S9-2

Bio-metallurgical process for extraction and recovery of lead from low-grade mineral tailings of zinc refining

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Lead (Pb) is an important by-product during zinc extraction and refining from *franklinite* ($ZnFe_2O_4$) and *jarosite* ($KFe_3(SO_4)_2(OH)_6$) minerals. It is persistent during hydrometallurgical extraction using concentrated sulfuric acid and resides in a *gypsum* ($CaSO_4 \cdot 2\ H_2O$) tailing which has unfavourable properties for pyro-metallurgical treatment. Currently, the contaminated residue is stored on land, despite its relatively high metal content. Valorisation of the residual metal content and bulk gypsum matrix in *e.g.* construction material, is envisioned during the proposed bio-metallurgical extraction and recovery process. Heterotrophic bioleaching is done through the production of organic lixiviants by microorganisms, *Aspergillus niger* in this case, in the presence of and external energy and carbon source. Due to their low-carbon impact and operation at ambient temperature, bio-metallurgical extraction techniques have distinct advantages over traditional refining processes. Complete Pb extraction from the mineral tailings is achieved upon optimal bioleaching conditions. A design of experiments in which the concentration of citrate as lixiviant, the solution's pH and incubation time were varied, resulted in a Pb concentration of 15 g/L in the pregnant leachate. Full depletion of the substrate was confirmed by SEM-EDX measurements. Finally, an electrochemical system of two-compartments that operated potentiostatically at 3.00 V, was used to induce lead precipitation in the metal-bearing anolyte, whilst ensuring alkaline conditions for consecutive bioleaching at the cathode compartment. Characterization of the recovered lead precipitate by ICP-OES analysis, PXRD and Raman spectroscopy indicated for an amorphous, white residue containing 25 m% Pb.

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