Conference Paper

Scandium Recovery from Red Mud by Carbonate Assist

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Abstract

Known methods for production of scandium compounds are based mainly on the acidic leaching of scandium-containing materials, followed by its isolation as sparingly soluble compounds. However, these schemes have many operations, consume high amounts of reagents and electric power, resulting in a high cost of the final product. The effect of carbonate ions concentration, contact time, temperature, the ratio of S:L, type and amount of sorbent on the degree of scandium separation directly from red mud slurry was studied in this work. It has been shown that the greatest capacity of macroporous adsorbents exhibit scandium acrylic copolymers iminodifosfonic group situated closer to the polymer skeleton.

Keywords: Scandium, red mud, leaching, sorption, ion exchange resin, extraction

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Received: 6 June 2017
Accepted: 9 July 2017
Published: 24 August 2017

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Selection and Selection and Peer-review under the responsibility of the Technogen Conference Committee.

1. Introduction

The necessity in metal scandium and its compounds is significantly increasing during last decades. This is conditioned by the possibility of scandium compounds use in electronic industry (luminophors, ferrites, garnets) and for production of solar betteries; scandium tantalate has ferroelectric properties [1].

Known methods for production of scandium compounds are based mainly on the acidic leaching of scandium-containing materials, followed by its isolation as sparingly soluble compounds [2, 3]. However, these schemes have many operations; consume high amounts of reagents and electric power, resulting in a high cost of the final product.

These disadvantages are very significant for aluminum production waste treatment, particularly for the red mud treatment. This is conditioned by the fact that concentrations of the main components of the red mud (Fe, Al, Ca, Si, Ti, etc.) are higher than scandium concentration by an order of several magnitudes. Usually, an elevated amount of an acid is required for the red mud treatment, whereas the leachates contain very low scandium concentration. There are a number of methods for scandium separation from these leachates, including ion exchange [4].

	Al	Ca	Sc	V	Fe	Y	ΣLn	Th	U
Content, %	7.03	8.03	0.01	0.05	26.97	0.02	0.15	0.006	0.005

Table 1: The content of the main components in the red mud from BAZ plant.

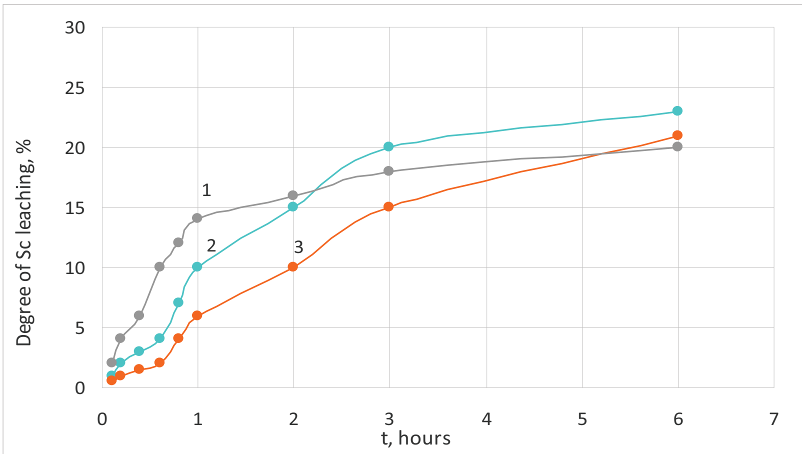

Figure 1: The kinetic curves of Sc leaching from the red mud by 20 g/L^{-1} $NaHCO_3$ solution (1), macroporous-type weak base anion exchange resin (2) and gel-type weak base anion exchange resin (3).

Non-acidic schemes are also prospective for scandium separation from industrial wastes. Some publications contain information about the possibility of scandium separation from the red mud via its autoclaving at the temperature of 300°C in presence of 300-500 g L^{-1} of sodium hydroxide [5]. Unacceptable conditions of scandium leaching and difficulty of its separation from solution are the main disadvantages of this scheme.

A significant research work was done for the development of methods for scandium separation after carbonate treatment of red mud [6, 7]. Certain difficulties, conditioned by transport of carbonate media (gas or salt) as well as by low degrees of scandium leaching, were limited the potential use of this method. The possibility of intensification of scandium carbonate leaching and further separation from the red mud with simultaneous cost reduction was studied in this work.

2. Carbonate Treatment

The red mud from the BAZ (RUSAL) aluminium producing plant was used in this work. The content of the main components is given in Table 1.

It is well-known that hydrolysis of scandium occurs in weak acidic solutions; the structure of hydrolized scandium ion may be described as $[Sc_4(OH)_m(H_2O)_{n-m}]^{(12-m)+}$. The gradual addition of CO_3^{2-} ions to the scandium solution results in the total scandium dissolving (at the molar ratio of CO_3^{2-} : Sc^{3+} = 0.75), then in its total precipitation as

