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Feasibility study on the use of imidazolium-based ionic liquids in the extraction of gold

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Abstract

The extraction of gold from low-grade sulfidic gold ores has been the focus of a great deal of research in recent years. In this study, the feasibility of the oxidative leaching of gold from a refractory sulfidic low-grade gold tailing (pyrite concentrate) with ionic liquids in the presence of thiourea (leaching agent) and ferric ion (oxidant) was investigated. Ionic liquids have many fascinating physicochemical properties, e.g. unmeasurable vapour pressure, low melting point and high thermal stability which allow them remain liquid over a wide temperature range. These features make them promising green solvents for dissolving different types of ores, including extracting gold in a manner that may not pose any threat to the environment.

The influence of operating parameters such as concentration of ionic liquid, pulp density, time and temperature on the extraction of gold was investigated with two imidazolium based ionic liquids, 1-butyl-3-methylimidazolium hydrogen sulphate [$Bmim^+HSO_4^-$] and 1-butyl-3-methylimidazolium trifluoromethansulfonate [$Bmim^+CF_3SO_3^-$]. The influence of these operating parameters were assessed and screened using a half fractional factorial design (2^{5-1}) approach. Results indicated that the concentration of the ionic liquid, pulp density and temperature were significant factors in the extraction of gold from refractory sulfidic low-grade gold tailing.

Additional experiments were carried out focusing on the most influential experimental factors. Central composite design (CCD) in conjunction with response surface methodology (RSM) was used to create an optimization design within selected ranges of the statistically significant factors (5%-25% IL [$Bmim^+HSO_4^-$], solid to liquid ratio of 1:10-1:2 and temperature 25-70 °C) in an attempt to find the optimal gold extraction conditions within this range. It was found that the optimum point for the concentration of ionic liquid [$Bmim^+HSO_4^-$] in the aqueous solution was 15% (v/v); pulp density was 15% (w/v) whereas the temperature was 55 °C. An amount of 35.4% gold extraction was achieved under these optimum conditions.

Furthermore, the effect of temperature on the gold extraction from the ore in a range of 20-65 °C in 20% (v/v) [$Bmim^+HSO_4^-$]-water solution, at pH = 1 and shaking speed of 250 rpm was examined for 12 h leaching time intervals. The experimental results generally revealed that the extraction of gold improved by increasing the temperature. The apparent activation energy was calculated based on the Arrhenius theory and it suggests that the kinetic process of ionic liquid gold leaching was limited by diffusion with an activation energy (E_a) of 28.4 kJ/mol. In addition, solid analysis on the ore before and after leaching was performed with SEM, XRD and Raman.