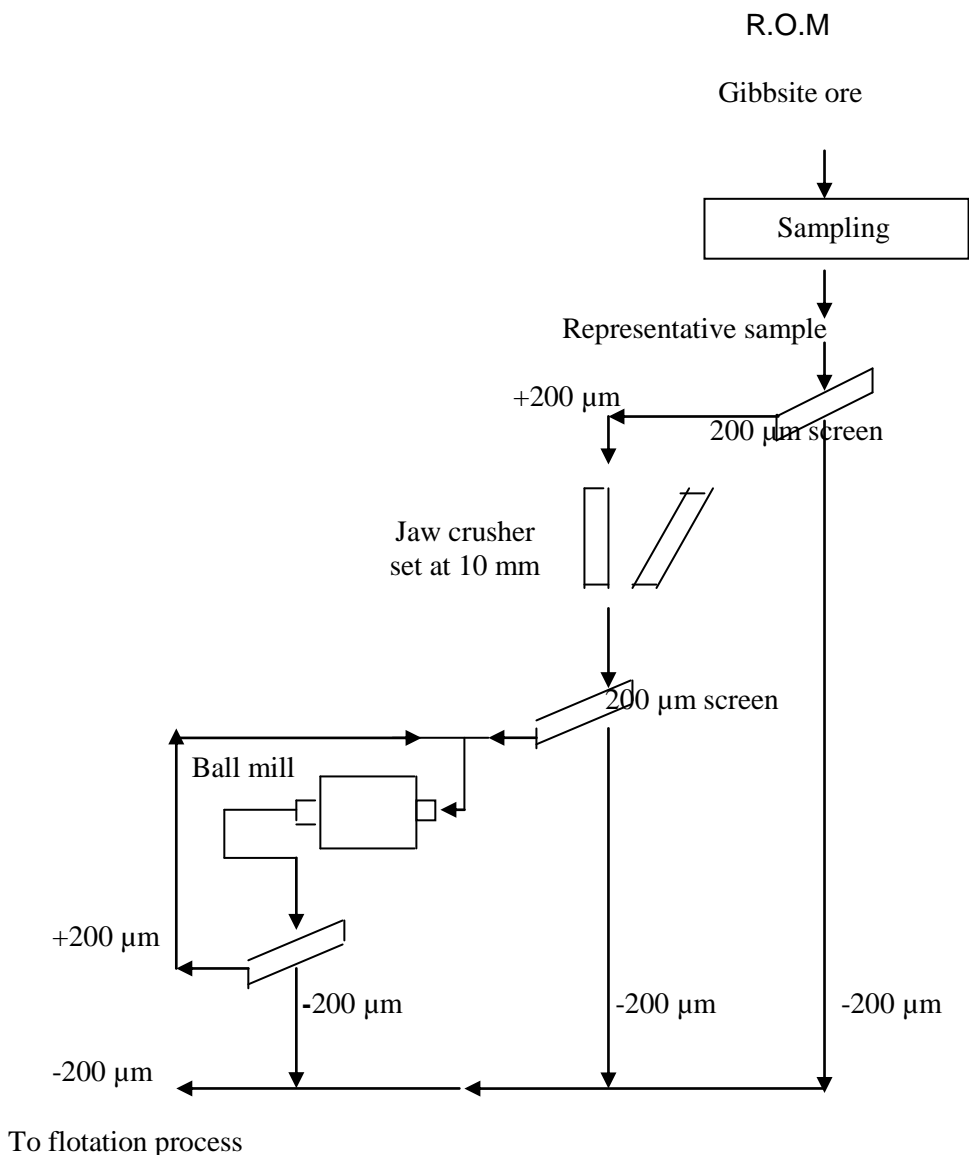


Fig. 4: Crushing & grinding flow-sheet of the head sample

Table 1: Chemical analysis of the head sample of gibbsite ore from South Western Sinai (Abuthur)

Al ₂ O ₃ %	SiO ₂ %	Fe ₂ O ₃ %	CaO%	P ₂ O ₅ %	MnO%	K ₂ O%	Na ₂ O%	Traces%	L.O.I.%	Total%
18.98	15.45	12.83	14.87	5.74	5.34	0.86	0.76	1.50	23.65	99.98

4. RESULTS AND DISCUSSION

4.1 Calculations of Experimental Mass and Component Recovery of Flotation products

Using the mass percent and assays of alumina in feed, concentrate, and tailings, the experimental value of the mass recovery and component recovery of alumina in concentrate and tailings can be calculated as follows:

$$\text{Mass recovery of concentrate} = R_m(c) = 100 \cdot \frac{C}{F} \quad (1)$$

$$\text{Mass recovery of tailings} = R_m(t) = 100 \cdot \frac{T}{F} \quad (2)$$

$$\text{Component recovery in concentrate} = R_c(c) = 100 \cdot \frac{C.c}{F.f} \quad (3)$$

$$\text{Component recovery in tailings} = R_c(t) = 100 \cdot \frac{T.t}{F.f} \quad (4)$$

