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Supercritical fluid extraction of rare earth elements from nitric acid solutions

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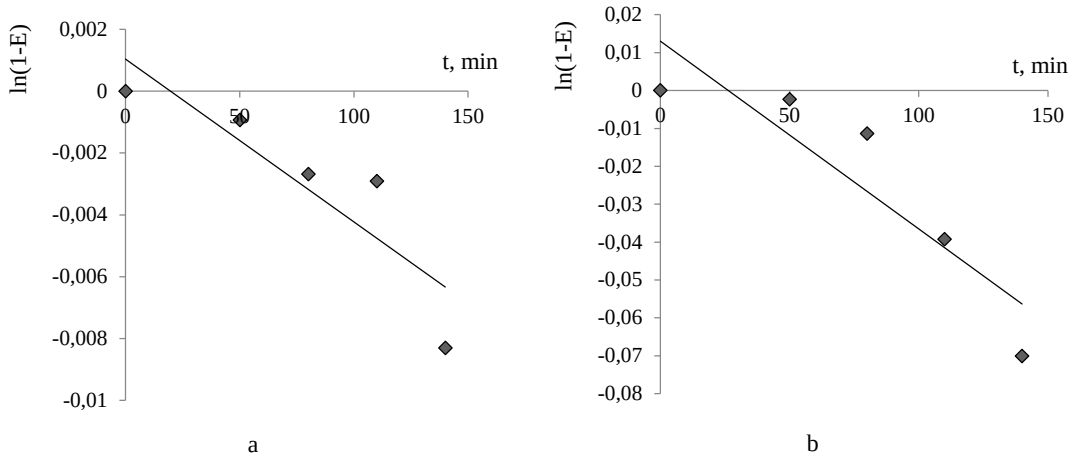
1. Introduction

Today, the actual problem is the search and processing of rare-earth raw materials for the production of pure metals, including their extraction from secondary raw materials. One of the promising sources of raw materials is phosphogypsum - a large-tonnage waste from the industrial production of phosphoric acid, the mass content of rare-earth metals can reach 0,5 %. In the phosphogypsum obtained at the "Mineral Fertilizers" LLP, (Zhambyl region, Kazakhstan), the prevailing REEs are yttrium 82.9 g/t, lanthanum 44.1 g/t, cerium 40.2 g/t, neodymium 36.9 g/t. The use of supercritical fluid extraction makes it possible to improve the process of extracting these metals from hard-to-recover raw materials in comparison with previously known heap leaching methods, and also provides a transition to a real green economy. The aim of the research is the development of highly efficient, energy-saving supercritical technologies for processing raw materials and industrial wastes for extracting rare-earth metals. In this work, we studied the kinetics of extraction of Y from Y_2O_3 with TBP-HNO_3 and DEPHA-HNO_3 complexes in supercritical carbon dioxide.

2. Results and discussion

The model system included yttrium oxide, nitric acid, TBP and DEHPA. In the cell for extraction, containing a portion of 0.1119 g of yttrium oxide with a particle size of 0.03 mm, was added nitric acid with a concentration of 3.5 mol/l, and an organic extractant in a ratio W:O = 10:1. The flow rate of SC-CO_2 was 20 ml/min. The concentrations of TBP and DEHPA in SC-CO_2 were 3% by weight, the temperature in the system was 318 K, and pressure was 20 MPa. From the literature data, it was found that the solubility of the organic extractant increases with increasing pressure and decreasing temperature[1]. Also, the extraction of REEs proceeds most fully when using nitric acid and organic extractants[2]. The yttrium concentration in the system was determined by the amount of yttrium concentration in the CO_2 eluate. The results are presented in Fig. 1.



(a) TBP (b) DEHPA

Figure 1. Change of reaction rate constant depending on extraction time

Processing of the results presented in Fig. 1 was carried out according to[3]. The extraction effiency E can be expressed as

$$E = \frac{C_{A0} - C_A}{C_{A0}},$$

where C_{A0} = 0.1190 g / l and $C_A = C_{A0}$-C(t) is the residue of yttrium oxide in the reactor.

As a result, the rate constant of yttrium extraction from yttrium oxide in the presence of TBP was obtained which was 5×10^{-5} min^{-1}, and for the process of yttrium extraction in the presence of DEHPA it was 7×10^{-4} min^{-1}.

3. Conclusions

To establish the optimal conditions for the SF extraction of REEs from phosphogypsum, yttrium was extracted from a model solution in the presence of TBP and DEHPA. Therefore, it was proposed to use DEHPA as a co-extractor of rare-earth metals from phosphogypsum (Zhambyl region, Kazakhstan) with sc-CO_2. Optimal leaching and extraction conditions were obtained on model yttrium solutions (pH, Cex, W:O), which were used for extraction under supercritical conditions.

References

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