Leaching of Korean monazite for the recovery of rare earth metals

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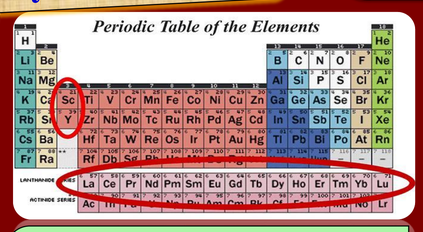
RE are usually dispersed, but rarely concentrated & found only in a group, not individually.

Abstract

The technological innovations resulted in various applications using rare earth metals (REM), which lead to a steep increase in their demand. Monazite is the second most essential naturally occurring phosphate mineral containing REM. The present work reports the recovery of REM from Korean monazite which contained mainly 50.12% rare earth oxide and 29.4% phosphate. For the recovery of REM from monazite, the hydrometallurgical process consisting of alkaline leaching of phosphate followed by acid dissolution of REM has been reported. As the presence of phosphate decreases the leaching efficiency of REM from monazite, the studies were carried out initially for hot digestion of phosphate present in the monazite in an autoclave using sodium hydroxide, which resulted in the formation of RE oxide and soluble sodium phosphate. To get the optimum condition for phosphate decomposition by alkaline leaching, the various process parameters such as concentration of sodium hydroxide, temperature, mixing time and pulp density were studied. The obtained slurry was washed with hot water and filtered to get sodium phosphate in the solution. A maximum of 99% phosphate was removed from monazite concentrate using 50% sodium hydroxide solutions (wt./vol.) at 170°C in 4 h mixing time maintaining the pulp density of 100 g/L. From the phosphate free monazite sample, REM was leached out using hydrochloric acid. More than 95% of REM was found to be leached out using 6M HCl at constant pulp density 100 g/L, temperature 90°C and mixing time 2 h. Further studies are in progress to obtain pure solution and salts of REM from chloride leach liquor using precipitation/ solvent extraction/ ion-exchange techniques.

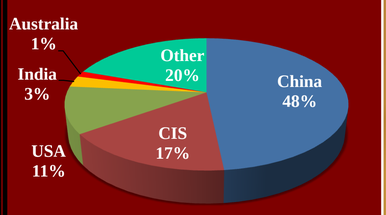
Keywords: Monazite, Hot alkaline digestion, Dephosphorization, HCl leaching, Rare earth metals (REMs).

Introduction



The group of rare earth metals (REMs) contains 17 elements namely scandium, yttrium and lanthanides (15) elements in the periodic table with atomic numbers 57 to 71.

According to the US Geological Survey,, 2011, Estimated Global RE Oxide Reserves(Mt): Total = 113.8, China–55.0, CIS–19.0, USA–13.0, India–3.1, Australia–1.6, Others–22.1.



World demand for REO's for 2014 is expected to be 190,000 tons as follows:

Applications	Growth p.a.(%)	Demand (tons)
Magnets	12	55100
Battery Alloy	15	32500
Auto Catalyst	8	12200
Fluid Catalysis Cracking	4	24900
Polishing Powder	10	28000
Glass Additives	0	7800
Phosphors	8	10800
Metallurgy ex batt	2	12700
Others	8	6100
Total	9	1,90,000

Source: Lynas Corporation presentation

Projected Supply & Demand (2016)

2016	Demand		Supply		Surplus
Element	tonnes	%	tonnes	%	(Deficit)
La	36,750	23.0%	52,000	26.7%	15,250
Ce	65,000	40.6%	81,000	41.5%	16,000
Pr	7,500	4.7%	9,500	4.9%	2,000
Nd	30,000	18.8%	31,500	16.2%	1,500
Sm	1,000	0.6%	3,750	1.9%	2,750
Eu	780	0.5%	500	0.3%	-280
Gd	2,225	1.4%	2,750	1.4%	525
Tb	450	0.3%	350	0.2%	-100
Dy	1,650	1.0%	1,450	0.7%	-200
Er	1,000	0.6%	800	0.4%	-200
Y	13,350	8.3%	10,000	5.1%	-3,350
Ho-Tm-Yb-Lu	250	0.2%	1,400	0.7%	1,150
TOTAL	159,955	100.0%	195,000	100.0%	35,045

Monazite

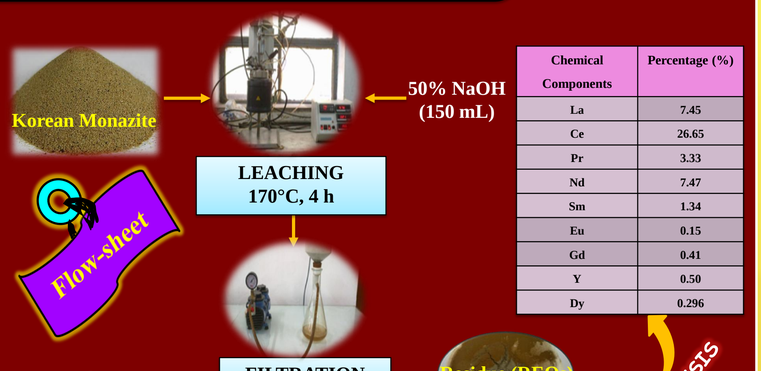
Monazite is a reddish-brown phosphate mineral containing REMs