4.2 Results of Using Sodium oleate as a Collector

4.2.1 Effect of pH value

Table 2 and Figure 5a show the effect of pH value on the grade, component recovery of alumina in the concentrate, and the mass recovery of concentrate. These experiments were carried out at a particle size of $-200 \mu\text{m}$, pulp density of 150 g/l, and collector dosage of 1500 g/t. From this figure, it is noticed that the best selectivity is achieved at a pH value of 11, where the component recovery of alumina in concentrate was 78.3%, the alumina grade was 40.1%, and the mass recovery of concentrate was about 37.1%. The grade of alumina decreases from 38.1% at a pH value of 6 to 33.5% at a pH value of 9, then increases at higher pH value.

The zero point charge of gibbsite is at pH values of (8.1–9). Below these values, the gibbsite surface is positively charged, thus, negatively charged ions of any anionic collector may be potentially adsorbed in this pH range [13]. Above the zero point charge value, the surface of gibbsite is negatively charged, so ions of any anionic collector are repelled from the gibbsite surface. Sodium oleate ($\text{C}_{17}\text{H}_{33}\text{COONa}$) is an alkali soap of oleic acid. Although sodium oleate is an anionic collector, it floats gibbsite above the isoelectric point of gibbsite. This indicates that, chemisorption rather than the electrostatic interaction occurs between the oleate anion and gibbsite surface [14, 15].

The isoelectric point of alumina shifts in the presence of sodium oleate and this shift of the isoelectric point of gibbsite is attributed to the chemisorption of sodium oleate on the gibbsite surface. It can be noticed that the component recovery of alumina decreases from 73.9% at a pH value of 6 to 57.4% at a pH value of 8, then increases at higher pH values.

Table 2: The effect of pH value on the mass recovery, grade, and component recovery of alumina

Exp. No.	pH value	Product	Mass Recovery, %	Alumina, %	
				Grade	Recovery
1	6	Concentrate	36.9	38.1	73.9
		Tailings	63.1	7.9	26.1
		Feed	100	19	100
2	7	Concentrate	34.2	35.5	63.8
		Tailings	65.8	10.4	36.2
		Feed	100	19	100
3	8	Concentrate	33.7	32.4	57.4
		Tailings	66.3	12.2	42.6
		Feed	100	19	100
4	9	Concentrate	33.7	33.5	59.3
		Tailings	66.3	11.6	40.7
		Feed	100	19	100
5	10	Concentrate	35.8	35.5	66.9
		Tailings	64.2	9.8	33.1
		Feed	100	19	100
6	11	Concentrate	37.1	40.1	78.3
		Tailings	62.9	6.6	21.7
		Feed	100	19	100

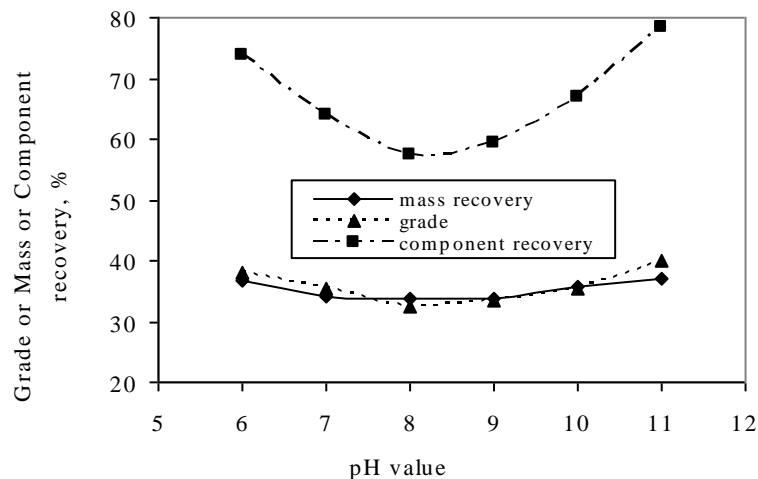


Fig. 5a: Effect of pH value on the grade, component recovery of alumina in the concentrate, and the mass recovery of concentrate.

Figure 5b shows the effect of pH value on the grade, component recovery of alumina in the tailings, and the mass recovery of tailings. From this figure, it is

revealed that the component recovery of alumina in the tailings increases from 26.1% at a pH value of 6 to 42.6% at a pH value of 8. At pH values greater than 8, the component recovery of alumina in the tailings is decreased. The grade of alumina increases from 7.9% at a pH value of 6 to 12.2% at a pH value of 8, and then decreases at higher pH values.

