

EXTRACTION OF ALUMINA FROM ZIARAT LATERITE BY ALKALINE LEACHING

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Abstract. Ziarat laterite has been subjected to leaching with caustic soda. The effects of (i) alkali concentration, (ii) temperature, (iii) duration of attack, and (iv) solid-liquid ratio; have been studied and optimum conditions for the maximum extraction of Al_2O_3 have been worked out. It has been observed that the extraction, which proceeds rapidly at the beginning of the reaction, slows down afterwards due to the formation of an insoluble complex.

Aluminium metal is produced from aluminous materials in two stages: extraction of alumina and its conversion to aluminium metal. Aluminium is extracted by various processes according to the nature of the raw material, but bauxite is the basic raw material from which most of the alumina used in the production of aluminium metal is extracted.

Statistics have shown that the world production of primary aluminium has increased by 250% between 1949-1960 while that of steel increased by only 115% and that of copper, zinc and lead by only about 80, 60 and 40% respectively. Due to the growing demand of aluminium, researches are being carried out in various countries of the world to obtain alumina from sources other than bauxite.

Pakistan is quite rich in raw materials from which alumina can be extracted for production of aluminium metal.¹ One of these is laterite which occurs in large quantities in various areas of Pakistan (i.e. Baluchistan, Punjab and Peshawar Division) the largest amongst these being that of Ziarat (Quetta Division). Preliminary work²⁻⁴ has already been done by the PCSIR for the extraction of alumina chiefly from the laterites and medium to low grade bauxites.

In the development of a suitable technique for the dressing of ores and their further utilization, main consideration is given to the mineralogical, chemical and physical characteristics of the ores.

The majority of the processes are based principally on the differences existing between the physical properties of different components of the ore but the mineral structure of certain ores sometimes makes it difficult to apply the physical methods based on these differences or point out to the application of chemical method.

It was thought to develop a chemical method particularly for the extraction of alumina from laterite as the Bayer process is based on the solubility of hydrated alumina. The caustic soda leaching method was undertaken due to the peculiar mineralogical composition⁵ of the ore. All the iron in the ore is in the form of haematite and it will not be affected by a caustic soda solution.⁶

While examining the results of analysis of the samples under investigation it was observed that there are samples which have high silica percentage while the rest are quite low in silica content. The amount of calcium oxide and magnesium oxide also varies considerably

(Table 1). It was essential to study the effect of alkali leaching procedure on all the samples with variable composition.

Iron which is present in the form of Fe_2O_3 is not dissolved in the alkali solution but gets converted into the paramagnetic form⁶ thus making it possible to separate it magnetically from the titanium which occurs in some of the samples up to 6%. Geological Survey of Pakistan in their detailed studies have reported that some samples contain titanium even up to 10% but the samples received for these investigations contained titanium up to 6% only.

The samples 1-4, and 8 were selected for the investigation in order to have representative compositions for alkali leaching experiments. Various factors which could affect the rate of the reaction are appended as (i) soda concentration, (ii) temperature, (iii) duration of the attack, and (iv) solid-liquid ratio.

Experimental

Reagents

Alkali Solution. Caustic soda (commercial grade) was used for this purpose. An alkali solution of 45% strength was prepared in bulk and kept in polythene flasks while the other solutions of alkali varying in strength from 10 to 45% were made from this stock solution by dilution to the calculated volume.

Ore Sample. The sampling of the bulk sample of each category was done by quartering procedure after initial crushing of the ore. The ore (1 kg) of different types were then ground in a ball mill to -200 mesh. The samples for digestibility studies were then drawn and weighed out from the ground sample after quartering procedure.

Apparatus

The apparatus used for the digestion of the ore consists essentially of (a) heating magnetic stirrer, (b) conical flasks 250 ml (with quickfit arrangement), and (c) water reflux condenser.

Experimental Procedure

Initial experiments were carried out with a solid-liquid ratio of 100 g/litre and heated for 1 hr. The ore

10 g samples were taken in a conical flask attached with a water reflux condenser. Caustic soda 100 ml solution of known strength were added and the contents digested by constant stirring and heating the solution to the boiling point 110–120°C. Simultaneous heating and stirring was done with the help of a heating magnetic stirrer. Time of the reaction in each case was noted from the time when the alkali solution started boiling. The concentration of the alkali solution was varied from 10 to 45% in different sets of experiments. Experiments were also carried out at fixed alkali strength with varying times of reaction.