- Chemistry:$(Ce, La, Th, Nd, Y)PO_4$
- Class: Phosphate
- Group: Monazite
- Uses: As an ore of RE metals & used in radioactive dating

Materials and Methods

Korean monazite
$Ce\ (Ce, La, Pr, Nd, Th, Y)PO_4$

Chemical Components	Percentage (%)
La	13.74
Ce	24.29
Pr	2.45
Nd	7.28
Sm	1.11
Eu	0.054
Gd	0.62
Y	0.58
U	0.67
Th	3.13
Fe	1.02
PO_4^{--}	29.44

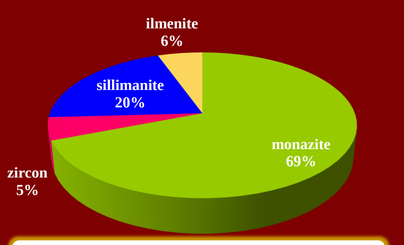


Chemical Components	Percentage (%)
La	7.45
Ce	26.65
Pr	3.33
Nd	7.47
Sm	1.34
Eu	0.15
Gd	0.41
Y	0.50
Dy	0.296

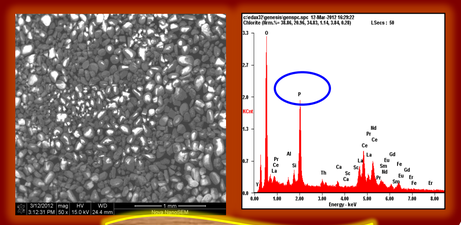
Characterization of Korean monazite

Zoom Stereo Microscope is an optical microscope, variantly designed for low magnification observation or a sample using incident light illumination. Monazite mineral was identified, characterized and quantified using zoom stereo microscope.

Zoom stereo microscope



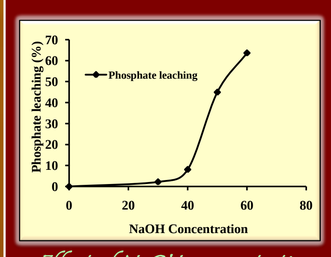
MODAL ANALYSIS OF MONAZITE



SEM/ EDS

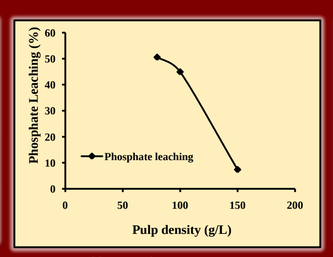
Results and Discussion

Dephosphorization of monazite



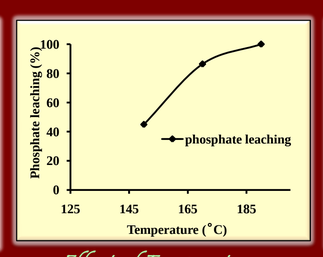
Effect of NaOH concentration

Experimental Condition:
Temperature = 150 C,
Pulp density = 100 g/L
Time = 3 h



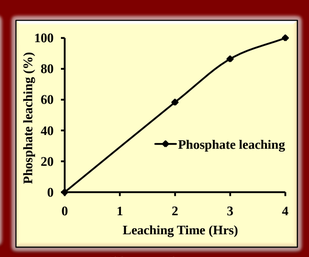
Effect of Pulp Density

Experimental Condition:
NaOH = 50% 150 mL,
Temperature = 150 C,
Time = 3 h



Effect of Temperature

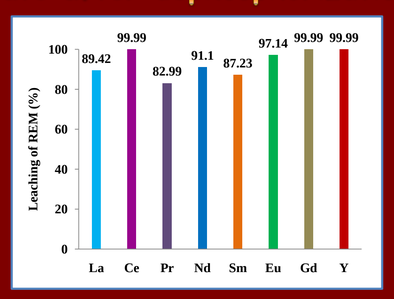
Experimental Condition:
Pulp density = 100 g/L
NaOH = 50% (150 mL)
Time = 3 h



Effect of Time

Experimental Condition:
NaOH = 50% 150 mL,
Temperature = 170 C,
Pulp density = 100 g/L

Leaching of REM from REO concentrate after dephosphorization



Experimental Condition:
REO = 5 g, HCl (6M) = 50 mL
Temperature = 90 C, Time = 2 h,
Pulp density = 100 g/L

- A rare earth absorber batch is used.
- Direct handling of sources of penetrating radiation should be avoided.
- Apron, hand gloves, goggles, mask, etc. are essential.
- Use forceps, tongs, custom-designed holders and spacers is must to maintain distance .
- The residue or the filtrate left after the experiments are stored nicely in air tight jars.

Conclusion

1. Dephosphorization is necessary for the recovery of REM from monazite.
2. Alkaline leaching process (NaOH) is used for the removal of phosphorous .
3. Results showed that on increasing the NaOH concentration, temperature, and leaching time the dephosphorization increases whereas low pulp density is required for improving the leaching efficiency.
4. Almost 95% of REM was leached under optimized condition from the REO concentrate obtained after dephosphorization of monazite.

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Thank You