Extractable but not recoverable: sulfuric acid extraction from gold mining wastewater by dispersive solvent extraction using Alamine 336

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EXTENDED ABSTRACT

After gold mining, a pressure oxidation process (POX) is applied; this step ensures a higher gold recovery in subsequent cyanidation processes. This beneficiation stage occurs at high temperatures and pressures, and generates an effluent with soluble metals, sulfates, and major concentrations of sulfuric acid. Its disposal, without proper treatment, can cause serious impacts on the ecosystem of the region and on human health. Moreover, its recovery can be an economic benefit to the operation, since the acid can be reused in mining, for example, as a leaching reagent, reducing commodity acquisition costs (FOUREAUX *et al*., 2021). Thus, the present study evaluates the recovery of sulfuric acid through liquid-liquid extraction, starting with its extraction with organic solvent, and subsequently, its stripping with distilled water and diluted acid.

The liquid-liquid extraction technique was applied to the concentrate generated after direct contact membrane distillation (DCMD) treating the effluent generated in the POX. The organic phases used were: Alamine 336, Aliquat 336, Cyanex 923, TEHA and Versatic. The liquid-liquid extraction is carried out in three steps: extraction, stripping, and recovery of the extractant.

Among the extractants used, Alamine 336 had the highest level of efficiency, which was approximately 71.8%. This extractant is considered a tertiary amine and its extraction mechanism is called ionic association. In this case, the anionic species are extracted in the form of ion pairs, through exchange with the non-metallic anions of the extractant. Therefore, the mechanism in which there is the formation of ion association complexes, promoting the formation of neutral species, is efficient for sulfuric acid extraction (SALUM and KONZEN., 2009). The efficiency rate was done as follows:

$$Efficiency\% = \frac{C_{acid\ DCMD} - C_{acid}}{C_{acid\ DCMD}}\ x\ 100 \quad (1)$$

The overall recovery rate of acid from the effluent was 38.8%, evidencing that the acid re-extraction phase with distilled water at 60 °C was not effective. The recovery rate was done according to the following equation:

$$Global\ Recovery\ from\ effl.\% \ = \frac{C_{acid\ post-stripping\ 1} + C_{acid\ post-stripping\ 2}}{C_{acid\ DCMD}}\ x\ 100 \quad (2)$$

In general, the low recovery rate of sulfuric acid can be explained by the strong interaction between the acid and the extractant, in addition to the fact that the steric hindrance caused by the long carbon chains of the tertiary amine complicates the interaction of water with sulfuric acid. The graphs expressing the cited values are shown in Figure 1:

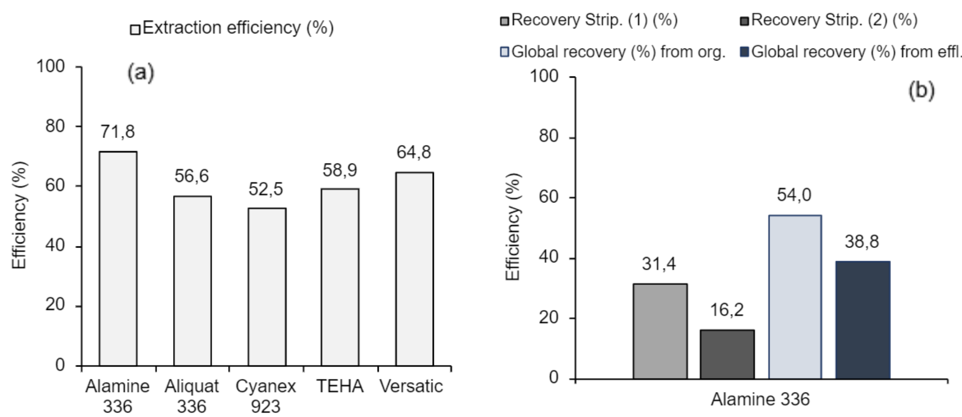

Figure 1 - (a) Extraction efficiency of the extractants tested (b) Percent recovery of Alamine 336

In published studies on acid recovery using the same extractant, it has been noted that water or diluted acid are not efficient re-extraction agents. According to Sarangi (2006) the use of a diluted base (NaOH, 1 mol/L) for stripping is more effective, although it makes the acid recovery impossible. Consequently, it is necessary to evaluate the application of stripping with water and diluted acid for the acid recovery, and subsequently, the application of diluted base solution for the organic phase recovery, analyzing the cost-benefit on an industrial scale.

KEYWORDS: Sulfuric acid, Alamine 336, Extraction, Gold Mining.

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