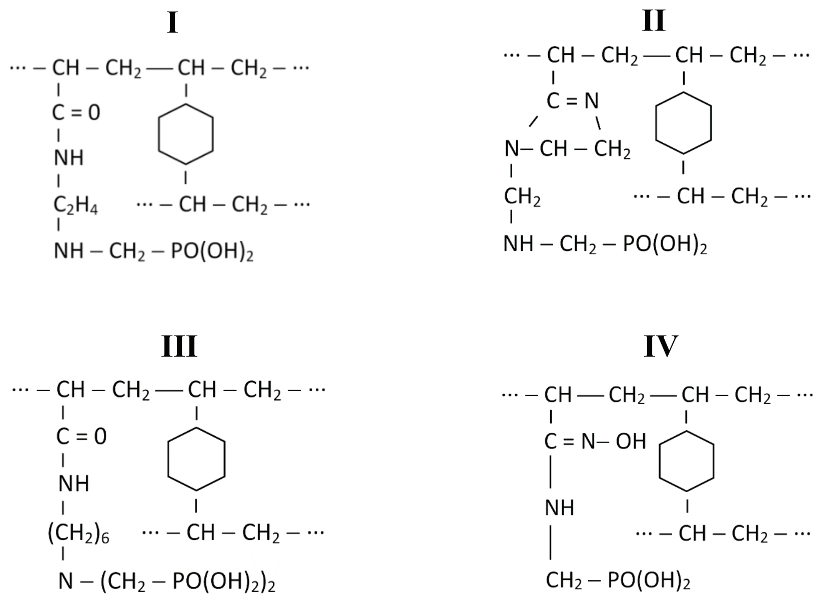

Figure 2: The structure of functional groups of studied ampholites.

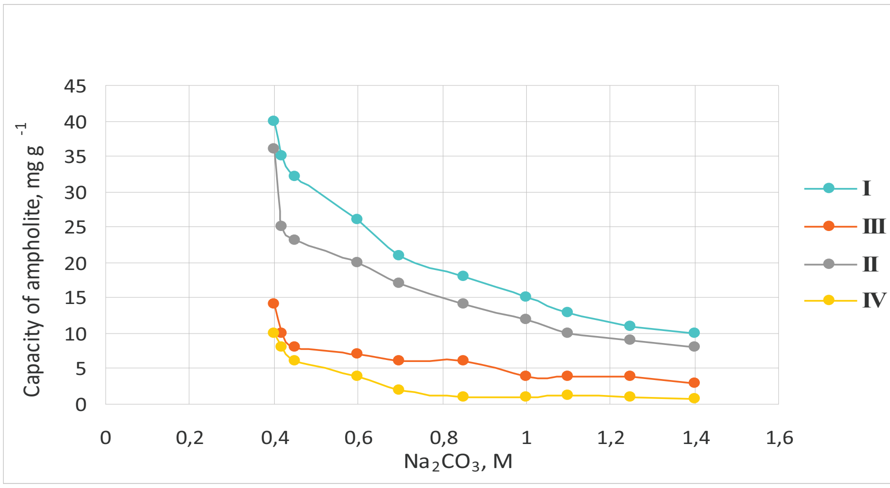

Figure 3: The dependences of ampholites capacity of Na_2CO_3 concenration in the red mud.

a base carbonate $[Sc_4(OH)_m(CO_3)_p]^{(12-2m-p)}$ and finally in the total dissolving of this precipitate at the molar ratio of CO_3^{2-}: Sc^{3+} = 8.35.

In practice, carbonation of the red mud is performed using either alkaline metals and ammonium carbonate solutions or carbone dioxide. As a rule, these variants have such disadvantages as a high salt consumption, accumulation of alkaline metals in the main producing scheme as well as high cost of carbonation by carbone dioxide.

The method of the red mud carbonation via CO_3^{2-} ions introduction using an anion exchange resin was studied in this work. This method allows for saving the cation and volume balance of the producing scheme. In addition, the suggested RIP-process (Resin In Pulp) is a simple process from the point of view of used apparature. The ion exchange process with anionite occurs according to the following equation:

$$2R - CO_3 + Sc(OH)^{+}_{-} \longleftrightarrow 2R - OH + Sc(CO)^{-}_{3} \quad (1)$$

Anionites with various basicity, composition and matrix structure were studied. In addition, the same anionites in CO_3^{2-} and HCO_3^- forms were studied. Some of the obtained results are shown at Figure 1.

The dependences from Figure 1 have shown that use of anionites for carbonation resulted in the same degrees of Sc leaching as use of sodium carbonate; whereas, significantly lower kinetics of scandium leaching was typical for use of anionites, especially of the gel-type modification.

3. Scandium Sorption

Our research group was the first one in the former USSR that developed the technology of scandium sorption separation from the red mud using the RIP method with simultaneous carbonation of the slurry [8, 9]. Phosphate cation exchange resins with phosphonic functional groups and a St-DVB matrix with varous DVB content were used for scandium sorption.

Formation of the coordination bond between scandium and oxygen from the phosphonic group results in sorption of scandium carbonate complexes by a phosphate cationite. This coordination bond is stronger than the chemical bond between scandium and carbonate ion. Also, variation of a substituent near phosphorus atom as well as the structure of cationit's matrix results in a change of energy of the chemical bond between scandium and phosphate functional group; this allows obtaining stronger complex compounds [10].

Several ampholites based on copolymer of styrene and polyacrylate were studied in this work. The copolymer was aminated by various reagents that allows regulating the distance between the matrix and phosphate functional group. The structure of functional groups of studied ampholites is shown at Figure 2.

The sorption capacity of these ampholites with respect to scandium was studied in presence of various concentrations of sodium carbonate. The obtained results are summarized at Figure 3.

Differences of exchange capacity of ampholites I-IV in the process of scandium sorption from the red mud slurry may be explained by various distance between the phosphate functional group and the polymer matrix. Low capacity of the ampholite IV with respect to scandium is probably conditioned by the negative influence of the =N-OH group, presenting in this ion exchange resin.

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