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Sorption Extraction of Lanthanum from Ash and Slag Waste of Novo-Angren TPP

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ABSTRACT: This article studies sorption method of extraction of rare earth elements (REEs) from ash and slag waste of Novo-Angren TPP. In this regard, the possibility of extracting REE from acidic solutions on the Purolite C100-H cation exchanger was investigated in the example of one of the REEs, lanthanum. Furthermore, dependence of the sorption of lanthanum on Purolite C-100N cation exchanger on pH of solution and dependence of the sorption of lanthanum on the Purolite C-100H cation exchanger on the concentration of the equilibrium solution were studied. In addition, lanthanum sorption was calculated from the difference in concentrations in the initial and equilibrium solutions.

KEY WORDS: rare earth elements (REEs), acidic reagent, cation exchanger, sulfo group, static exchange capacity, sorbent.

I. INTRODUCTION

Huge masses of coal waste create serious environmental problems in the Angren region and require a comprehensive approach to development. Ash and slag waste should be considered as a complex raw material containing valuable rare, scattered and rare earth metals, the extraction of which creates products with high added value. With the complex management of ash and slag waste from TPPs, it is possible to reduce the negative environmental impact on the environment, rationally distribute secondary material resources and abandon investments in the reconstruction and construction of a new ash dump.

II. SIGNIFICANCE OF THE SYSTEM

The development of highly selective technologies for the isolation of rare, scattered and rare earth elements from all possible sources and the creation of new materials on their basis are actual tasks from both an economic and an environmental point of view.

There are various methods of extracting valuable elements (including rare earth elements) from the mineral part of coals, which consist in the chemical treatment of ash and slag waste after burning coal with various chemical reagents. The main method for processing ash and slag wastes is opening them with acidic reagents, mineral acids and organic cation exchangers in the H^+ form.

III. METHODOLOGY

With sulfuric acid opening of ash and slag waste from the combustion of Novo-Angren coals, up to 92-95% of rare earth metals are extracted into solution. From the literature it is known that for the sorption of rare earth elements, cation exchangers with strongly acidic groups are used [1]. For example, one of cation exchangers is the domestic cation exchanger KU-2, obtained on the basis of a sulfonated copolymer of styrene and divinylbenzene and containing sulfo groups. Many studies have been carried out on the sorption extraction of REE on the KU-2 cation exchanger [2]. The modern analogue of the KU-2 cation exchanger is the Purolite C100-H cation exchanger.

We investigated the possibility of extracting REE from acidic solutions on the Purolite C100-H cation exchanger using the example of one of the REEs, lanthanum.

The strongly acidic cation exchanger Purolite C-100H is used in the framework of the current work. This exchanger is a cation exchanger which is in the H^+ form, which is in the shape of spherical particles, which are obtained on the basis of a sulfonated copolymer of styrene and divinylbenzene, which has a high exchange capacity and which is completely ready for use both in household and industrial water treatment systems. As soon as the capacity of the resin layer is exhausted, the exchange capacity is restored with acid solutions (in most cases, hydrochloric or sulfuric). The recovered capacity largely depends on the amount of acid used in the recovery [3].

IV. EXPERIMENTAL RESULTS

Like most common polystyrene sulfonated resins, Purolite C-100H is thermally stable up to 150 °C in salt form (for example, sodium, calcium, or magnesium form). The dependence of lanthanum sorption on the pH of the initial solution was studied under static conditions. The initial solutions contained 1 g/l of lanthanum, the pH of the environment was changed in the range from 1 to 5 units, the sample of the ion exchanger was 0.100 g, the contact time was 24 hours. The concentration of lanthanum in the initial and equilibrium solution was determined photometrically. The data obtained were used to calculate the sorption of lanthanum at different pH values (Figures 1-2).

