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LEACHING OF THORIUM AND LANTHANIDES

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ABSTRACT

Leaching of thorium and lanthanides from thorium ore of KTS-1 with HNO_3 and H_2SO_4 were investigated. In this study, solid/liquid ratio was taken as 1/2. Leaching experiments were performed for different acid/ore ratios and varying leaching periods with HNO_3 and H_2SO_4. The maximum leaching efficiency for thorium was obtained to be 44 % with 1400 g HNO_3 and 56 % with 900 g H_2SO_4, both for 2 hours. Lanthanides (La, Ce, Eu, Tb and Yb) were leached with over 90 % efficiency with HNO_3 and 60 % efficiency with H_2SO_4.

ÖZET

KTS-1 toryum cevherlerinden toryum ve lantanitlerin özütlenmesi HNO_3 ve H_2SO_4 ile denenmiştir. Özütleme çalışmalarında katı/sıvı oranı 1/2 alınmıştır. HNO_3 ve H_2SO_4 ile değişen asit miktarı ve süreler için özütleme çalışmaları yapılmıştır. En yüksek toryum verimi, 2 saatte 1400 g HNO_3 ile % 44, 900 g H_2SO_4 ile % 56 bulunmuştur. Lantanitler (La, Ce, Eu, Tb ve Yb) HNO_3 ile % 90'ın üzerinde, H_2SO_4 ile % 60 kadar verimle çözeltiye alınmışlardır.

INTRODUCTION

The aim of this study was to leach thorium and lanthanides from thorium ore under suitable conditions. Extent of leaching is dependent on physical and chemical characteristics of ore and leach solutions.

Chemical reaction rate and diffusion are effective on leaching of thorium and lanthanides from thorium ore. Chemical reaction rate is dependent on temperature and leach solution concentration.

Th leaching efficiencies were not altered

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significantly at high temperatures /1,2/. Therefore leachings were made at room temperature (25°C), without heating.

Leaching of thorium containing KTS-1 ore with particles 0.025 mm, 0.035 mm, 0.2 mm (-1 mm) and 1 mm in size, has been investigated. It is reported that -1 mm is sufficient for Th leaching /1, 3/. Therefore, all the experiments were made with thorium ore ground to - 1 mm.

Leaching efficiency increases with mixing due to increased dissolution and diffusion of acid into pores, therefore throughout this work a constant mixing rate was maintained. Type and amount of acid, length of leaching period were the only variables changed to obtain the optimum conditions.

EXPERIMENTAL

Leachings were made by using 50 grams of ore and 100 ml of acid of varying concentration to maintain the solid/liquid ratio of 1/2.

Nitric acid leaching: By using 65 % HNO_3, 1, 2, 3 and 4 hours of leaching were done at 400, 600, 800, 1000 and 1400 g HNO_3/1000 g ore ratios. Leach solution and residue were separated by centrifugation and filtration.

Sulfuric acid leaching: By using 96 % H_2SO_4, 1, 2, 3 and 4 hours of leaching were done at 400, 700, 900, 1100 and 1500 g H_2SO_4/1000 g ore ratios. Leach solution and residue were separated by centrifugation and filtration.

On the other hand, at 1000, 1400 g HNO_3/1000 g ore and 900, 1500 g H_2SO_4/1000 g ore ratios, repeated leachings were performed for 2 and 3 hours. The residues were leached again with acids having the initial concentration but only for 30 minutes. Finally, the residues were washed with 100 ml H_2O for 15 minutes.

Instrumental neutron activation analysis technique was applied to determine the elemental composition of residues and leach solutions.

Calculations of leaching efficiencies: Single-stage leaching efficiencies of the elements were calculated as percent by comparison of the element concentrations of leach solutions with that of ore.

For repeated leaching; concentrations of elements were estimated both from leach solutions and residues,

and leachnig efficiencies were calculated accordingly.

RESULTS AND DISCUSSION

In Table-1 leaching efficiency for thorium is given. Amount of Th leached increases with increasing amount of HNO_3. Two hours of leaching yields the highest efficiency. At longer leaching periods efficiency decreases which means that precipitation of Th takes place. Maximum efficiency of 44 % was obtained for 1400 g HNO_3/1000 g ore for two hours.

