Studies of Scandium (III) Ion Adsorption/Desorption from Acidic Sulfate Solutions Using Chelating Ion Exchangers

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Abstract

One of the potential sources of raw materials to produce Rare Earth Elements (REEs) and scandium is the technogenic waste of the alumina industry – red mud and dust from electrostatic precipitators of the bauxite sinter processing, in which REEs are concentrated during alkaline leaching. The developing of the new REEs recovery approach with the selective leaching by acid at pH > 3 in the presence of $MgSO_4$ leads to the formation of the solution with the low concentration of Fe and Ti and high amount of valuable elements that should be further processed to obtain REEs concentrate. The study contains research on the sorption recovery of Sc (III) ions from acidic sulfate solutions on selective chelating ion exchange resin Puromet MTS9580. The static sorption data was analyzed using the Langmuir, Freundlich, and Temkin isotherm models. The best fitting for the scandium (III) ions sorption was obtained using the Langmuir (the highest value of the correlation coefficient $R^2 = 0{,}9834$) and Freundlich isotherm models. The dynamic experiments results were better fitted to Thomas model with the equilibrium capacity more than 7 mg Sc per gram of resin.

Keywords: Sorption, Scandium, Isotherm, Sulfate solutions, Puromet MTS9580.

1. Introduction

One of knowing potential sources of raw materials to produce rare earth elements (REEs) and scandium is the technogenic waste of the alumina industry – red mud (RM) and dust from electrostatic precipitators (EPD) of the bauxite sinter processing, in which REEs are concentrated during alkaline leaching of aluminum-containing raw materials. Along with environmental pollution, they contain a relatively large amount of scandium and other rare earth elements. According to available estimates, 70–80 % of the world's scandium reserves are found in bauxites [1].

It can be summarized that despite such complex composition of aluminum-containing waste, its treatment can overcome the unfavorable environmental impacts of mining and be REEs sustainable source at the same time.

The hydrometallurgical technology of treatment of the listed wastes with the Sc and REE production involves the stages of leaching into the aqueous phase in the first stage and selective separation from the leaching solution in the second. The low extraction degree of rare metals at high costs forces the search for more efficient methods characterized by better selectivity.
In our previous studies [2] of the processes of hydrometallurgical treatment of aluminum raw materials, it was found that it is necessary to carry out leaching at pH < 2 in order to extract more than 50 % of REEs. Additional thermochemical or mechanical activation is required to intensify

the leaching process at a higher pH value. EPD particles previously washed from soda and aluminates using water (EPDW) have already thermal and alkaline activated and are sufficiently crushed. In addition, as a result of dust leaching with water, almost all REEs are concentrated in the solid residue because their content approximately doubles according to the analysis. The results of electron probe microanalysis (EPMA) showed that the scandium in the red mud obtained after EPD water leaching is mainly associated with iron minerals. However, scandium exhibits a direct dependence on magnesium extraction, but Sc particles are not associated with it according to EPMA. Therefore, we can conclude that magnesium acts as a leaching agent and helps to dissolve the adsorbed-on iron minerals REE.

We have proposed a novel method for rare earth elements extraction from RM with the addition of $MgSO_4$ at the stage of selective acid leaching at $pH > 3$, which can obtain a solution with a low content of Fe and Ti with a simultaneous high content of valuable elements [2]. The resulting solution is further processed into the required REE concentrate.

This study extends our previous work and estimates Sc recovery by chelating resin Puromet MTS9580 from sulfuric acid solutions since sorption extraction is the most promising among the methods for extracting Sc from complex productive leaching solutions.

2. Materials and Methods

2.1 Materials

The chelating ion exchange resin Puromet MTS9580 which has selectivity to rare earth elements was used in this study. A model solution was prepared with a scandium concentration of 1–20 mg L^{-1} at a pH = 3.5 to static adsorption experiments. The simulated solution for dynamic experiments containing 24 g L^{-1} $MgSO_4$ and 10 mg L^{-1} Sc was prepared by dissolving Sc_2O_3 in diluted sulfur acid. Specifically, a certain amount of $MgSO_4$ was added and stirred continuously until all had been dissolved by using a laboratory magnetic mixer (Daihan). The required pH values were adjusted by adding concentrated sulfuric acid. All chemicals used were of analytical grade.

2.2 Experimental Methods

The static adsorption was carried out by mixing 50 mL feed solution and 0,1 mL of resin in a conical flask at ambient temperature 25 °C and pH = 3,5 for 8 hours. Mixing took place on a rotary laboratory shaker PE-6410 (Ekros Group of companies). The dynamic adsorption was carried out by using a 5 ml ion exchange column. The dynamic ion exchange experimental unit is shown in Figure 1. The resin volume in the column was 2 mL. The peristaltic pump supplied the initial solution to the bottom of the ion exchange column at different speeds as 2.5, 5, and 7.5 mL per minute. Samples of ion-exchanged liquid that outflowed from the top of the column had been taken periodically for analysis. The saturated resins were washed with distilled water and then statically desorbed with 200 g L^{-1} Na_2CO_3 solution. The equilibrium ion concentrations of Sc (mg L^{-1}) and impurities in the solution samples were measured by using an inductive coupled plasma optical emission spectrometer (ICP-OES, Variant) via Varian AA-240FS spectrometer (Agilent Technologies, San Jose, CA, USA).

5. References

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