RECOVERY OF COBALT WITH ACIDIC AND AMINE-BASED EXTRACTANTS FROM HYDROMETALLURGICAL PLANT SIDE STREAM

By

Mohammadreza Arefzadeh, Sami Virolainen

LUT University, Finland

Presenter and Corresponding Author

Mohammadreza Arefzadeh

ABSTRACT

During metal extraction processes, a significant amount of acidic waste solutions containing valuable metals and organic acids can be generated as side-streams. It is efficient and beneficial for the environment, resource utilization, and economics to recover metals with high purity and organic/inorganic acids from these side-streams in metallurgical plants. Several methods can be used to recover metals from side-streams, such as chemical precipitation, solvent extraction, ion exchange, electrowinning, and thermal treatment. The most suitable method for recovering a specific metal from a side stream depends on several factors, including the type of side stream, the concentration of the targeted metal, and the desired level of purity. In some cases, a combination of methods may be needed to achieve efficient metal recovery.

This study explores three different approaches for recovering cobalt from a synthetic acidic solution containing 37 and 10 g/l of hydrochloric and oxalic acids, respectively. The first option for cobalt recovery from the feed solution involves chemical precipitation. This process does not require any pre-treatment or purification of the feed solution and involves adjusting the pH with NaOH. The resulting cobalt precipitate is separated from the solution through filtration and/or centrifugation which can be further processed to obtain high-purity metals. Chemical precipitation is a highly effective and easily operable method for recovering metals with high concentration from solutions that have low levels of impurities.

The second option for recovering cobalt involves solvent extraction of cobalt in its anionic form from a solution that has a high concentration of chloride. This is done using amine-based extraction systems such as Aliquat 336 (quaternary amine), trioctylamine, and Alamine 304-1 (tertiary amine). In this method, an anion exchange occurs between the amine extractants and the $CoCl_4^{2-}$ species, which is achieved by adding an HCl+NaCl solution to the feed to increase the chloride concentration. Based on the preliminary results obtained, it appears that this is a promising method for the recovery of cobalt.

The third option for recovering cobalt involves extracting it in its cationic form using commercially available acidic extractants such as D2EHPA and Cyanex272. However, prior to this extraction process, oxalate removal is required as a pre-treatment step. This is because increasing the pH of the acidic feed solution, as is necessary for the cation exchange mechanism, would cause cobalt precipitation in the presence of oxalate in the solution (which is the first approach).

In the batch equilibrium experiments the effect of some operational factors like, initial concentration of chloride in the aqueous phase, Acidity of feed solution (pH), concentration of extractant, the influence of time and temperature on the equilibrium have been studied. The stoichiometric coefficient of extracted cobalt species from aqueous solution has been determined based on the correlation between logarithmic distribution coefficient and concentration of extractant. Extraction isotherm experiments have been conducted, and McCabe-Thiele diagrams are constructed for initial process design (number of counter-current stages, phase ratio) to obtain highest possible yield and purity for cobalt. The results of solvent extraction experiments show that the recovery and separation of cobalt from the hydrochloric-oxalic acid solution using acidic and amine-based extractants as cation and anion exchangers is possible. Additionally, it is possible to recover cobalt with high purity through precipitation without pre-treating the feed solution. However, in this method, co-precipitation of oxalate is a significant issue that can result in the oxalate waste.

Keywords: Plant side-stream, Hydrometallurgy, Solvent extraction, Cobalt, Amine extractants, Acidic extractants, Precipitation