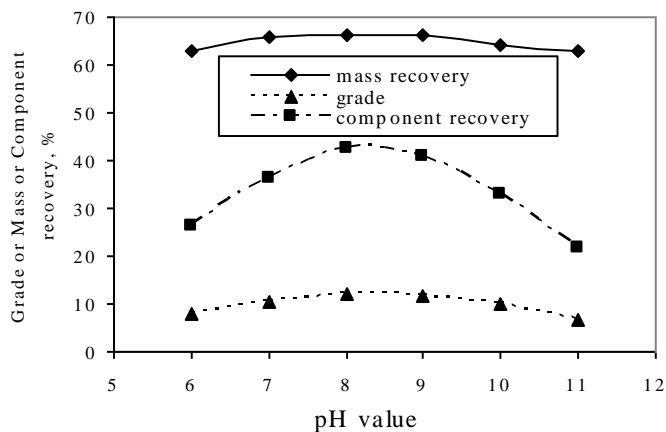


Fig. 5b: Effect of pH value on the grade, component recovery of alumina in tailings, and the mass recovery of tailings.

4.2.2 Effect of sodium oleate concentration

Table 3 and Figure 6a illustrate the effect of sodium oleate concentration on the grade, component recovery of alumina in the concentrate, and the mass recovery of concentrate at the optimum value of pH (11) obtained from the previous experiments. These experiments were carried out at the same conditions of pulp density (150 g/l) and particle size ($-200\ \mu\text{m}$). From this figure, it is shown that the component recovery of alumina increases from 61.8% at a concentration of 500 g/t sodium oleate to about 79.9% at a dosage of 2000 g/t, then decreases at higher collector dosages. The mass recovery of concentrate is increased from 27.6% to 38.9% at the same concentrations, and then decreases at collector dosages higher than 2000 g/t.

The grade of alumina decreases also from 42.5 % to 39.1% at the same dosages, and then increases at collector dosages higher than 2000 g/t. There is a gradual increase in the recovery of alumina with the increase of the collector concentration up to a maximum value. This may be due to the rapid reaction, more rapid approach of exchange adsorption equilibrium, and may also be attributed to the powerful action of sodium oleate to produce a water-repulsion and monomolecular layer on particle surfaces thereby imparting hydrophobicity to the particles [16,17,18]. An excessive addition of collector dosages leads to an inverse effect and hence decreases the component recovery of alumina. This may be due to the development of collector multilayer on the particles, reducing the proportion of hydrocarbon radicals oriented into the bulk solution. The hydrophobicity of particles is reduced and tends to float other minerals, reducing selectivity and floatability [17].

Table 3 : The effect of sodium oleate concentration on the mass recovery, Grade, and component recovery of alumina.

Exp. No.	Collector dosage, g/t	Product	Mass Recovery, %	Alumina, %	
				Grade	Recovery
1	500	Concentrate	27.6	42.5	61.8
		Tailings	72.4	9.9	38.2
		Feed	100	19	100
2	1000	Concentrate	33.7	41.1	72.9
		Tailings	66.3	7.8	27.1
		Feed	100	19	100
3	1500	Concentrate	37.1	40.1	78.3
		Tailings	62.9	6.6	21.7
		Feed	100	19	100
4	2000	Concentrate	38.9	39.1	79.9
		Tailings	61.1	6.3	20.1
		Feed	100	19	100
5	2500	Concentrate	35.9	40.1	75.5
		Tailings	64.1	4.5	24.5
		Feed	100	19	100
6	3000	Concentrate	34.4	41.1	73.7
		Tailings	65.6	4.9	26.3
		Feed	100	19	100

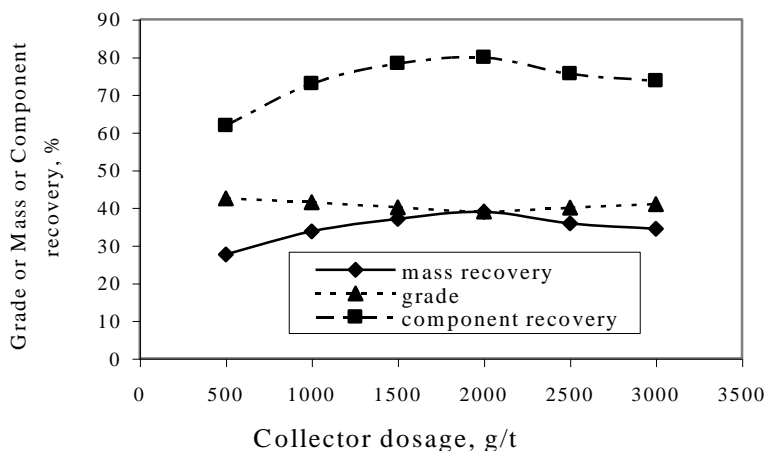


Fig 6a: Effect of sodium oleate dosage on the grade, component recovery of alumina in concentrate, and the mass recovery of concentrate.

