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Bioleaching of Metals Contained in Spent Catalysts by Acidithiobacillus thiooxidans DSM 26636

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Abstract : Spent catalysts are considered as hazardous residues of major concern, mainly due to the simultaneous presence of several metals in elevated concentrations. Although hydrometallurgical, pyrometallurgical and chelating agent methods are available to remove and recover some metals contained in spent catalysts; these procedures generate potentially hazardous wastes and the emission of harmful gases. Thus, biotechnological treatments are currently gaining importance to avoid the negative impacts of chemical technologies. To this end, diverse microorganisms have been used to assess the removal of metals from spent catalysts, comprising bacteria, archaea and fungi, whose resistance and metal uptake capabilities differ depending on the microorganism tested. Acidophilic sulfur oxidizing bacteria have been used to investigate the biotreatment and extraction of valuable metals from spent catalysts, namely Acidithiobacillus thiooxidans and Acidithiobacillus ferroxidans, as they present the ability to produce leaching agents such as sulfuric acid and sulfur oxidation intermediates. In the present work, the ability of A. thiooxidans DSM 26636 for the bioleaching of metals contained in five different spent catalysts was assessed by growing the culture in modified Starkey mineral medium (with elemental sulfur at 1%, w/v), and 1% (w/v) pulp density of each residue for up to 21 days at 30 °C and 150 rpm. Sulfur-oxidizing activity was periodically evaluated by determining sulfate concentration in the supernatants according to the NMX-k-436-1977 method. The production of sulfuric acid was assessed in the supernatants as well, by a titration procedure using NaOH 0.5 M with bromothymol blue as acid-base indicator, and by measuring pH using a digital potentiometer. On the other hand, Inductively Coupled Plasma - Optical Emission Spectrometry was used to analyze metal removal from the five different spent catalysts by A. thiooxidans DSM 26636. Results obtained show that, as could be expected, sulfuric acid production is directly related to the diminish of pH, and also to highest metal removal efficiencies. It was observed that Al and Fe are recurrently removed from refinery spent catalysts regardless of their origin and previous usage, although these removals may vary from 9.5 ± 2.2 to 439 ± 3.9 mg/kg for Al, and from 7.13 ± 0.31 to 368.4 ± 47.8 mg/kg for Fe, depending on the spent catalyst proven. Besides, bioleaching of metals like Mg, Ni, and Si was also obtained from automotive spent catalysts, which removals were of up to 66 ± 2.2, 6.2±0.07, and 100±2.4, respectively. Hence, the data presented here exhibit the potential of A. thiooxidans DSM 26636 for the simultaneous bioleaching of metals contained in spent catalysts from diverse provenance.

Keywords : bioleaching, metal removal, spent catalysts, Acidithiobacillus thiooxidans
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