Unlike HNO_3 leaching, maximum efficiency for each H_2SO_4 amount were obtained at different leaching periods. For a constant leaching period, decrease in efficiency was observed after a maximum, with increasing acid amount. It can be concluded that leaching efficiency is directly related to H_2SO_4 amount. Increase in H_2SO_4 concentration, results in precipitation of sulfate compounds and the amount of Th in solution diminishes.

In Tables-(2-5) leaching efficiencies of Sc and lanthanides (La, Ce, Eu, Tb, Yb) are given.

For Sc, maximum efficiencies were obtained as 38.7 % and 45.3 % for HNO_3 and H_2SO_4 respectively, both for 4 hours.

Lanthanides have higher efficiencies with both acids and at all ratios, compared to Th and Sc. Maximum efficiency of about 90 % was obtained for HNO_3 but remained around 60-70 % for H_2SO_4.

It is obvious from Tables-(1-5), repeated leachings have not resulted in higher efficiencies with respect to single-stage leachings.

CONCLUSION

Low-grade KTS-1 thorium ore is efficiently leached with both acids, although Th is the least recovered, lanthanides are readily dissolved. Depending on economic considerations, higher leaching efficiency for thorium can be obtained by altering the experimental conditions. It should be stated that recovery process can be economic if lanthanides are produced along with thorium.

TABLE-1. Thorium leaching efficiency

Ore : 50 g, KTS-1, 1 mm
T : 25°C
Solid/Liquid: 1/2

Acid	g acid / 1000 g ore	Leaching Efficiency, % — Leaching Time, Hour			
		1	2	3	4
HNO_3	400	15.1	17.0	16.3	14.5
"	600	26.1	25.7	20.5	18.5
"	800	30.7	31.5	27.3	24.5
"	1000	36.4	37.5	38.1	34.0
"	1400		44.0	41.0	
"	*1000		53.7	54.7	
"	*1400		58.7	57.7	
H_2SO_4	400	39.9	42.2	41.9	43.5
"	700	43.9	50.5	40.7	54.2
"	900	37.5	55.7	53.0	43.6
"	1100	33.9	35.6	40.0	34.7
"	1500		34.0	38.2	
"	* 900		56.0	61.0	
"	*1500		55.5	61.0	

* Repeated leaching

TABLE-2. Leaching efficiencies for 1 hour, %.

Ore : 50 g, KTS-1, - 1 mm
Solid/liquid : 1/2
T : 25°C

g acid		Elements								
1000 g ore		Sc	Cr*	Ba	La	Ce	Eu	Tb	Yb	Th
400	HNO_3	22.7	0.16	-	62.4	66.6	75.6	71.4	70.7	15.1
600	"	26.7	0.14	-	80.1	79.5	70.5	80.9	65.3	26.1
800	"	28.0	0.17	-	89.5	76.0	96.7	90.6	72.7	30.7
1000	"	32.0	0.13	3.3	95.6	83.5	100.0	90.3	63.3	36.4
1400	"	-	-	-	-	-	-	-	-	-
** 1000	"	-	-	-	-	-	-	-	-	-
** 1400	"	-	-	-	-	-	-	-	-	-
400	H_2SO_4	26.7	0.17	-	55.2	55.2	61.7	53.7	60.0	39.9
700	"	29.3	0.14	-	52.9	56.5	60.6	53.7	67.3	43.9
900	"	25.3	0.16	-	43.1	49.7	58.9	44.3	60.0	37.5
1100	"	30.7	0.24	-	43.5	53.1	60.2	53.4	54.7	33.9
1500	"	-	-	-	-	-	-	-	-	-
** 900	"	-	-	-	-	-	-	-	-	-
** 1500	"	-	-	-	-	-	-	-	-	-

