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Ion-exchange Resins for Metals Recovery (Cu and Zn) from Acidic Mine Waters

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Abstract: Environmental and economic concerns over the last decades have introduced new research opportunities for the application of several techniques in order to improve the removal of contaminants, as well as to explore methods to recover added-value elements. One example could be the recovery of metals ions from mining activity wastewaters in an approach to circular economy scheme. Therefore, in this work the separation and recovery of Zn and Cu, from acidic mine waters, as valuable metals is proposed. For that, an ion-exchange process with resins using a fixed bed configuration is used at lab-scale. A solvent impregnated (e.g. Lewatit VP OC 1026) and a chelating (e.g. Lewatit TP 207) resins were used for the recovery of Zn and Cu, respectively. Results showed that it was possible to separate and concentrate both metals (Zn around 10 times and Cu about 40 times). For that, ion-exchange resins provide a circular economy approach for metallurgical processing plants.

Keywords: ion-exchange; acidic mine waters; metal recovery.

INTRODUCTION Mining industry is the major producer of sulfuric acid-rich effluents, which often contain high concentrations of heavy metals (e.g. Cd, Cr, Hg, Ni, Pb, Cu, Zn, among others), and non-metals (e.g. As, Se) (. The most widespread method used to mitigate acidic effluents is an active treatment involving a chemical-neutralizing agent to increase the pH of water, causing the precipitation as hydroxides and carbonates of many of the metals present in the solution. After this, metal-rich sludge is obtained. Although chemical treatments can provide effective remediation of acidic mine drainage, they have some disadvantages, such as high operating costs and sludge disposal problems (López et al. 2019). Therefore, as prices for several valuable metals (e.g. Zn and Cu) are increasing over the last years, the main objective of this work is to separate and recover Cu and Zn-rich streams, from mining effluents, by means of ion-exchange resins using a fixed bed configuration.

MATERIALS AND METHODS Previous to the ion-exchange stage, a pre-treatment step was planned to remove solids and precipitates in order to prevent column clogging. In this pre-treatment, Fe and Al were removed with H_2O_2 (35%) and 2M NaOH increasing the pH up to 4.8. Resins used in this work consisted of Lewatit VP OC 1026 (solvent impregnated resin) and Lewatit TP 207 (chelating resin) for Zn and Cu recovery, respectively. Before use, Lewatit TP 207 was converted into Na^+ form by washing the resin sequentially with 1 M NaOH solution and distilled water (until pH = 7), while Lewatit VP OC 1026 was not converted since it is a polymeric matrix impregnated with a solvent extractant.

The separation of Zn and Cu was carried out in two consecutive steps. First separation stage was focused on Zn adsorption from an acidic mine water. For that, 30 g of Lewatit VP OC 1026 resin were packed in a column and feed solution was circulated through it at 2.0 mL/min and pH=2.7. Once the Zn was removed from the initial acidic mine water, the feed pH was adjusted at 3.5 before being treated by the second column set-up, using Lewatit 207 resin (4 g), and fed at 1.4 mL/min. For desorption steps, 100 g/L of H_2SO_4 solution was used at 1.0 and 0.7 mL/min for Zn and Cu recovery, respectively.

Metal concentration was determined by Inductively Coupled Plasma (ICP) atomic emission spectroscopy (OES) and mass spectrometry (MS); conductivity and pH were also measured during the process.

RESULTS AND DISCUSSION After the pre-treatment stage, the acidic mine water was composed by: 771 mg Zn/L, 272 mg Cu/L, 22 mg Al/L, 2 mg Cd/L, 195 mg Mn/L, 1976 mg Mg/L, 1115 mg Na/L and 496 mg Ca/L. In this step, 100% Fe and 90% Al removal were achieved successfully, whereas target metal loss (Zn and Cu) was below the 10% of the inlet concentration. On the other hand, it was possible to recover Zn (23.3 ± 2.2 mg Zn/g resin) and also to concentrate it around 10 times by the elution process using Lewatit VP OC 1026 resin; while the Cu recovery was around 37.8 ± 2.1 mg Cu/g resin and it was concentrated around 40 times using Lewatit 207 resin.

Overall, the application of ion-exchange process with resins shows a great potential in the separation and recovery of valuable metals from acidic mine waters (Zn and Cu) to promote the circular economy scheme in the hydrometallurgical industries.

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