Table 3 and Figure 6b show the effect of sodium oleate concentration on the grade, component recovery of alumina in tailings, and the mass recovery of tailings. From this figure it is seen that, the component recovery of alumina in tailings decreases from 38.2% at a concentration of 500 g/t of sodium oleate to 20.1% at 2000 g/t, then

increases at higher collector dosages. The mass recovery of tailings decreases from about 72.4% to 61.1% at the same collector concentrations, and then increases at collector dosages higher than 2000 g/t.

The grade of alumina in tailings is decreased from 9.9% at a concentration of 500 g/t to 4.5% at 2500 g/t, and then increases at higher collector dosages.

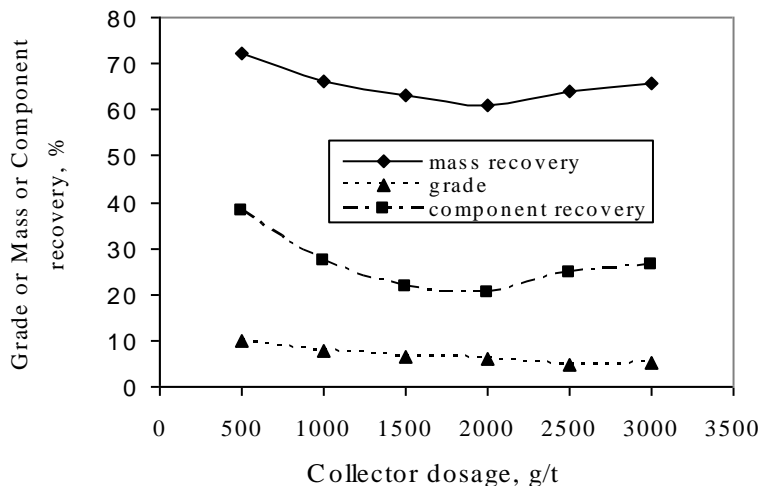


Fig 6b: Effect of sodium oleate dosage on the grade, component recovery of alumina in tailings, and the mass recovery of tailings

4.2.3 Effect of pulp density

Table 4 and Figure 7a show the effect of pulp density on the grade, component recovery of alumina in the concentrate, and the mass recovery of concentrate. These experiments were carried out at a pH value of 11, 2000 g/t sodium oleate dosage, and with the same above stated particle size ($-200 \mu\text{m}$). From this figure, it is seen that the component recovery increases from 79.9% at a pulp density of 150 g/l to 95.9% at 350 g/l, then decreases to 94.9% at a pulp density of 400 g/l. The mass recovery of the concentrate is increased from 38.9% to 66.8% at the same pulp densities, and then decreased to 59.9% at 400 g/l. The grade of alumina in concentrate decreased from 39.1% to 27.3% at the same pulp densities, and then increased to 30.1% at 400 g/l.

Wills [17] has reported that as a matter of economics, flotation separation must be carried out in as dense a pulp as possible with good selectivity and operating conditions. The denser the pulp, the lesser cell volume required, since the effectiveness of most reagents is a function of their concentrations in solution. The pulp must be diluted enough to permit particle re-arrangement to proceed freely. Over dilution should be avoided as it results in greater amount of water consumption, reagent consumption and more equipment for each tone of ore treated [24]. Therefore, 250 g/l is chosen as the optimum value of the pulp density.

Table 4: The effect of pulp density on the mass recovery, grade, and component recovery of alumina

Exp. No.	Pulp density, g/l	Product	Mass Recovery, %	Alumina, %	
				Grade	Recovery
1	150	Concentrate	38.9	39.1	79.9
		Tailings	61.1	6.3	20.1
		Feed	100	19	100
2	200	Concentrate	42.1	38.6	85.5
		Tailings	57.9	4.8	14.5
		Feed	100	19	100
3	250	Concentrate	44.8	38.2	90.1
		Tailings	55.2	3.3	9.9
		Feed	100	19	100
4	300	Concentrate	56.1	31.5	93.1
		Tailings	43.9	2.9	6.9
		Feed	100	19	100
5	350	Concentrate	66.8	27.3	95.9
		Tailings	33.2	2.3	4.1
		Feed	100	19	100
6	400	Concentrate	59.9	30.1	94.9
		Tailings	40.1	2.4	5.1
		Feed	100	100	100