Analysis of Results

Effect of Alkali Concentration. The effect of alkali concentration on the leaching of alumina from laterite samples has been shown in Fig. 1. It can be observed that percentage of alumina leached with 10% alkali solution is very small while it rises slowly with the increase in concentration of the alkali solution to 25% but with 45% alkali solution a fairly high percentage of alumina is leached out in each case in 1 hr.

Effect of Temperature. The maximum temperature in such experiments is the boiling temperature of a particular concentration of alkali solution. This was found to be between 110–120°C.

Effect of Time. Further experiments were carried out with 45% caustic soda solution and the effect of variation in the time of reaction of the ore with caustic soda was studied, the results are indicated in Table 2.

It can be seen from the results that for laterite with compositions as in samples 1, 4 and 8, there is a quick rise in the alumina content for the first 1 hr of the reaction and then the concentration of alumina decreases in the leached solution. This effect is, however, less pronounced in samples 2 and 3.

As in most of the cases there is an appreciable quantity of alumina left in the residue it was planned to study the effect of re-leaching. For this purpose residues left from different samples, after treatment with 45% alkali solution for 45 min, were taken, complete analysis was carried out first (Table 3), and weighed quantities of the residues were then treated with fresh alkali solutions under the same conditions for 45 min. The results of further extraction of alumina were 78.4, 98.5, 93.5, 85.8 and 95.4 for residue nos. 1, 2, 3, 4 and 8 respectively.

Effect of Solid-Liquid Ratio. A series of experiments were performed on different samples after varying the solid-liquid ratios to 50 g/l, 100 g/l, 200 g/l, 300 g/l and 400 g/l. The results are shown in Fig. 2.

As can be seen from Fig. 2, the percentage of alumina leached out decreases with the increase in the solid-liquid ratio. It can be seen that higher percentage yield of alumina is obtained with a solid-liquid ratio of 50 g/l and 100 g/l. Thus 100 g/l was considered to be the best ratio for studying other parameters.

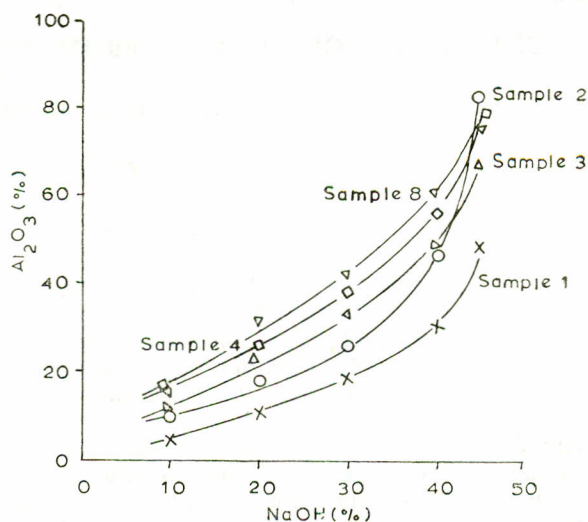


Fig. 1. The dissolution of alumina from the ore as a function of the soda concentration.

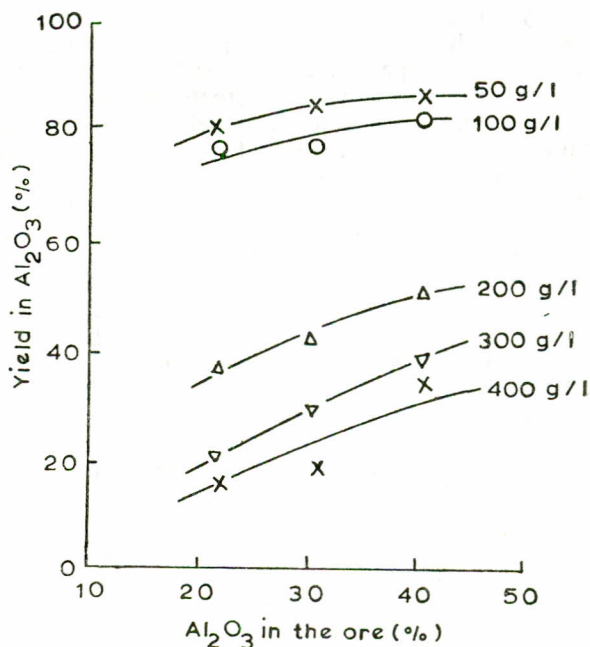


Fig. 2. The influence of the percentage of alumina in the ore on the alumina yield as a function of solid liquid ratio.

