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ACID TREATMENT OF LATERITE FOR THE RECOVERY OF IRON, ALUMINIUM AND TITANIUM*

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Ziarat laterite was leached with different acids for recovering titanium, aluminium and iron. Solvent extraction with high molecular weight amines and alkylphosphates was used for separation of iron from leach liquors. Titanium and aluminium recoveries were of good purity. The residue left after the acid treatment was rich in aluminium. The process is promising for commercial exploitation of laterite.

INTRODUCTION

Laterite is primarily a composite ore of iron and aluminium. The percentage of aluminium and iron is such that it is regarded as a low grade ore of little industrial significance, particularly in presence of the available richer ores of iron and aluminium for exploitation by the conventional methods. The ore is occassionally, found associated with metals like titanium, cobalt or nickel. In Pakistan, sizable deposits of laterite occur in Ziarat (Baluchistan), Sargodha (Punjab) and Hazara (NWFP). Ziarat laterite contains nearly 4 to 6% TiO_2.Concerted efforts have been made to analyse [1,2] and beneficiate laterite by alkali leaching [3] or by sintering with Na_2CO_3 and $CaCO_3$ [4]. None of these methods has proved to be viable. Likewise pyrometallurgical beneficiation of the ore did not yield any tangible results. [5]. The present study aims at the recovery of iron, aluminium and titanium through acid leaching of Ziarat laterite. The valuables from leach liquors were recovered by solvent extraction and selective precipitation.

EXPERIMENTAL

The Ore Samples. Two representative samples of laterite were taken by channel sampling from a 10-20 ft deep trench across the strike of the bed. Sample D was collected from Tari Kund area (lat. 30° 20′ 20″: long 68° 0′ 50″). This massive laterite deposit is oolitic in character and contains mainly boehmite or diaspore minerals with minor amounts of limonite and quartz. Sample K was collected from a 10 ft deep trench in the Akram Tangi area (lat.30° 23′, 30″: long 67° 45′, 3″). The aluminium mineral in this area is either diaspore or boehmite associated with small amounts of hematite and quartz. These samples were homogenized and ground; 90% of the ground ore was –150 mesh size.

Acid Treatment. 10 to 100 gms of powdered laterite was subjected to different treatments and the leach liquor was analysed for TiO_2, Fe_2O_3 and R_2O_3 by conventional methods. Al_2O_3 was found by difference. The residue left after the acid leaching was weighed and separately analysed. The acid-ore mixture was stirred and heated over a magnetic stirrer/heater. Commercial grade acids were used for leaching. High molecular weight amines such as trilaurylamine, aliquot 336 and alkyl derivatives of phosphoric acid, such as tributyl phosphate (TBP), di-2-ethyl-hexylphosphoric acid were used as extractant. Methyl isobutyl ketone (MIBK) or *o*-xylene were used as the diluents. A 30% V/V solution of the amine and 50% V/V TBP with 1:1 aqueous to organic phase ratio were used for extraction. The organic phase was stripped with distilled water before its recycling.

RESULTS AND DISCUSSION

Detailed chemical analysis of the laterite samples has already been covered by previous workers [1,4]. As an example, sample K was found to contain 38.8% Fe_2O_3, 40.1% Al_2O_3, 6.1% TiO_2 and 4.1% SiO_2. Sample D contained 40.3% Fe_2O_3, 5.0 TiO_2 and 5.2% SiO_2. The main purpose of the present analysis of the ore was to keep track of the material balance involved in the system. Results of a few experiments are summarized in Table 1.

It can be inferred from Expts 1, 2 in Table 1 that HCl leaches most of the iron, leaving titanium and aluminium

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Table 1.
Leach: Results were calculated on the basis of the ore weight.
Residue: Results were calculated on the basis of the residue weight.

Expt. No.	R_2O_3 %	Fe_2O_3 %	Al_2O_3 %	TiO_2 %	SiO_2 %	Remarks
1. Leach	38.0	32.4	5.4	0.2	–	(K) 10 gm+28 ml. of 1:1 HCl, 6 hrs. 70-90°
Residue	–	–	–	–	–	5.1 gm. (weight)
2. Leach	40.6	35.6	4.8	0.2	–	(K) 10 gm+30 ml of conc. HCl, 6 hrs 70-90°
Residue	–	–	–	–	–	4.8 gram (weight)
3. Leach	39.2	35.2	3.4	0.6	–	(K) 10gm+10gm NaCl + 30 ml HCl conc. 70°, 6 hrs.
Residue	–	–	–	–	–	4.8 gm (weight)
4. Leach	55.0	30.4	18.8	5.8	–	(K) 10 gm + 1gm powdered charcoal, calcined at 850° for 1½ hr. Leach with 30 ml of conc. HCl, 70-90°, 6hr.
Residue	–	–	–	–	–	–
5. Leach	53.0	36.0	12.0	5.0	–	(K) 10 gm + 50 ml, 60% H_2SO_4, 120°, 6 hr.
Residue	–	–	–	–	–	3.4 gm (weight).
6. Leach	46.4	36.0 (92.8% extd)	6.3	4.1 (67.2% extd)	–	(K) 50 gm + 250 ml 1:1 H_2SO_4 120°, 6hr.
Residue	71.8	1.5	62.9	3.7	3.6	26.9 gm (weight)
7. Leach	47.0	38.4 (98.9% extd)	4.1	4.5 (75.0% extd)	–	(K) 50 gm + 250 ml 1:1 H_2SO_4, 125°., 6 hr.
Residue	75.6	0.8	71.8	3.0	3.5	25.1 gram (weight)
8. Leach	55.7	39.5 (98.7% extd)	12.3	3.9	–	(D) 100 gm + 500 ml 1:1 H_2SO_4 125° 6 hrs.
Residue	65.8	2.0	61.1	2.7	6.6	40.0 gm (weight)

