RECOVERY OF SCANDIUM FROM TITANIUM TAILINGS SOLUTION USING II-VI SIR TECHNOLOGY

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Abstract

The II-VI Selective-Ion Recovery (SIR) Technology includes the use of a composite extractant-enhanced ion-exchange resin to extract scandium (Sc) from acidic solution or slurries, and its subsequent recovery as Sc concentrate. The work presents the applicability of the SIR process for recovery of Sc from acidic waste solution from the carbothermal chlorination processing of titanium ores. It is known that titanium (Ti) loads to the SIR resin so the solution pre-treatment to remove Ti was required to increase the capacity of the resin for Sc loading. Precipitation experiments were carried out to determine the required pH and reagent at which Ti is preferentially precipitated to produce a Pregnant Leach Solution (PLS) while maintaining Sc in solution. Under the optimized conditions, the generated PLS was used to develop the adsorption isotherm and loading profile. It was determined that the Sc loading capacity could be as high as 20,000 mg/L SIR resin. Under this project, the SIR pilot plant was built. The acid waste solution was treated to remove Ti. The solution from the Ti Removal step contained low concentration of Ti, Th, Nb and Zr. During the pilot plant operation, 95% recovery of Sc through SIR IX was achieved. The crude Sc concentrate produced contained about 20% Sc. *The research leading to these results has received funding from the European Community's Horizon 2020 SCALE Programme (H2020/2014-2020/No. 730105). This publication reflects only the authors' views, exempting the SCALE Consortium from any liability for the information presented herein.*

Introduction

The II-VI Selective-Ion Recovery (SIR) Technology includes the use of a composite extractant-enhanced ion-exchange resin to extract Sc from acidic solution or slurries and the recovery of Sc as Sc concentrate. Various Sc-containing solutions and slurries including Ti tailings solution were tested to a great extent to establish the parameters and evaluate the overall performance of this technology. It has been determined that Ti can co-adsorb with Sc and consequently lower the capacity of the resin for Sc recovery. Therefore, it was important to remove Ti prior to loading the PLS on the SIR resin.

Experimental

The Ti tailings solution was obtained from a Ti production plant employing carbothermal chlorination processing of Ti ores. This solution was pre-treated with a base to adjust its pH to remove Ti, followed by filtration to recover the PLS for the adsorption experiments.

The PLS was delivered through a silicon tube to the column using a peristaltic pump at flowrate of 2 bed-volumes per hour (BV/hr) until the exhaustion point of the resin for Sc uptake was attained.

All samples were analysed for Sc and impurities content using Agilent 5110 ICP-OES. The determination of free acid was done by titration and pH by using TPS Aqua pH.

Results and Discussion

Laboratory Scale

As a preliminary evaluation on the effect of the other metal cations particularly Ti to the loading capacity of the SIR resin for Sc loading, the acidic Ti tailings solution containing 80 ppm Sc, 5,000 ppm Ti, and other transition metal ions was contacted with the SIR resin. As shown in Figure 1, the Sc and Ti loading capacity of the SIR resin were 1,000 and 51,000 mg/L, respectively; which suggested the need for Ti removal to increase the Sc loading on the SIR resin.

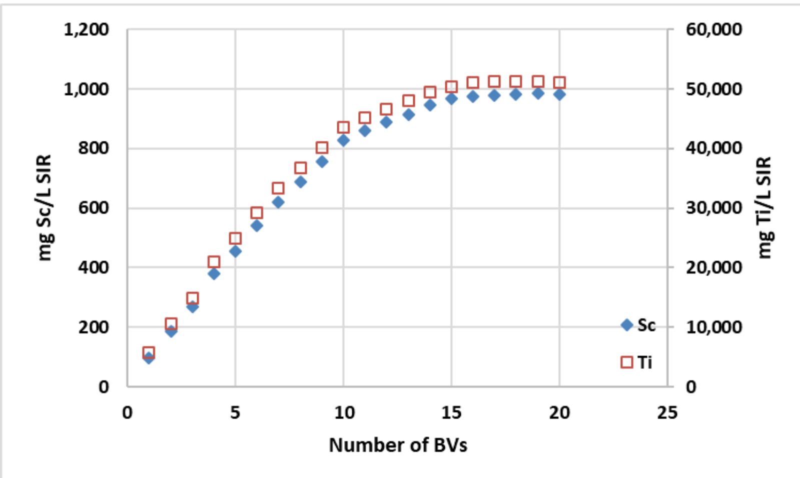


Figure 1: Loading Capacity of the SIR for Sc and Ti from "As Received" Ti Tailings Solution

The solution pH was gradually adjusted from 0 to 1.75 using hydrated lime ($CaO.H_2O$). The precipitation profile of Sc and Ti from the acidic Ti tailings solution is shown in Figure 2. The optimum pH for the preferential precipitation of Ti was found to be at 0.70±0.10 where more than 98% of the Ti precipitated while over 80% of Sc remained in the solution.

