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Bioprocess for Leaching of Copper from Mixed Sulfide and Oxide Minerals

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Extended Abstract

Processing of copper ores can be done by pyrometallurgical or hydrometallurgical methods. Biohydrometallurgical processes are based on leaching of nonferrous metals from ores and concentrates in ferric containing sulfuric acid media with application of acidophilic chemolithotrophic microorganisms. Acidophilic microorganisms that are able to oxidize sulfidic minerals are phylogenetically heterogeneous and include representatives of several bacterial and archaeal phyla, such as mesophilic (*Acidithiobacillus ferrooxidans, Leptospirillum ferrooxidans*), thermotolerant (*Leptospirillum ferriphilum*, *Ferroplasma acidiphilum*), moderately thermophilic (*At. caldus*, *Sulfobacillus* spp.), and thermophilic species (*Acidianus brierleyi*, *Metallosphaera sedula*) (Kondrat'eva et al., 2012). However, commercial application of biohydrometallurgical processes is constrained by insufficient speed, and therefore long duration (Watling, 2006). It is known that the temperature has the most effect on kinetic of heterophase reactions. In this study a bioprocess of oxide-sulfide copper flotation concentrates from the Udokan copper deposit (East Siberia, Russia) has been proposed. It includes: i) leaching with sulfuric acid solution, ii) high temperature ferric leaching with microbially produced Fe^{3+}-containing solution, and iii) bioregeneration of ferric iron along with additional biooxidation of the sulfide minerals using moderately thermophilic acidophilic microorganisms. The flotation copper concentrates contained 27–37.4% copper as sulfide (digenite, bornite, etc.) and oxide (malachite, azurite, tenorite, etc.) minerals. The acid leaching under batch conditions at 50°C and pH 1.2 during 22 hours led to 40.6% of copper recovery from the concentrate. The final concentration of copper in the pregnant leach solution was 30.4 g/L. Subsequent ferric leaching of the acid leach residue at 80°C, pulp density 9%, initial concentration of Fe^{3+} 30.7 g/L, and pH 1.2–1.3 during 7 hours increased the total copper recovery to 94.5%. At the end of the first cycle of ferric leaching within 2 hours copper concentration was 15.4 g/L, while the average rate of accumulation of copper in the solution for the cycle was 7.7 g/L·h, at the end of the second cycle within 5 hours these values were 12.0 g/L and 1.4 g/L·h, respectively. Bioregeneration of the Fe^{3+} was conducted using moderately thermophilic microorganisms including bacteria of the genus *Sulfobacillus* and archaea *F. acidiphilum* at 40°C in the presence of 3% leach residue. The average ferrous iron oxidation rate and total copper recovery within 2 days were 1.0 g/L·h and 97%, respectively. Leaching of copper under continuous conditions with bioregeneration of Fe^{3+} at 50°C using bacteria of the genus *Sulfobacillus* to minimize temperature difference between chemical and biological steps was studied. It was found that copper recovery achieved 90% within 22 hours and the average oxidation rate of ferrous iron was up to 0.95 g/L·h.

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References

Kondrat'eva T.F., Pivovarova T.A., Tsaplina I.A., Fomchenko N.V., Zhuravleva A.E., Murav'ev M.I., Melamud V.S., Bulayev A.G. (2012). Diversity of the communities of acidophilic chemolithotrophic microorganisms in natural and technogenic ecosystems. Microbiol., 81, 3–27

Watling H.R. (2006). The bioleaching of sulphide minerals with emphasis on copper sulphides – A review. Hydrometallurgy, 84, 81–108.