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Biotechnological Recovery of Zinc from Low-Grade Sulfide Concentrate during Two-Step Processing

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Extended Abstract

Biohydrometallurgical processes are based on leaching of nonferrous metals from sulfidic ores and concentrates in ferric iron containing sulfuric acid media with application of acidophilic chemolithotrophic microorganisms. Bioleaching of sulfide sources is used for decades around the world for recovery of metals [1]. Biohydrometallurgy has many advantages over conventional chemical hydrometallurgy and pyrometallurgy that include (i) lower cost, (ii) low environmental impact, (iii) generation of less hazardous waste, and (iv) no need for toxic chemicals and high energy. The environmental benefits of biohydrometallurgical processing of copper-zinc concentrates based on the use of acidophilic microorganisms were previously shown [2, 3]. Zinc concentrates produced from polymetallic sulfide ores of the Urals region (Russia) by flotation methods contain large amounts of iron and copper. Their further processing at metallurgical enterprises is therefore accompanied by significant losses of nonferrous metals in slags. Metal leaching from sulfides at elevated temperatures, using ferric sulfate solutions generated during biooxidation with acidophilic microorganisms (two-step process), can be promising for processing of the low-grade zinc concentrates. A flotation sulfide concentrate used in this study contained 43.3% of zinc, 2.03% of copper, and 13.6% of iron. The main minerals of the concentrate were sphalerite, pyrrhotite, and chalcopyrite. Ferric leaching during 14.3 hours at 80 °C, pH of 1.3, initial Fe^{3+} concentration of 25 g/L, pulp density of 10% allowed to recover 92.3% of zinc and 51.6% of copper into the aqueous phase. Biooxidation of the ferric leaching products (leach solution and leach residue) during 21 days under batch conditions at 40 °C, pH of 0.6–2.0, pulp density of 10% by consortium of acidophilic microorganisms containing *Acidithibacillus caldus*, *Leptospirillum ferriphilum*, *Ferroplasma acidiphilum*, *Sulfobacillus thermotolerans*, *S. thermosulfidooxidans*, and *Cuniculiplasma* sp. led to an increase in zinc and copper recoveries up to 98.6 and 69.0%, respectively. The biooxidation residue was mainly composed of jarosite and gypsum and contained 0.52% of zinc, 0.55% of copper, and 0.40% of elemental sulfur. Therefore, this residue can be considered inert dump waste. The final oxidation levels (compared to the original concentrate) of pyrrhotite and sphalerite reached the highest values among sulfide minerals since these minerals have low rest potentials in comparison with chalcopyrite. Chalcopyrite is normally highly refractory to biooxidation in acidic media containing ferric iron. The ferrous iron in the leach solution can also be oxidized within 4 days by the same consortium of microorganisms at the pulp density of 1%. It allows to bioregenerate the oxidizer more rapidly for the ferric leaching step. Therefore, the two-step processing of low-grade zinc sulfide concentrate based on biohydrometallurgical approach was found to be effective for recovery of metals.

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