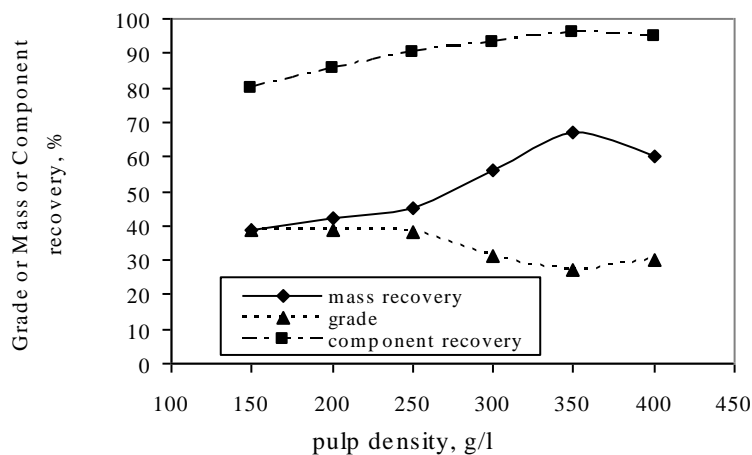


Fig. 7a: Effect of pulp density on the grade, component recovery of alumina in concentrate, and the mass recovery of concentrate.

Figure 7b shows the effect of pulp density on the grade, component recovery of alumina in tailings, and the mass recovery in the tailings. From this figure, it is seen that the component recovery of alumina in tailings decreases from 20.1% at a pulp density of 150 g/l to 4.1% at 350 g/l, then increases to 5.1% at 400 g/l. The mass recovery of tailings decreases from 61.1% to 33.2%, and then increases to 40.1% at the same pulp densities. The grade of alumina in tailings decreases from 6.3% to 2.3%, and then increases to 2.4% at the previous pulp densities. The excessive pulp density leads to a low level of mineral extraction in the concentrate and increase the recovery of alumina in the tailings.

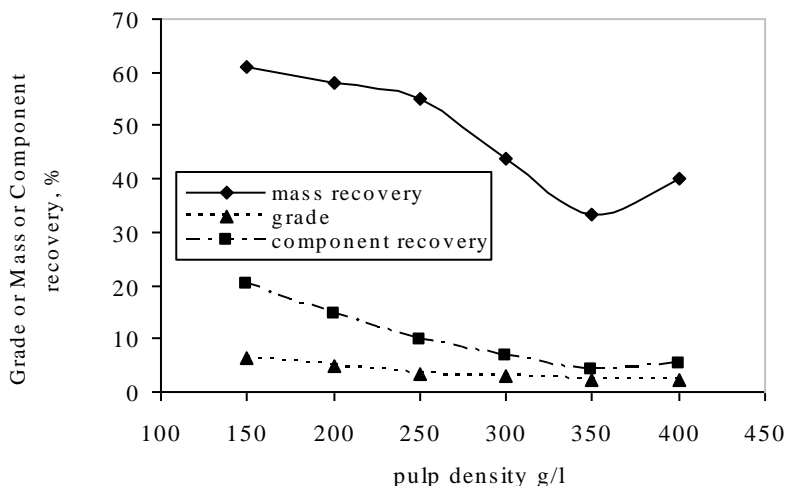


Fig. 7b: Effect of pulp density on the grade, component recovery of alumina in tailings, and the mass recovery of tailings.

4.2.4 Effect of particle size

Table 5 and Figure 8a show the effect of particle size on the grade, component recovery of alumina in the concentrate, and the mass recovery of concentrate. These experiments were executed at a pH value of 11, 2000 g/t sodium oleate concentration, and a pulp density of 250 g/l. From this figure, it is seen that, the component recovery of alumina increases from 69.1% at a particle size of $(-200+160)$ μm to 97.6% at $(-80+63)$ μm , then decreases to 89.9% at $(-63+0)$ μm .

The mass recovery of concentrate increases from 22.4% to 64.7% at the same particle sizes, and then decreases to 54.7% at $(-63+0)$ μm . The grade of alumina in concentrate decreases from 46.9% at a particle size of $(-200+160)$ μm to 33.2% at $(-80+63)$ μm , and then increases to 34.5% at $(-63+0)$ μm .

Particle liberation plays an important role in the flotation process, where particles of various sizes do not float equally well. Increasing particle sizes may result in longer induction times, a commensurate deterioration in floatability, as well as, it is expected that the coarser particles would tend to settle in the lower part of the flotation cell [19,20]. The recovery is maximum for some intermediate size ranges, with a

distinct fall towards the extreme coarse and extreme fine ranges [16,21]. Vijayendra [16] reported that, the particles should not be overground, as the recovery and selectivity decrease markedly if the particles are finer than 5 to 10 microns.

