

Extraction and Characterisation of Rare-earth Oxides from Titaniferous and Monazite Concentrates

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Abstract

The rare-earth lanthanide (Ln³⁺) oxides often co-exist with the ilmenite and zircon sands, and are considered undesirable impurities in the titanium dioxide and zirconium oxide products, because the Ln³⁺-oxides form colour centres and impart colour in TiO₂ and ZrO₂ matrices. The separation of Ln³⁺-ions during processing of titaniferous minerals is energy demanding, as a result the purification costs are high.

Table 1: A comparison of magnetic and non-magnetic fractions of Anatase of Brazillian origin

Constituents	Magnetic part (weight percent)	Non-magnetic part (weight percent)
TiO ₂	61	75.6
FeO	28.4	0.1
Fe ₂ O ₃	8.4	15.5
Al ₂ O ₃	0.5	1.2
MgO	0.2	0.4
Mn ₃ O ₄	0.2	0.3
CaO	0.1	0.1
SiO ₂	1.2	2.2
P ₂ O ₅	0.7	0.9
Cr ₂ O ₃	0.2	0.2
CeO ₂	0.2	0.9
La ₂ O ₃	0.0	0.3
LOI at 1100 C	1.05	1.7

Also, as the richer resources of titaniferous minerals and zirconia are diminishing in the world, the leaner deposits with higher concentrations of rare-earth oxides are becoming more important for developing methodologies, that would not only yield the primary oxides (TiO₂ and ZrO₂), but also secondary metal

oxides such as rare-earth oxides for further processing. An example of compositions (in weight %) of magnetic and non-magnetic fractions of beneficiation process is compared in Table 1.

In this presentation, we have investigated the alkali roasting of ilmenite and monazite minerals above 700°C in controlled redox and oxidative conditions for extracting and further refining of the rare-earth oxides. The physical chemistry of rare-earth oxides separation from ilmenite matrix is explained in view of the decomposition of ilmenite lattice in air in the presence of alkali. The role of different alkali on the decomposition characteristics of ilmenite and changes in the morphologies of reaction product are explained, on the basis of a combined crystal-chemical and lattice model. The physical chemistry of the separation of rare-earth from monazite minerals is also explained, by investigating the morphologies and compositions of the phases formed.

Following the high-temperature redox reaction, the rare-earth oxides were separated via leaching with hot water, which promotes the liberation of fine rare-earth oxides as colloidal suspension from the parent mineral matrix. The alkali titanate is recovered for TiO₂ extraction and purification. From the mixture of RE oxides in colloid forms which was analysed using X-ray powder diffraction technique, as shown in Figure 1. From this mixture, the separation of Nd₂O₃ and Pr₂O₃ were carried out for magnetic materials manufacturing, however, the CeO₂ and La₂O₃ were separated for catalyst and alloy manufacturing for catalytic convertors and fuel cell applications.

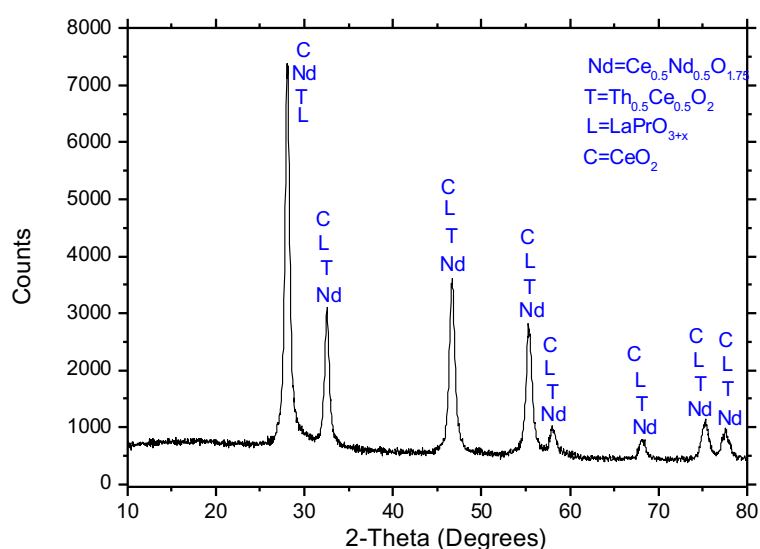


Figure 1: X-ray powder diffraction pattern of extracted rare-earth oxide mixture from the leaching and hot water and dilute acid washing shows the presence LREE with thorium-cerium oxide solid solution. The rare-earth oxide forms colloidal suspension during alkali roasting of non-magnetic fraction at 700°C in air for 3 hrs.

Further leaching of alkali titanate was carried out with oxalic (0.3M) and ascorbic (0.01M) acid solution which removes the remaining Fe²⁺ ions into the leachate and allows precipitation of high-purity synthetic rutile containing more than 95% TiO₂. The importance of chlorination reaction is emphasized for effective physio-chemical separation using high and low-temperature electro-chemistry using molten salt and ionic liquids.

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