with the residue. Most of iron and titanium could be leached by roasting the ore with 10% charcoal (Expt.4). Considerable amount (18.8%) of aluminium was also leached simultaneously.It was thought that the ore treated with concentrated HCl in presence of excess NaCl (Expt.3) would enhance the formation of more soluble and extractible chloro-complexes of iron, titanium and aluminium in desired results. The chloride medium offered very favourable distribution for the separation of iron and titanium in the solvent extraction steps. However, it was considered worthwhile to leach out both iron and titanium leaving the residue enriched in aluminium alone. Moreover, the vapour produced by heating HCl mixtures caused problems. Leaching with H_2SO_4 could be a step in positive direction (Expts 5-8). The residue is also quite favourably enriched in aluminium for exploitation by the conventional methods. Sample D, however, showed higher (6.6%) SiO_2 in the residue, but this needs confirmation by working with more samples.

Leaching Time. The percent Fe_2O_3 leached against time for iron and titanium is plotted in Figs.1,2. It can be seen that more than 90% iron gets extracted within 2 hrs. The recovery of titanium, however, is non-linear and six hr leaching time was considered reasonable.

Solvent Extraction. The solvent extraction of iron, aluminium and titanium with high molecular weight amines and different alkylphosphates from a variety of aqueous media has been studies by a number of workers [6,7,8]. The same was adopted to our system with suitable modifications.

A few batch extractions using 50% V/V tributyl phosphate, TBP, and 30% aliquot 336 were tried with 500 ml

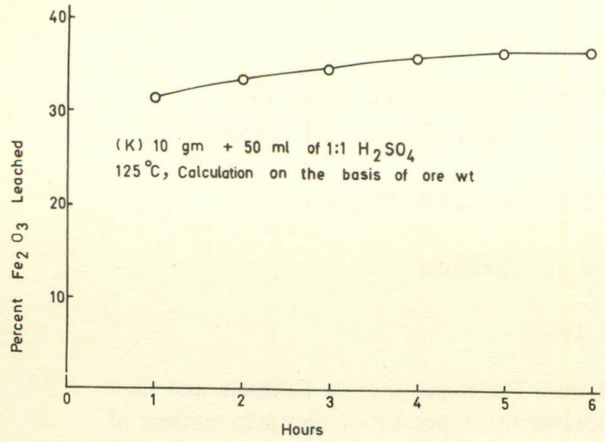

Fig. 1

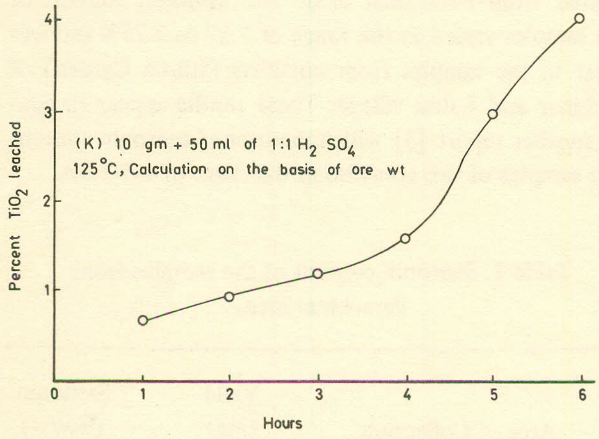

Fig. 2

of leach-liquors. The leach liquor contained approximately 45% Fe_2O_3, 4% TiO_2 and 5% Al_2O_3 · From this solution iron could be effectively removed by two or three contacts. Titanium and aluminium which remained in the aqueous phase were recovered by precipitation. The product TiO_2 contained minor quantities of iron which imparted a greyish tinge to TiO_2.

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REFERENCES

1. Nabi Buksh, Fazal Mohammad and Bashir Hussain, Pakistan J.Sci.Ind.Res., **6**, 86 (1963).
2. Fazal Mohammad, Ibid; **11**, 490 (1968).
3. R.A. Shah, A. Rauf and Mehdi Hassan, Ibid, **18**, 65 (1974).
4. S.M. Ali and Mohammad Amin, Ibid; **11**, 31 (1968).
5. A.A. Qureshi (PCSIR Laboratories, Lahore), Private Communications.
6. L. Kuca, E. Hogfeldt and L.G. Sillen, *Proceedings Int.Conf. on Solvent Extractions Chem.* edited by D. Dyressen J.O. Liljenzin and J.Rydberg (North Holland Publ:Co.,1967), pp.454.
7. Y. Marcus and A.S. Kertes, *Ion-exchange and Solvent Extraction of Metal Complexes* (Wiley Interscience, London, 1968).
8. T. Ishimori and E. Nakamura, *Japan Atomic Energy Research Institution* (JAERI) Pub. No. 1047, (1963).