Table 5 : Effect of particle size on the mass recovery, grade, and component recovery of alumina.

Exp. No.	Particle size, μm	Product	Mass Recovery, %	Alumina, %	
				Grade	Recovery
1	-200+160	Concentrate	22.4	46.9	69.1
		Tailings	77.6	6.1	30.9
		Feed	100	15.2	100
2	-160+125	Concentrate	29.8	44.5	85.5
		Tailings	70.2	2.5	14.5
		Feed	100	15.5	100
3	-125+100	Concentrate	40.6	41.6	92.9
		Tailings	59.4	1.8	7.1
		Feed	100	18.2	100
4	-100+80	Concentrate	51.5	40.1	96.1
		Tailings	48.5	1.7	3.9
		Feed	100	21.5	100
5	-80+63	Concentrate	64.7	33.2	97.6
		Tailings	35.3	1.5	2.4
		Feed	100	22	100
6	-63+0	Concentrate	54.7	34.5	89.9
		Tailings	45.3	4.7	10.1
		Feed	100	21	100

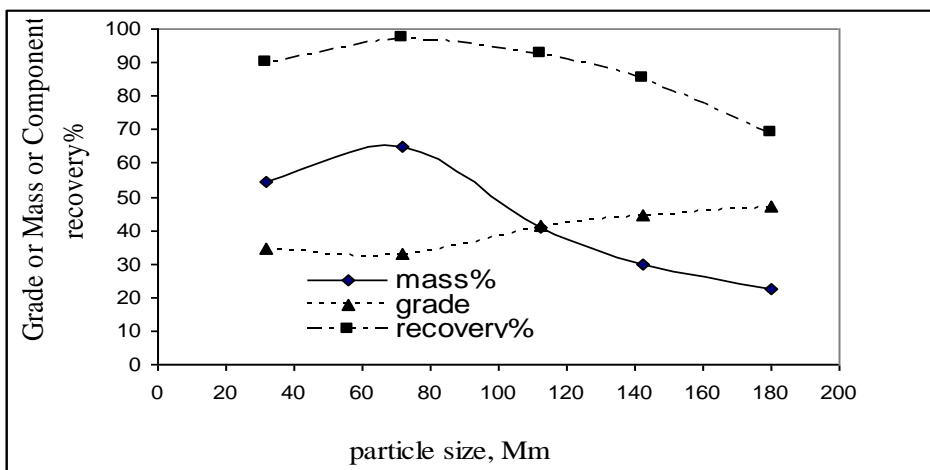


Fig. 8a: Effect of particle size on the grade, component recovery of alumina in concentrate, and the mass recovery of concentrate.

Figure 8b shows the effect of particle size on the grade, component recovery of alumina in tailings, and the mass recovery of tailings. From this figure, it is seen that, the component recovery of alumina decreases from 30.9% at a particle size of $(-200+160)$ μm to 2.4% at $(-80+63)$ μm , then increases to 10.1% at $(-63+0)$ μm . The mass recovery of tailings decreases from 77.6% to 35.3% at the same particle sizes, then increases to 45.3% at a particle size of $(-63+0)$ μm . The grade of alumina in tailings decreases from 6.1% at a particle size of $(-200+160)$ μm to 1.5% at $-80+63$ μm , then increases to 4.7% at $(-63+0)$ μm . It can be noticed also that the rise in tailing assays in the coarser fractions might be read to denote simply a progressive decrease in liberation and failure of coarse free mineral to float.

