Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29470

Microencapsulation of Sulfide Mining Waste: A Strategy for Pollution Prevention and Acid Mine Drainage Mitigation

MAIRA CASTELLANOS VÁSQUEZ[1], CARLOS R. CÁNOVAS[2], FRANCISCO MACÍAS[2] AND JOSE MIGUEL NIETO[2]

[1]Department of Earth Sciences & Research Center on Natural Resources, Health and the Environment, University of Huelva, Campus 'El Carmen', 21071, Huelva, Spain
[2]Department of Earth Sciences & Research Center on Natural Resources, Health and the Environment. University of Huelva, Campus 'El Carmen', 21071, Huelva, Spain

Acid mine drainage (AMD) is a critical environmental issue in metal mining, especially in sulfide-rich regions like the Iberian Pyrite Belt (SW Spain). Its generation is primarily induced by the oxidation of sulfide minerals, specifically pyrite (FeS_2), during mining activities and operations. While sulfides remain stable under anoxic conditions, their exposure to oxygen and water triggers oxidation, leading to AMD generation[1].

Traditional AMD management focuses on treating contaminated water, but preventive measures are preferred to minimize its formation at the source. The most commonly used preventive measures to reduce the generation of acid leachates (dry covers, wet covers, surface water diversion, etc.) need to be complemented with more effective and sustainable remediation strategies to mitigate the impacts associated with the accumulation of these mining residues, especially in abandoned mine sites.

Microencapsulation is a promising preventive technique that involves coating reactive minerals with a chemically inert layer to reduce oxidation and acid generation. Different reagents have been studied to achieve this effect, including potassium permanganate, phosphates, phosphate-thiocyanate combinations, aluminum hydroxide, and silica-rich solutions.

This research evaluates the effectiveness of microencapsulation of pyrite-rich mining waste as a preventive measure in abandoned mine sites. Laboratory scale experiments were carried out with pyrite samples from the Tharsis mining complex (SW Spain) considering local precipitation patterns and the real dimensions of the Tharsis waste dump. Encapsulating solutions of sodium silicate (Na_2SiO_3), potassium dihydrogen phosphate (KH_2PO_4), aluminum chloride hexahydrate ($AlCl_3$-$6H_2O$) and calcium carbonate ($CaCO_3$) were added, with the latter used as an alkaline agent.

The results show that the aluminum-based solution was the most effective in the encapsulation process, reducing pyrite oxidation by 70% in the short term and up to 20% in the long term, and, as a result, releasing lower concentrations of toxic metals. A detailed analysis of the factors limiting its efficiency in the long term is therefore essential and requires further investigation.

ACKNOWLEDGEMENTS

This research was supported through the projects DYNAMICO (PID2023-151504OB-I00) and CuSlag (PCI2024-153497) funded by the Spanish Ministry of Science, Innovation and Universities and the Spanish Research Agency.

REFERENCES

[1] Moreno-González, Macías, Olías & Cánovas (2022). Environmental Pollution,295,118697.