* : mg/g ore
** : Repeated leaching

TABLE-3. Leaching efficiencies for 2 hours, %

Ore : 50 g, KTS-1, - 1 mm
Solid/Liquid : 1/2
T : 25°C

g acid		Elements								
1000 g ore		Sc	Cr*	Ba	La	Ce	Eu	Tb	Yb	Th
400	HNO_3	25.3	0.17		66.3	74.9	83.9	78.9	88.7	17.0
600	"	29.3	0.23	4.25	98.3	79.3	100.0	95.1	75.3	25.7
800	"	29.3	0.16	4.23	93.4	73.3	94.1	89.1	88.7	31.7
1000	"	32.0	0.13	2.5	100.0	89.4	100.0	100.0	78.7	37.0
1400	"	35.1	-	1.1	86.6	89.4	91.5	89.1	68.8	44.0
**1000	"	32.8	-	4.2	84.7	84.0	95.3	85.7	62.7	53.7
**1400	"	41.2	-	3.8	91.2	91.3	92.5	89.3	72.5	58.7
400	H_2SO_4	29.3	0.16	-	57.0	61.1	67.6	58.5	69.3	42.2
700	"	34.7	0.15	-	59.1	65.0	68.7	61.4	80.0	50.5
900	"	42.7	0.18	-	64.8	76.5	78.3	69.1	80.0	55.7
1100	"	34.7	0.21	-	51.2	58.5	68.9	62.3	71.3	35.6
1500	"	28.2	-	-	35.2	46.4	36.7	42.2	39.9	34.0
** 900	"	36.9	-	-	61.7	65.0	69.2	68.0	69.3	56.0
**1500	"	36.1	-	-	63.7	68.6	69.3	68.9	66.0	61.9

* : mg/g ore
** : Repeated leaching

TABLE-4. Leaching efficiencies for 3 hours, %

Ore : 50 g KTS-1, - 1 mm
Solid/liquid : 1/2
T : 25°C

g acid		Elements								
1000 g ore		Sc	Cr*	Ba	La	Ce	Eu	Tb	Yb	Th
400	HNO_3	33.3	0.17	-	79.6	89.5	99.5	94.0	93.3	16.3
600	"	32.0	0.20	4.6	100.0	83.0	100.0	100.0	82.7	20.5
800	"	29.3	0.15	4.0	89.0	69.9	88.9	83.4	80.7	27.3
1000	"	34.7	0.11	2.7	100.0	87.3	100.0	97.0	80.7	38.1
1400	"	33.5	-	1.7	86.3	85.9	85.8	81.8	67.8	41.0
**1000	"	33.4	-	4.4	88.2	86.0	89.7	86.1	67.3	54.7
**1400	"	37.2	-	4.3	90.2	91.0	90.0	86.7	67.2	57.7
400	H_2SO_4	36.0	0.16	-	61.7	67.1	73.1	64.0	90.7	41.9
700	"	32.0	0.10	-	49.4	52.8	58.2	48.9	68.0	40.7
900	"	40.0	0.16	-	65.7	70.0	73.4	66.6	73.3	53.0
1100	"	38.7	0.20	-	52.4	68.3	74.8	67.4	68.7	40.0
1500	"	37.2	-	-	37.5	51.3	42.0	44.8	49.4	38.2
** 900	"	37.9	-	-	68.2	71.6	72.4	72.0	64.6	61.0
**1500	"	44.9	-	-	63.7	68.6	69.3	68.9	66.0	61.0

* : mg/g ore
** : Repeated leaching

TABLE- 5. Leaching efficiencies for 4 hours, %.

Ore : 50 g KTS-1, - 1 mm
Solid/liquid : 1/2
T : 25°C

g acid		Elements								
1000 g ore		Sc	Cr*	Ba	La	Ce	Eu	Tb	Yb	Th
400	HNO_3	34.7	0.18	-	82.9	94.9	100.0	100.0	100.0	14.5
600	"	29.3	0.21	4.7	98.9	76.2	99.4	91.4	81.3	18.3
800	"	34.7	0.12	3.7	100.0	91.5	100.0	99.4	89.3	24.3
1000	"	38.7	0.05	2.8	100.0	85.9	100.0	94.0	76.7	34.0
1400	"	-	-	-	-	-	-	-	-	-
**1000	"	-	-	-	-	-	-	-	-	-
**1400	"	-	-	-	-	-	-	-	-	-
400	H_2SO_4	40.0	0.17	-	67.2	73.9	82.1	69.7	82.7	43.5
700	"	42.7	0.14	-	60.6	53.0	78.8	66.0	86.0	54.0
900	"	45.3	0.18	-	58.5	67.3	81.1	73.4	74.0	43.6
1100	"	38.7	0.23	-	47.5	60.0	65.0	62.6	67.3	34.7
1500	"	-	-	-	-	-	-	-	-	-
** 900	"	-	-	-	-	-	-	-	-	-
**1500	"	-	-	-	-	-	-	-	-	-

* : mg/g ore
** : Repeated leaching

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