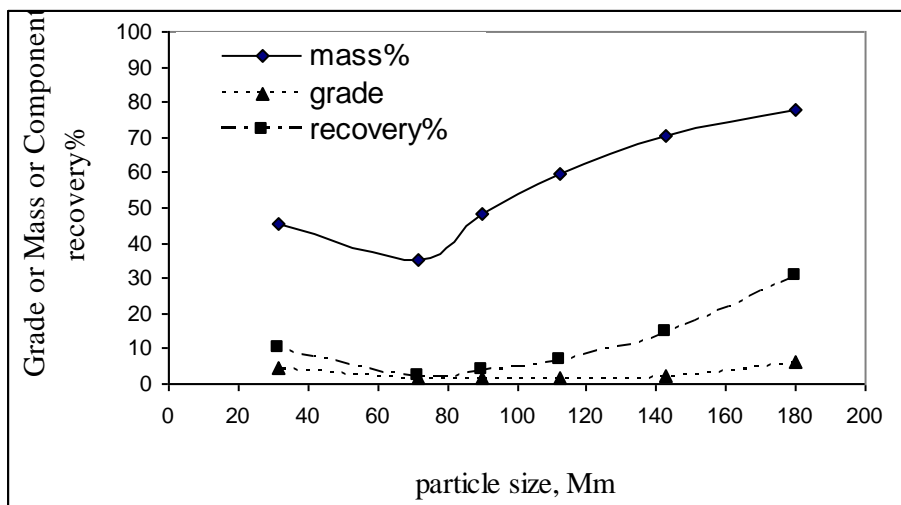


Fig. 8b: Effect of particle size on the grade, component recovery of alumina in tailings, and the mass recovery of tailings.

5. CONCLUSIONS

From the obtained results the following conclusions can be drawn:

1. Cationic collectors can not be applied for the gibbsite ore due to the presence of significant amounts of quartz.
2. The optimum operating conditions were as follows: sodium oleate dosage = 2000 g/t, pulp density = 250 g/l, pH = 11 and a particle size of $(-100+80)$ μm .
3. At optimum operating variables of flotation process, a concentrate of 51.5% mass recovery containing 40.1% alumina grade with a component recovery 96.1% was obtained. The assays of other ore constituents in the final concentrate were as follows: 5.9% SiO_2 , 4.8% CaO , 5.4% Fe_2O_3 , 3.2% P_2O_5 , 3.5% MnO , 1.3% K_2O , 1.2% Na_2O , 2.7% traces, and 31.4% loss on ignition. The component recoveries of SiO_2 , CaO , Fe_2O_3 , P_2O_5 , MnO , K_2O , Na_2O , and traces in the final concentrate were 21.4%, 17.5%, 21.2%, 38.4%, 42.9%, 75.3%, 89.6%, and 86.9%, respectively.
4. The final product is suitable for many industrial purposes such as aluminous chemicals (aluminum sulfate and sodium aluminate are used for water

treatment and aluminum chloride is used in refining crude petroleum), abrasive products (coated abrasives, sharpening stones and grinding wheels). The final product may be also applied for alumina refractories and alumina extraction after its processing by Bayer process.

REFERENCES

1. Helena, S. S., Teresa, W. C., Persio, S. S., and Perdo, K. K., "Thermal phase sequences in gibbsite/kaolinite clay: electron microscopy studies", *Ceramics International*, Vol. 31, pp. 1077-1084, 2005.
2. Burkin, A.R., "Production of aluminum and alumina", John & Sons, New York, pp. 3-13, 1987.
3. O'Connor, D.J., "Alumina extraction from non bauxitic materials", *Aluminum-Verlag GmbH*, Germany, pp. 1-10, 1988.
4. Bittencourt, L.R.M., Lin, C.L., and Miller, J.D., "Flotation recovery of high purity gibbsite concentrates from a Brazilian bauxite ore", In: *Advanced Materials—Application Mineral and Metallurgical Processing Principles*, Society of Mining Engineers of AIM, pp. 77-85, 1990.
5. Zhenghe, X., Plitt, V., and Liu, Q., "Recent advances in reverse flotation of diasporic ores—A Chinese experience", *Minerals Engineering*, Vol. 17, pp. 1007-1015, 2004.
6. Hinds, S.A., Husain, K., and Liu, N., "Beneficiation of bauxite tailings", *Light Met.*, Vol. 54, pp. 17-30, 1985.
7. Andreev, P.I., Anishchenko, N.M., and Mishakenkova, N.P., "Mechanism of the action of amines during the flotation of bauxite ore minerals", *Tsvetnye Metally*, Vol. 18, pp. 13-17, 1975.
8. Bulut, G. and Yurtsever, C., "Flotation behaviour of bitlis kyanite ore", *Int. J. Miner. Process.*, Vol. 73, pp. 29-36, 2004.
9. Doss, S.K., "Adsorption of dodecyltrimethylammonium chloride on alumina and its relation to oil-water flotation", *Min. Process. Extr. Metall.*, C195-C199, 1976.
10. Wang, Y., Hu, Y., He, P., and Gu, G., "Reverse flotation of silicates from diasporic-bauxite", *Minerals Engineering*, Vol. 17, pp. 63-68, 2004.
11. Marie, C.J., Fabien, G., and Bernard, H., "Limitations of potentiometric studies to determine the surface charge of gibbsite γ -Al(OH)₃ particles", *Journal of Colloid and Interface Science*, Vol. 6, pp. 1-11, 2005.
12. Murray, B.M., "Adsorption of fatty acid spin probes on amorphous alumina", *Journal of Colloid and Interface Science*, Vol. 76, pp. 393-398, (1980).
13. Hu, Y. and Dai, J., "Hydrophobic aggregation of alumina in surfactant solution", *Minerals Engineering*, Vol. 16, pp. 1167-1172, 2003.
14. Vamvuka, D. and Agridiotis, V., "The effect of chemical reagents on lignite flotation", *Int. J. Min. Process.*, Vol. 61, pp. 209-224, 2000.