Discussion

The extraction of alumina varies with time as is evident from the results in Table 2. One particular aspect, which is noted from the results, is the reduction in the extraction of the amount of alumina after the lapse of certain time which varies with different samples.

The nature of the ore was studied in order to explain this factor. The samples contain varying amounts of bohemite and diaspore phases and it found that these two phases had different solubilities.

TABLE 1. ANALYSIS OF LATERITE SAMPLE.

Loss on ignition	10.07	09.73	10.19	08.77	11.20	08.45	07.57	08.85	11.86	09.48
Silica	05.20	02.79	04.04	04.81	16.67	06.15	09.82	10.31	07.49	07.79
Iron oxide	48.40	39.80	36.51	48.40	41.60	45.20	55.90	55.20	31.40	45.20
Titanium oxide	06.39	05.53	05.65	04.75	04.30	05.60	03.82	03.70	03.30	04.50
Aluminium oxide	27.43	40.87	42.92	30.62	26.12	32.91	20.76	21.85	43.45	33.37
Calcium oxide	00.35	Nil	Nil	00.17	Nil	01.05	01.05	00.95	00.70	00.70
Magnesium oxide	01.27	02.03	01.52	01.77	00.69	00.89	00.76	00.51	00.52	00.25
Total	99.11	100.75	100.83	99.29	100.58	100.25	99.68	101.37	99.72	101.20

TABLE 2. EFFECT OF LEACHING TIME ON THE DISSOLUTION OF ALUMINA (PERCENTAGE OF ALUMINA LEACHED OF THE TOTAL QUANTITY PRESENT IN THE SAMPLES).

Time (min)	Sample No.				
	1 Al ₂ O ₃ =2.47 g*	2 Al ₂ O ₃ =4.10 g*	3 Al ₂ O ₃ =4.30 g	4 Al ₂ O ₃ =3.06 g*	8 Al ₂ O ₃ =2.20 g*
15	28.7	26.7	32.8	42.7	42.7
30	36.2	69.2	43.2	60.2	62.1
45	42.3	81.2	61.2	79.0	71.6
60	48.9	83.3	67.3	77.3	77.4
75	48.7	93.4	75.4	70.7	70.5
90	59.5	96.3	88.5	70.6	68.4
105	64.5	95.2	94.5	75.6	68.5
120	48.3	98.6	90.2	80.3	66.6
135	48.3	98.9	90.9	80.4	67.4
150	52.6	99.1	93.5	81.2	68.9
180	53.6	99.1	94.6	83.5	69.2

* The quantities of alumina shown represent the actual amount of alumina present in 10 g of each sample.

TABLE 3. ANALYSIS OF THE RESIDUE OF FIRST LEACHING FOR 45 MIN.

	1R	2R	3R	4R	8R
Loss on ignition(%)	11.10	11.85	11.40	09.75	09.60
Silica (%)	02.30	02.20	00.95	02.20	09.38
Iron oxide (%)	59.00	58.22	56.40	55.00	59.52
Titanium oxide (%)	07.17	07.94	06.67	05.04	03.92
Aluminium oxide (%)	18.18	11.02	20.48	19.46	07.93
	(1.59 g)	(0.70 g)	(1.67 g)	(0.64 g)	(0.63 g)
Calcium oxide (%)	00.70	01.75	Nil	01.05	02.45
Magnesium oxide (%)	01.27	01.14	01.14	01.27	Nil
Sodium oxide (%)	Balance	Balance	Balance	Balance	Balance

Experiments showed that the samples containing diaspore phase dissolved rapidly while those containing bohemite phase dissolved fairly slowly. Moreover, by the time diaspore phase has dissolved completely, the caustic soda solution contains silica in it and does not attach bohemite. It is at this stage that free alumina already liberated starts forming some complex, thus causing the reduction in the extraction of alumina.

It is at this stage that pure alumina already liberated forms some insoluble complex. The complex is probably one of the felspathoid aluminosilicates frequently encountered in the Bayer process.

Conclusions

It may be concluded that 45% alkali concentration at a temperature of 120°C is suitable for the maximum extraction of alumina from Ziarat laterite.

Laterite samples of compositions as in no. 1, 4 and 8 are more amenable to the procedure suggested.

Releaching of the residue is essential for almost complete extraction of alumina.

The solid-liquid ratio of 100 g/l is the best ratio for the maximum yield of alumina.

Detailed study will be conducted for the liquor compositions which are vital for evaluating this process.

The economics of the process will depend upon the procedure to be worked out for the treatment of the residue for the extraction of iron and titanium.

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