MODELING AND OPTIMIZATION OF BIOLEACHING PROCESS TO RECOVER HEAVY METALS FROM SPENT CATALYST

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Abstract:

In petroleum refinery solid catalyst are extensively used. Catalyst after usage contain high concentration of base valuable metals such as nickel (Ni), Molybdenum (Mo), Cadmium (Cd), Copper (Cu); they represent a large amount of refinery solid waste and are classified as hazardous waste by the environmental Protection agency in the USA (F. Beolchini et al 2010). Waste containing sulfide or metal form need oxidant (H_2O_2, O_3, chromates) which may be chemically or biologically degraded. Since spent catalyst contains sulfides, they are easily oxidized by atmospheric oxygen and create environmental problems which are hazardous waste in nature. (Ferella, Francesco, et al., 2011).The objective is to develop an economically feasible, technically viable and environmental friendly bioleaching process for metal recovery from the spent catalyst and to demonstrate the use of a mixed culture of three strains of Fe/S oxidizing bacteria *A. ferrooxidans, Aspergillus niger* in leaching metals from spent catalyst. The long term objective of this research is to find out a suitable bioleaching process for the metal recovery from spent catalyst. The primary aim of the project is to develop a bioleaching process which will be technically viable, economically feasible, environmental friendly and can be used an alternative to chemical leaching. Although bioleaching technology offers many advantages over other conventional methods due to its relative simplicity, mild operating condition requirements, low energy input, reduced skilled labour requirements, and environmental friendliness, it requires a longer period of operation compared to other methods, such as chemical leaching. This work has shown that heavy metals from spent industrial catalyst may be mobilized by different methods of bioleaching with *Acidithiobacillus ferrooxidans* and *Aspergillus niger* and the effect of pH, temperature, percentage of on Cd/Cu/Mo/Ni recovery from a spent refinery catalyst was investigated using RSM. Bioleaching studies were carried out by varying three parameters such as pH, temperature and contact time. In all cases the kinetics can be divided into two parts, i.e., initial faster rate followed by slower rate. The initial faster rate accounted for more than 70% of total leaching efficiency and lasted around to 10 days. The slower kinetics then continued upto 15 days and beyond that leaching was negligible. Therefore in all cases leaching time was limited to 10 days. The maximum leaching efficiency of different metals was observed at contact time of five days at pH-3 and at the optimum temperature of 40°C. The dual rate of leaching may be due to either depletion of easily available reacting species or formation of product layer. These results suggest that optimizing the bioleaching method using *Acidithiobacillus ferrooxidans* and *Aspergillus niger* could facilitate the creation of an alternative to conventional waste treatment methods. Such a method could be used to obtain higher efficiencies and rates of metal recovery, while minimizing process costs by using cheaper substrate sources. Petroleum refinery industry uses catalysts in several processes and need to be safely discharged after exhausting its capacity. Bioleaching is one of the major emerging and environmental friendly option to recover the metals from spent catalysts. Fresh and spent catalyst was collected from petroleum industry which was characterized physically and chemically to examine the trace amounts of metals such as Al, Cd, Cu, Fe, Mo, Ni, Si , and V. Fe/S oxidizing bacteria such as *Acidithiobacillus ferrooxidans and Aspergillus niger* were collected from NCIM-Pune and sub-cultured for bioleaching process. Various leaching parameters

such as pH, temperature, and contact time were considered for the study and leaching process was optimized using Response Surface Methodology (RSM). Experiments were designed as per the central composite design (CCD) technique. Four mathematical models were derived for prediction of the responses. In process optimization, maximal values of Cd, Cu, Mo and Ni recoveries were achieved as 56%, 80% and 67% and 66 respectively, with a pH of 3.0, a temperature of 40 °C and at contact time of 5 days. The recovery of these metals decreases the environmental impact of the waste catalyst and the recycled product can be further used for industrial purposes.

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