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EXTRACTION OF ALUMINA FROM NEPHELLINE SYENITE BY SINTERING WITH LIMESTONE

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Nepheline Syenite of Koga (Lower Swat area) Pakistan was sintered at 125°C with suitable quantity of limestone followed by water leaching for the formation of alkali abuminates which are further processed for the extraction of alumina. Parameters such as particle size variation, ratio of nepheline syenite and limestone, time temperature of sintering and sodium hydroxide concentration were optimized to obtain maximum recovery of alumina. The extraction of alumina on the basis of alumina in Nepheline synite has been found to be about 70%. Such a process may be of vital importance to countries without ready access to supplies of alumina in the form of bauxite.

Key words: Extraction, Alumina, Nepheline syenite, Sintering with lime stone.

Introduction

Economically important and sizable reserves of nepheline syenite lin Lower Swat area Pakistan was first reported by Martin *et al.* [1] and Siddiqi *et al.* [2]. The preliminary mineralogical, chemical and beneficiation studies [3], indicated considerable variation in rock composition and mineralogy at depth intervals of about 50 meters in the out cropping area. The rock after beneficiation and market evaluation was found to be in much demand for local glass, ceramics, rubber, plastic and paint industries. It is also considered by the above mentioned industries an excellent substitute for conventional feldspar in view of low-cost, consistent large reserves and chemical durability. It acts as a flux and because of the higher alkali contents, it reduces the melting temperature.

Extraction of alumina from laterite was studied by Mehdi *et al.* [4] by sintering of the ore with lime and soda followed by leaching operation. The production of alumina from bauxite has been made by Pederson [5].

The interaction between nepheline syenite and limestone was studied in the USSR [6,7]. Moner *et al.* [8] studied the auto clave treatment of nepheline syenite with sodium hydroxide to form an intermediate product which is further sintered with ammonium sulphate to separate alumina. Acid leaching studies of nepheline syenite for the separation of alumina was made by Zapolskii *et al.* [9]. Nikolaev *et al.* [10], studied that magnesium in dolomitic limestone narrows the temperature region of sintering and thereby increases the aluminium recovery. Safaryan *et al.* [11] found that the reocvery of alumina could be increased if nepheline syenite is pre-treated with KOH before sintering with with limestone. The effect of temperature and concentration of KOH on the decomposition of alumina was made by Tikhonov *et al.* [12]. The autoclave treatment of nepheline syenite with NaOH in presence of $Ca(OH)_2$ for maximum recovery of alumina was studied by Sazhin [13]. The recovery of alumina from nepheline syenite bychlorination has been reported by Mirzoev *et al.* [14], but the techniques applied in all these studies are combersome and time consuming.

In the present in vestigation nepheline syenite from Koga (Lower Swat), containing 20-24% alumina was processed by sintering with limestone followed by leaching operations for the extraction of alumina.

Experimental

The chemical analysis of nepheline syenite was undertaken using the conventional titrimetric and instrumental techniques [15]. The results are shown in Table 1. The chemical composition of the rock indicates that it contain 24% alumina in the form of aluminium silicates forming mainly alkaline aluminium silicates, combined in the proportions of the rock model composition with 14% of the alkali metals, Na_2O and K_2O.

Sintering of nepheline syenite. The rock is powdered so as to pass through a 150mm screen. After thoroughly mixing with limestone in a graphite crucible, the mixture is heated in a gas fired furnace at temperatures between 1250 and 1300°C. Silica formed an insoluble di-calcium silicate whereas alumina combine with the alkalis to form soluble, alkali-aluminates. The reaction is represented as follows.

$$(Na, K)\,AlSiO_4 + 2CaCO_3 \xrightarrow{1250°C} (Na,K)AlO_2 + Ca_2SiO_4 + 2CO_2\uparrow$$

The sintered mass is cooled to room temperature and broken into pieces. The broken pieces are further crushed to 150μm and leached with water on a water bath at 60°C for a

TABLE 1. CHEMICAL COMPOSITION OF NEPHELINE SYENITE AS OXIDE WEIGHT PERCENTAGES.

Oxide	Wt%
SiO_2	55.8
Al_2O_3	24.30
Fe_2O_3	2.30
CaO	1.50
MgO	0.38
Na_2O	10.31
K_2O	0.95
Loss on ignition	0.95
Total	99.63

period of 3 hr. The insoluble di-calcium silicates are filtered off and the soluble alkali aluminates are precipitated with sodium hydroxide to separate alumina as aluminium hydroxide which is further calcined to obtain alumina.

Results and Discussion

Nepheline syenite contains high percentage of alumina and alkali metals and therefore it could be utilized in glass, ceramics, rubber, plastic and paint industries in Pakistan. nepheline syenite acts as a flux in the manufacture of soda lime glasses from silica. In view of its low cost, large and consistent reserves, operative advantages, including low melting, decrease in devitrification of glass and chemical durability, it can replace feldspar.

Nepheline syenite of the out cropping area under study containing 20-24% alumina could be processed for the extraction of alumina by the above method. Some parameters of the process, such as particle size, ratio of nepheline syenite and limestone, temperature, time, and sodium hydroxide concentrations were studied to achieve maximum recovery of alumina and is briefly described as follow.

Effect of particle size variation. Different particle sizes of the crushed rock sample (nepheline syenite) were sintered with powdered limestone at a temperature of 1250° and further processed for the extraction of alumina as discussed above. We note that a particle size in the range between 125 and 150 μm results in maximum recovery of alumina (Table 2).

Effect of nepheline syenite and limestone ratio. The sample of particle size in the range between 125 and 150 μm was sintered with powdered limestone in different ratios and it was found that a ratio of 1:5 (nep-syenite:limestone) results in maximum yield of alumina (Table 3).