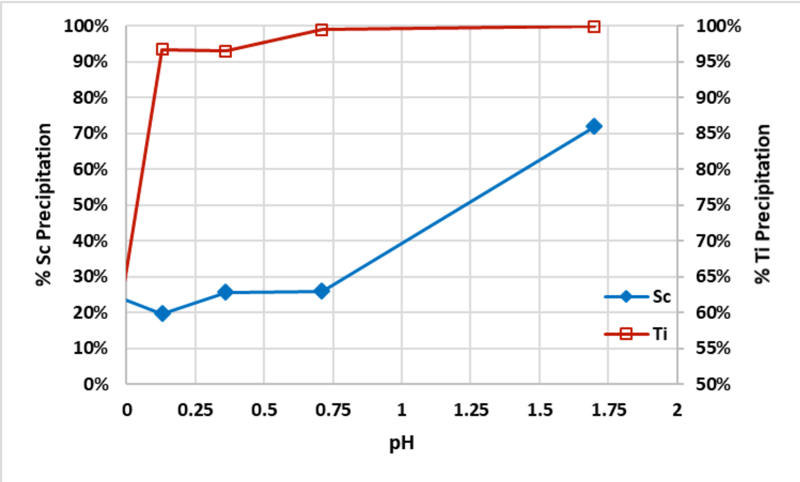
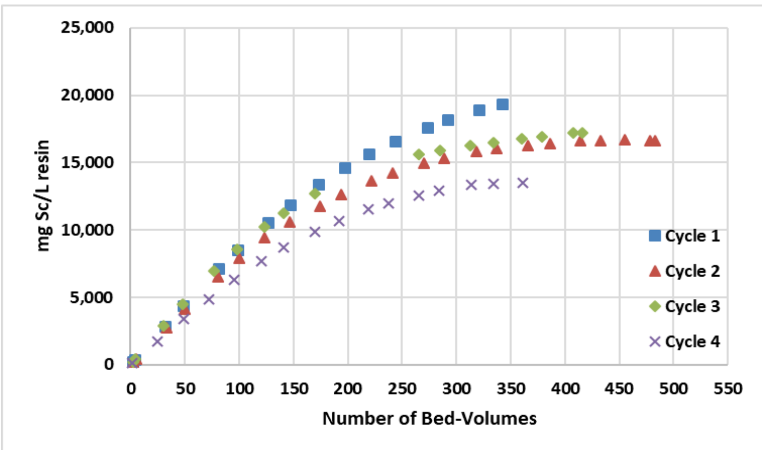


Figure 2: Precipitation of Sc and Ti from Ti Tailings Solution at Different pH using $CaO.H_2O$

This solution was subjected to the adsorption experiments to evaluate the performance of the SIR process in recovery of Sc from solution. To determine the average loading capacity of the SIR resin for Sc loading, the SIR resin was contacted with the PLS followed by washing, elution and regeneration of the resin. This cycle was repeated four times. Figure 3 and Figure 4 show the cumulative loading of the SIR resin for Sc and Ti, respectively, versus the number of bed-volumes (BV) of the PLS. Considering the loading results attained without Ti removal (Figure 1), the Sc loading increased significantly once pH was adjusted and Ti concentration was reduced. The Sc loading capacity increased to the average of 16,500 mg/L while Ti loading decreased to 6,500 mg/L at the Sc exhaustion point.



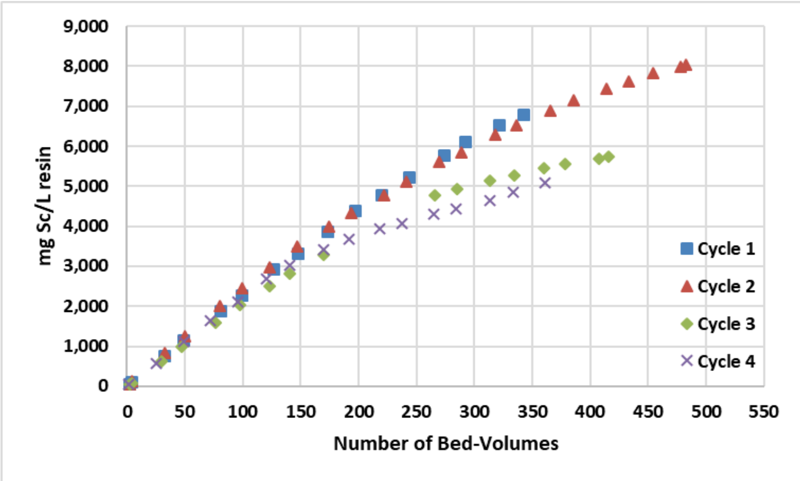


Figure 4: Loading Capacity of the SIR for Ti from Pre-Treated Ti Tailings Solution

In these experiments, 100% recovery of Sc through elution was achieved.

Pilot Plant Run

Under the SCALE program, the SIR Technology pilot plant was designed and constructed. The pilot plant was composed of three skids that contained the SIR resins and its columns, tanks for loading, elution and regeneration. A photo of the plant is shown in Figure 5.

Figure 5: II-VI SIR Pilot Plant

About 4,000 L of Ti tailings solution containing about 60 ppm Sc, 5,000 ppm Ti, and other transition metal ions was prepared in an agitated tank according to the established parameters for the removal of Ti. After filtering the slurry, the solution was found to contain above 50 ppm Sc, about 5 ppm Ti and low concentrations of the other transition metal ions which were consistent with the results obtained in the laboratory. Subsequently, this solution was fed to the 15-L SIR column. The pilot plant had been designed for a different Sc contained solution and Ti Tailings solution was run through the process only as part of the commissioning phase. Therefore, it was only operated for a short duration and the resin did not reach the exhaustion point.

The SIR was eluted and regenerated according to the established parameters. The crude concentrate containing about 20% Sc and 0.5%Ti was produced. The overall Sc recovery of 95% was achieved in the pilot plant of the SIR process.

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