15. Ye, H. and Matsuoka, I., "Oleate flotation of dickite from quartz with diluted HCl preconditioning. I. Effect of HCl preconditioning", Int. J. Min. Process., Vol. 40, pp. 83-98, 1993.
16. Vijayendra, H.G., "Handbook on mineral dressing", 2nd ed., Vikas, New Delhi, pp. 195-210, 1995.
17. Wills, B.A., "Mineral Processing technology", Elsevier Ltd., 7th ed., pp. 283-293, 2006.
18. Ahmed, M.M., "Kinetics of Magara coal flotation", M.Sc. Thesis, Assuit University, Egypt, pp. 73-78, 1995.
19. Feng, D. and Aldrich, C., "Effect of particle size on flotation performance of complex sulfide ores", Minerals Engineering, Vol. 12, pp. 721-731, 1999.
20. Zheng, X., Franzidis, J.P., Jounson, N.W., and Manlaping, E.V., "Modeling of entrainment in industrial flotation cells: the effect of solid suspension", Minerals Engineering, Vol. 18, pp. 51-58, 2005.
21. Ucurum, M. and Bayat, O., "Effects of operating variables on modified flotation parameters in the mineral separation", Separation Purification Technology, In Press 2006.

الوصول للحالة المثلى لتعويم الالومينا من خام طفلة جنوب غرب سيناء الحاملة

للجسيت باستخدام

Sodium Oleate كجمع

في هذا البحث تم دراسة تأثير Sodium oleate كجمع لتعويم الألو مينا المتواجدة في خام الطفلة الحاملة للجسيت بجنوب غرب سيناء بهدف تركيز الالومينا في خام الطفلة الحاملة للجسيت للحصول على منتج بمواصفات مناسبة لانتاج الالومينا عالية التركيز ومناسبة للصناعات المختلفة. زيادة تركيز الالومينا بها لكي تكون مناسبة للدخول في عملية Bayer والتطبيقات الصناعية المختلفة. وقد تبين من التحليل الكيميائي للعينة أن نسبة $Al_2O_3 = 18.98\%$ ونسبة $SiO_2 = 15.45\%$ ونسبة $Fe_2O_3 = 12.83\%$ ونسبة $CaO = 14.87\%$ ونسبة $P_2O_5 = 5.74\%$ ونسبة $MnO = 5.43\%$ ونسبة $K_2O = 0.86\%$ ونسبة $Na_2O = 0.76\%$ ونسبة $trace\ elements = 1.50\%$ ونسبة فاقد الحرق = 23.65% .

الظروف المثلى تم الحصول عليها عند وسط قاعدي ($pH=11$)، جرعة المجمع = $2000g/t$ ، كثافة المعلق = $250g/l$ وحجم الحبيبات = $(-100+80\mu m)$ وعند هذه الظروف تم الحصول على ركاز بالمواصفات الآتية: نسبة $Al_2O_3 = 40.1\%$ بنسبة استرجاع = 96.1% ونسبة $SiO_2 = 5.9\%$ بنسبة استرجاع = 21.4% ونسبة $CaO = 4.8\%$ بنسبة استرجاع = 17.6% ونسبة $Fe_2O_3 = 5.4\%$ بنسبة استرجاع = 21.2% ونسبة $P_2O_5 = 3.5\%$ بنسبة استرجاع = 38.4% و

نسبة $\text{MnO} = 3.5\%$ بنسبة استرجاع $= 42.9\%$ و نسبة $\text{K}_2\text{O} = 1.3\%$ بنسبة استرجاع $=$
 75.3% و نسبة $\text{Na}_2\text{O} = 1.2\%$ بنسبة استرجاع $= 89.6\%$ و نسبة 2.7% trace elements
بنسبة استرجاع $= 86.9\%$. وقد تم الحصول على 51.5% استرجاع للكثله بالنسبه لكثله الخام
المغذى لخليه التعويم.

ويمكن استخدام هذا المنتج في العديد من الأغراض الصناعية مثل المواد الكيميائية المستخدمة في
معالجة المياه (aluminum sulfate و minatesodium alu) و المواد المستخدمة في تكرير
البتروال مثل ال aluminum chloride و كذلك الصنفة و صناعة الحراريات و صناعة الألومنيوم بعد
تركيزها بطريقة Bayer