Effect of sintering time. The sample and limestone mixed in a ratio of 1:5 was sintered at 1250°C for different time intervals in order to see the effect of time of sintering on the yield of alumina from Nepheline syenite. It was observed that sintering of the mixture at a temperature of 1250°C for a period of 3 hrs or more resulted in maximum recovery of alumina of 70% (Table 4).

Effect of temperature of sintering. The best mixture of powdered rock sample and limestone were sintered at different temperatures ranging from 1000-1400°C and it was noted that sintering at a temperature of 1250°C or above resulted

TABLE 2. EFFECT OF PARTICLE SIZE RANGE ON THE EXTRACTION OF ALUMINA.

S. No.	Particle size μm	Neph- syenite limestone ratio	Temp. (°C)	Time (hrs)	%Recovery (Al_2O_3)
1.	250-355	1 : 5	1250	3	32.00
2.	210-250	1 : 5	1250	3	45.00
3.	150-210	1 : 5	1250	3	57.00
4.	125-150	1 : 5	1250	3	70.00
5.	105-125	1 : 5	1250	3	64.00
6.	90-105	1 : 5	1250	3	53.00
7.	75-90	1 : 5	1250	3	41.00
8.	63-75	1 : 5	1250	3	34.00
9.	53-63	1 : 5	1250	3	26.00

TABLE 3. EFFECT OF NEPHELINE SYENITE AND LIMESTONE RATIO ON THE EXTRACTION OF ALUMINA FOR A PARTICLE SIZE OF 125-150 μm.

S. No.	Nep-syenite:Limestone	Temp. (°C)	Time (hrs)	%Recovery (Al_2O_3)
1	1 : 1	1250	3	22.9
2	1 : 2	1250	3	38.8
3	1 : 3	1250	3	49.2
4	1 : 4	1250	3	60.8
5	1 : 5	1250	3	70.6
6	1 : 6	1250	3	65.4
7	1 : 7	1250	3	50.8
8	1 : 8	1250	3	39.1

TABLE 4. EFFECT OF SINTERING TIME ON THE EXTRACTION OF ALUMINA FOR A PARTICLE SIZE OF 125-150 μm.

S. No.	Nep-syenite:Limestone	Temp. (°C)	Time (hrs)	%Recovery (Al_2O_3)
1	1 : 5	1250	0.5	20.00
2	1 : 5	1250	1	30.00
3	1 : 5	1250	1.5	40.00
4	1 : 5	1250	2	52.00
5	1 : 5	1250	2.5	65.00
6	1 : 5	1250	3	70.00
7	1 : 5	1250	3.5	70.00
8	1 : 5	1250	4	70.00
9	1 : 5	1250	4.5	70.00

in the best yield of alumina (70%) as indicated in (Table 5).

Effect of NaOH concentration on the extraction of alumina from nepheline syenite. The sintered mass after leaching with water is treated with sodium hydroxide to separate alumina as aluminium hydroxide from the soluble alkali aluminates. Different concentrations of NaOH were used to study the effect of NaOH concentration on the extraction of alumina. It was observed that a concentration of 5 molar NaOH results in maximum yield of alumina (Table 6).

TABLE 5. EFFECT OF SINTERING TEMPERATURE ON THE EXTRACTION OF ALUMINA FOR A PARTICLE SIZE OF 125-150 µm.

S. No.	Nep-syenite:Limestone	Temp. (°C)	Time (hrs)	%Recovery (Al_2O_3)
1	1 : 5	1000	3	15.00
2	1 : 5	1050	3	27.00
3	1 : 5	1100	3	40.00
4	1 : 5	1150	3	51.00
5	1 : 5	1200	3	61.00
6	1 : 5	1250	3	70.00
7	1 : 5	1300	3	70.00
8	1 : 5	1350	3	70.00
9	1 : 5	1400	3	70.00

TABLE 6. EFFECT OF SODIUM HYDROXIDE CONCENTRATION ON EXTRACTION OF ALUMINA FOR A PARTICLE SIZE OF 125-150 µm.

S. No.	Nep-syenite: Limestone	Temp. (°C)	Time (hrs)	Conc. of NaOH (M)	%Recovery (Al_2O_3)
1	1 : 5	1250	3	1	22.00
2	1 : 5	1250	3	2	35.00
3	1 : 5	1250	3	3	45.00
4	1 : 5	1250	3	4	56.00
5	1 : 5	1250	3	5	70.00
6	1 : 5	1250	3	6	63.00
7	1 : 5	1250	3	7	50.00
8	1 : 5	1250	3	8	38.80
9	1 : 5	1250	3	9	27.00

Conclusion

The studies undertaken not only describe the proccess for the extraction of alumina from nepheline syenite but also provide potential opportunities for chemical industries and user investors.

Alumina has wide applications in industries for e.g. those which use electricity to refine aluminium metal, and those which use aluminium to produce wire, plate, coil other wares, aluminium alloys and aluminium based chemicals. Aluminium is also used in high temperature bricks for refractories.

Alumina is imported in millions of tonnes each year to meet Pakistan's demand. Extraction of alumina from nepheline syenite by the foregoing method is a successful way. From the above observations it has been found that the overall yield of Al_2O_3 on the basis of alumina in nepheline syenite is about 70%. The use of this extraction method would save foreign exchange being spent on the import of this raw material.

The method is economically viable as the reactants i.e. nepheline syenite and limestone are abundantly available in Pakistan. Moreover no complicated operations and sophisticated instruments are required for processing the ore and undergoing the reaction.

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