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Integration of diffusion dialysis for sulphuric acid recovery from metallurgical process streams

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Introduction

In the metallurgical industry large amounts of wastes are generated, which are characterized by a high acidity (pH < 1), a huge amount of dissolved metal ions (e.g. Fe, Cu, Zn) and a minor presence of non-metal ions (e.g. As, Se). The combination of these properties make these effluents a dangerous waste and, in some cases, difficult to handle.

Diffusion dialysis (DD) arises as a technology for treat these waters and to recover acids. DD is a membrane separation process which uses ion-exchange membranes and it is driven by a concentration gradient. In acid purification, due to the presence of an anionic exchange membrane (AEM), acid will permeate easily, while the transport of all the metallic cations in solutions would be impeded (Luo et al., 2011). Several works have studied the sulphuric acid recovery from acidic leach solutions with DD (e.g. Li et al., 2016 and Wei et al., 2010).

In this study the sulphuric acid recovery and metal rejection have been evaluated from a synthetic solution mimicking an acidic effluent, which was generated in the gas cleaning procedure of a metallurgical plant.

Material and Methods

A lab-scale equipment (AP-L05 Lab Unit Mech-Chem Associates, Inc.) was used to carry out the experiments. Tests were carried out with AFX membranes (AMSTOM) in a stack of 8 membranes (7.62x15.24 cm) in a plate and frame configuration. The effect of flow rate was studied in the acid recovery.

An acidic stream with concentrations up to 220 g/L H_2SO_4, 3.4 g/L As and 0.5 g/L Zn was treated. All the elements (e.g. Cu, Fe, Cd,…) with concentrations below 0.1 g/L were not added to the solution. Two kinds of waters were treated, depending on the oxidation state of the As in solution. One contained 50% of As(V) and 50% of As(III), while the other one had 100% As(III). Depending on the oxidation state (see Figure 1), As could be found as a neutral specie (H_3AsO_4 or H_3AsO_3) or even as a cationic specie ($H_2AsO_2^+$).

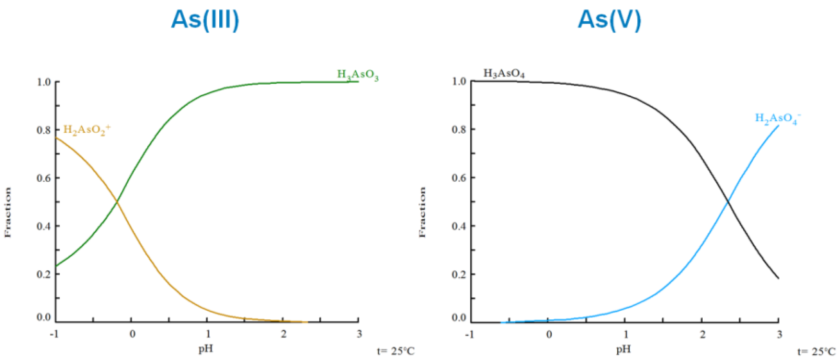

Figure 1. Speciation diagrams for As(III) and As(V), respectively.

Results and Discussion

Working with the solution containing a mixture of As(V) and As(III), sulphuric acid recovery was around 80% at the lowest flow rates evaluated (0.4 L/m^2h) and it decreased to 63% when flow rates increased up to 1.5 L/m^2h. As rejection increased from 50% to 69% when flow rate was increased, while Zn rejection was higher than 90%. When the solution containing only As(III), sulphuric acid recovery and Zn rejection barely varied. Nevertheless, the As rejection decreased due to the presence of $H_2AsO_2^+$ in solution, thus its transport across the membrane was impeded.

Conclusions

It was possible to recover sulphuric acid from hydrometallurgical streams. The fact that non-metal ions (i.e. As) are presented in solution as a neutral species (H_3AsO_4 and/or H_3AsO_3) resulted in the transport of these species across the membrane. Nevertheless, its leakage could be reduced working with As(III), which implies that $H_2AsO_2^+$ is presented in solution, and then rejected by the membrane.

References

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