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Bioleaching of Precious Metals from an Oil-fired Ash Using Organic Acids Produced by Aspergillus niger in Shake Flasks and a Bioreactor

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Abstract : Heavy fuel oil firing power plants produce huge amounts of ashes as solid wastes, which seriously need to be managed and processed. Recycling precious metals of V and Ni from these oil-fired ashes which are considered as secondary sources of metals recovery, not only has a great economic importance for use in industry, but also it is noteworthy from the environmental point of view. Vanadium is an important metal that is mainly used in the steel industry because of its physical properties of hardness, tensile strength, and fatigue resistance. It is also utilized in oxidation catalysts, titanium–aluminum alloys and vanadium redox batteries. In the present study bioleaching of vanadium and nickel from an oil-fired ash sample was conducted using Aspergillus niger fungus. The experiments were carried out using spent-medium bioleaching method in both Erlenmeyer flasks and also bubble column bioreactor, in order to compare them together. In spent-medium bioleaching the solid waste is not in direct contact with the fungus and consequently the fungal growth is not retarded and maximum organic acids are produced. In this method the metals are leached through biogenic produced organic acids present in the medium. In shake flask experiments the fungus was cultured for 15 days, where the maximum production of organic acids was observed, while in bubble column bioreactor experiments a 7 days fermentation period was applied. The amount of produced organic acids were measured using high performance liquid chromatography (HPLC) and the results showed that depending on the fermentation period and the scale of experiments, the fungus has different major lixiviants. In flask tests, citric acid was the main produced organic acid by the fungus and the other organic acids including gluconic, oxalic, and malic were excreted in much lower concentrations, while in the bioreactor oxalic acid was the main lixiviant and it was produced considerably. In Erlenmeyer flasks during 15 days fermentation of Aspergillus niger, 8080 ppm citric acid and 1170 ppm oxalic acid was produced, while in bubble column bioreactor over 7 days of fungal growth, 17185 ppm oxalic acid and 1040 ppm citric acid was secreted. The leaching tests using the spent-media obtained from both of fermentation experiments, were performed at the same conditions of leaching duration of 7 days, leaching temperature of 60 °C and pulp density up to 3% (w/v). The results revealed that in Erlenmeyer flask experiments 97% of V and 50% of Ni were extracted while using spent medium produced in bubble column bioreactor, V and Ni recoveries were achieved to 100% and 33%, respectively. These recovery yields indicate that in both scales almost total vanadium can be recovered, while nickel recovery was lower. With help of the bioreactor spent-medium nickel recovery yield was lower than that of obtained from the flask experiments, which it could be due to precipitation of some values of Ni in presence of high levels of oxalic acid existing in its spent medium.

Keywords : Aspergillus niger, bubble column bioreactor, oil-fired ash, spent-medium bioleaching
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