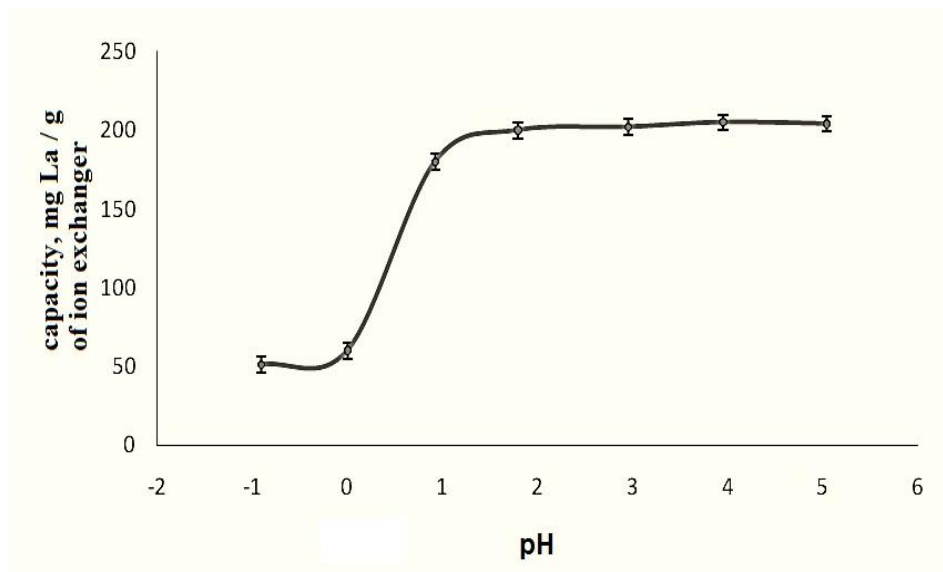


Figure 1. Dependence of lanthanum sorption on Purolite C-100H cation exchanger on pH of the initial solution

The study of the dependence of the sorption of lanthanum from hydrochloric acid solutions on the Purolite C-100H cation exchanger on the pH of the initial solution showed that in the pH range from 2 to 5 units the static exchange capacity of the ion exchanger practically does not change and the sorption value averages 200 mg/g.

The lanthanum sorption isotherm was constructed from hydrochloric acid solutions in the range of initial concentrations from 0.25 to 3.2 g/l, and the pH of the solution was 2. Sorption was carried out for 24 hours.

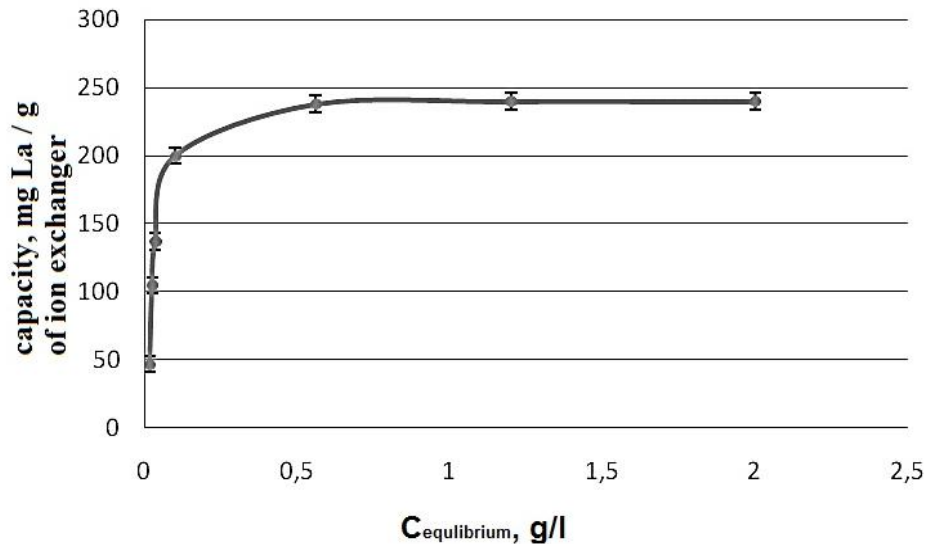


Figure 2. Dependence of the sorption of lanthanum on the Purolite C-100H cation exchanger on the concentration of the equilibrium solution

Lanthanum sorption was calculated from the difference in concentrations in the initial and equilibrium solutions. The data obtained were used to calculate the sorption of lanthanum on Purolite C-100H. Purolite C-100H is a convex curve gradually reaching a plateau. The maximum static exchange capacity (SEC) of the Purolite C-100H ion exchanger is achieved at a lanthanum concentration in the equilibrium solution of 0.51 g/l and amounted to 240 mg/g or 5.1 mg \times eq/g ($C_d = 120$). The distribution coefficient was calculated using the formula:

$C_d = \bar{X}/X$, where \bar{X} – equivalent fraction of ions in the ion exchanger, X – in solution [2].

Under similar conditions, the maximum static exchange capacity of the KU-2 cation exchanger at an equilibrium metal concentration of 1.6 g/l is 3.3 mg \times eq/g ($C_d = 50$). This means that Purolite C-100H has higher capacitive characteristics than the KU-2 cation exchanger.

V. CONCLUSION

It has been established that the exchange equilibrium is achieved after 5 hours of contact of the ion exchanger with the solution on the Purolite C-100H sorbent. Thus, it was established that the cation exchanger Purolite C-100H has high kinetic characteristics in relation to lanthanum in hydrochloric acid solutions.

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