ACID RECOVERY FROM GOLD MINING WASTEWATER BY SOLVENT EXTRACTION: A SINGLE STEP IN A JOURNEY OF THOUSAND MILES

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EXPANDED ABSTRACT

The pressure oxidation, or pressure hydrometallurgy, of refractory gold ores, is a hydrometallurgical process responsible to promotes the dissolution of gold from its ore at high temperatures and pressures. These conditions contribute to higher oxidation rates of sulfides (*e.g.*: pyrite - FeS_2) that would lower the gold recovery at the subsequential cyanidation leaching step. In an acid autoclave (pH <2) operating at temperatures greater than 175 ºC, different reactions may occur and are responsible to produce free-acid levels leaving the autoclave normally in the range of 10 to 25 g/L H_2SO_4.

If recovered, sulfuric acid might represent savings for the beneficiation plant, or additional incomes by its commercialization. Before the autoclave circuit, sulfuric acid is added to the slurry to lower the levels of carbonate below 2 %; otherwise, an excessive amount of CO_2 would be produced along with pressure oxidation. Sulfuric acid is also an important commodity for the chemical and pharmaceutical industries, which market is expected to grow in the next years according to the forecasts made by Mordor Intelligence. From the above-written, we decided to investigate the performance of liquid-liquid extraction (LLE) for sulfuric acid recovery from gold mining wastewater (acid:0.079 mol/L, iron: 1,541 mg/L, aluminum: 950 mg/L, and magnesium: 5,324 mg/L). Versatic acid diluted in kerosene (30 vol.%) was used as the organic phase. The extraction occurred at 60ºC, with an organic to aqueous ratio of 2:1 for 10 min. After settling, the sulfuric acid was striped with hot distilled water (60ºC). Besides extraction and stripping efficiency, the separation factor ($\beta_{H2SO4/Mi}$) was used to estimate the LLE selectivity (Equations 1-2). The variables M_{org} (mg/L) and M_{aq} (mg/L) refers to a given compound concentration in the organic and aqueous phase and were used to estimate its respective distribution coefficient (D_M). The raffinate from extraction and the extract from stripping were quantified for their acid content and the presence of impurities, which results were presented in Figure 1.

$$D_M = [M_{org}]/[M_{aq}] \quad (1)$$

$$\beta_{M_1/M_2} = [D_{M1}]/[D_{M2}] \quad (2)$$

Considering that co-extraction (competitiveness) may occur, the extraction efficiency of sulfuric acid could be view as satisfactory; however, the acid will start to build up in the organic phase if stripping efficiency is not improved, inactivating it from further reuses. From all impurities considered, co-extraction of magnesium could compromise the purity of sulfuric acid recovery since among all impurities manganese had the lowest selectivity value.

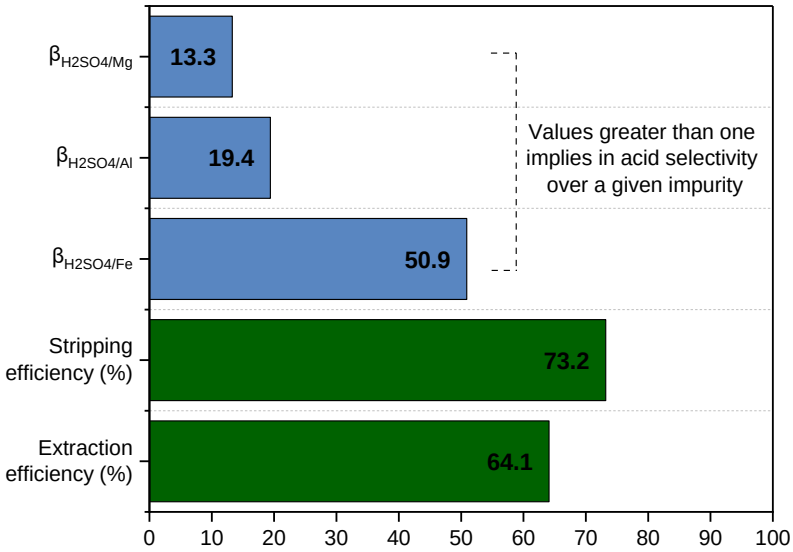

Figure 1 – Extraction efficiency, stripping efficiency, and extraction selectivity of sulfuric acid over iron, aluminum, and manganese.

Co-extraction might be solved by scrubbing stages; however, a frequent organic phase replacement certainly impacts the overall operating costs. Currently, we are under a scenario that extraction is possible, but strategies should be sought to improve the sulfuric acid recovery in a selective manner. Different organic phases could be the first alternative. From current literature, tertiary amines as Alamine 336, and phosphine oxide, as Cyanex 923, were pointed out as potential extractants for sulfuric acid recovery, with stripping rates greater than 99% (KESIEME *et al.* 2018). Different alternatives for the stripping agent could be investigated as well. The same authors reported that conditions of higher temperature contributed to greater acid stripping efficiency when Cyanex 923 was used, whereas the stripping from Alamine 336 was favored at a lower temperature. The operation must be economically viable as well, otherwise, the hypothesis of savings and additional incomes related to sulfuric acid commercialization would not be valid. Currently, sulfuric acid is marketed at 0.87 – 1.14 US$/kg, values that could be used as the start point to decide the economical viability of sulfuric acid recovery. These research gaps and the favorable extraction results, motivate future investigations towards the long journey related to acid recovery from mining wastewater.

KEYWORDS: Versatic 10; Mining from wastewater; Liquid-Liquid extraction.

REFERENCES

KESIEME, Uchenna et al. A review of acid recovery from acidic mining waste solutions using solvent extraction. *J. of Chemical Technology & Biotechnology*, v. 93, n. 12, p. 3374-3385, 2018.