

Extraction of Scandium (Sc) from an Ore with Functionalized Nanoporous Silicon Adsorbent

Authors : Arezoo Rahmani, Rinez Thapa, Juha-Matti Aalto, Petri Turhanen, Jouko Vepsäläinen, Vesa-Pekka Lehto, Joakim Riikonen

Abstract : Production of Scandium (Sc) is a complicated process because Sc is found only in low concentrations in ores and the concentration of Sc is very low compared with other metals. Therefore, utilization of typical extraction processes such as solvent extraction is problematic in scandium extraction. The Adsorption/desorption method can be used, but it is challenging to prepare materials, which have good selectivity, high adsorption capacity, and high stability. Therefore, efficient and environmentally friendly methods for Sc extraction are needed. In this study, the nanoporous composite material was developed for extracting Sc from an Sc ore. The nanoporous composite material offers several advantageous properties such as large surface area, high chemical and mechanical stability, fast diffusion of the metals in the material and possibility to construct a filter out of the material with good flow-through properties. The nanoporous silicon material was produced by first stabilizing the surfaces with a silicon carbide layer and then functionalizing the surface with bisphosphonates that act as metal chelators. The surface area and porosity of the material were characterized by N₂ adsorption and the morphology was studied by scanning electron microscopy (SEM). The bisphosphonate content of the material was studied by thermogravimetric analysis (TGA). The concentration of metal ions in the adsorption/desorption experiments was measured with inductively coupled plasma mass spectrometry (ICP-MS). The maximum capacity of the material was 25 µmol/g Sc at pH=1 and 45 µmol/g Sc at pH=3, obtained from adsorption isotherm. The selectivity of the material towards Sc in artificial solutions containing several metal ions was studied at pH one and pH 3. The result shows good selectivity of the nanoporous composite towards adsorption of Sc. Scandium was less efficiently adsorbed from solution leached from the ore of Sc because of excessive amounts of iron (Fe), aluminum (Al) and titanium (Ti) which disturbed the adsorption process. For example, the concentration of Fe was more than 4500 ppm, while the concentration of Sc was only three ppm, approximately 1500 times lower. Precipitation methods were developed to lower the concentration of the metals other than Sc. Optimal pH for precipitation was found to be pH 4. The concentration of Fe, Al and Ti were decreased by 99, 70, 99.6%, respectively, while the concentration of Sc decreased only 22%. Despite the large reduction in the concentration of other metals, more work is needed to further increase the relative concentration of Sc compared with other metals to efficiently extract it using the developed nanoporous composite material. Nevertheless, the developed material may provide an affordable, efficient and environmentally friendly method to extract Sc on a large scale.

Keywords : adsorption, nanoporous silicon, ore solution, scandium

Conference Title : ICMEH 2020 : International Conference on Metallurgical Engineering and Hydrometallurgy

Conference Location : Paris, France

Conference Dates : May 14-15, 2020