**Bio Recovery of Platinum and Palladium From Spent Automotive Catalysts Using the Cyanogenic Bacterium *Chromobacterium Violaceum.***

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**Highlights**

* Development of two-step bioleaching process for Pt and Pd recovery from SAC.
* Pretreatment of catalysts significantly removed the non-target metals.
* Subsequent bioleaching with *C. violaceum* showed recovery of Pt (52%) and Pd (59%).

**1. Introduction**

Spent automotive catalysts (SAC) are rich in platinum group metals (PGMs: platinum, palladium, and rhodium) [1]. The recovery and recycling of PGMs from SAC is important due to the need for resource conservation and environmental protection [1-3]. Hydrometallurgical and pyrometallurgical processes which are conventionally used for metal recovery are unfortunately highly pollutive. In recent years, there has been increasing interest in the use of bio-hydrometallurgical processes for metal recovery since this approach constitutes a green process [4]. Studies have reported that mesophilic bacteria such as *Chromobacterium violaceum* produce cyanide as a secondary metabolite which may be used in metal extraction due to its ability to form water soluble complexes with many metals. One such study on the recovery of gold from electronic waste by *C violaceum* reported a 23% gold recovery from pretreated electronic waste [5]. In the present study, an environmentally-friendly, sustainable, and an effective process for platinum (Pt) and palladium (Pd) recovery from spent auto catalysts was developed. As a preliminary step, SAC was first pretreated to remove interfering metals at the early stage due to its negative effect on the bio metallurgical processing. Bioleaching was subsequently conducted with *C. violaceum* for enhanced Pt and Pd recovery.

**2. Methods**

Ultrasonic-assisted nitric acid (US-HNO3) pretreatment was performed in order to remove interfering (non-target metals Cu, Zn, Fe, and Ti) which otherwise compete with PGMs for the formation of metal-cyanide complexes. Central composite design was used to optimize the factors (US duration, US power, US frequency, HNO3 conc., and temperature) in the pretreatment process. Using a *C. violaceum*, platinum and palladium were subsequently recovered from the pre-treated SAC in a two-step bioleaching process (where the SAC was added to the bacterial culture after the maximum cyanide concentration has been attained). Various factors affecting the biorecovery (pH, glycine conc., pulp density, additional oxidant H2O2, and temperature) were also examined using central composite design. Multivariate optimization i.e. response surface methodology (RSM) was used to develop the models for optimization of the SAC pretreatment and bioleaching studies.

**3. Results and discussion**

The interactive effects of various factors were studied in an empirical response surface methodology (RSM) model for process optimization. For SAC pre-treatment study, results showed significant removal of Cu (75%) and Zn (84%) under optimal conditions (US duration 60-90 min, US power 90-108W, US frequency 37kHZ, HNO3 conc. 7-9M, and temperature 70oC). Subsequent bioleaching of the pre-treated SAC using *C. violaceum* resulted in a recovery of platinum (52%) and palladium (59%) from pre-treated SAC under optimal conditions (pH 9.5, pulp density 0.5 %w/v, glycine conc. 8-10 g/L, H2O2 conc., 0.08 %v/v, and temperature 30 oC) over five days [Figure 1].



**Figure 1.** Pt and Pd recovery in two-step bioleaching by *C. violaceum* from SAC (pretreated SAC samples, pH 9.5, glycine conc. 8g/L, H2O2 conc., 0.08 %v/v, and temperature 30 oC) at various pulp densities.

**4. Conclusions**

Overall, this study demonstrates (i) the effect of ultrasonic assisted pretreatment for maximal removal of interfering base metals from SAC and (ii) the potential of cyanogenic bacteria for the recovery of Pt and Pd from SAC under two-step bioleaching process.

**References**

[1] M. K. Jha, J.-c. Lee, M.-s. Kim, J. Jeong, B.-S. Kim, and V. Kumar, "Hydrometallurgical recovery/recycling of platinum by the leaching of spent catalysts: A review," *Hydrometallurgy,* vol. 133, pp. 23-32, 2013/02/01/ 2013.

[2] A. Fornalczyk and M. Saternus, "Catalytic converters as a source of platinum," *Metalurgija,* vol. 50, no. 4, pp. 261-264, 2011.

[3] G. M. Mudd, "Key trends in the resource sustainability of platinum group elements," *Ore Geology Reviews,* vol. 46, pp. 106-117, 2012.

[4] M. A. Faramarzi, M. Stagars, E. Pensini, W. Krebs, and H. Brandl, "Metal solubilization from metal-containing solid materials by cyanogenic Chromobacterium violaceum," (in eng), *J Biotechnol,* vol. 113, no. 1-3, pp. 321-6, Sep 30 2004.

[5] G. Natarajan and Y. P. Ting, "Pretreatment of e-waste and mutation of alkali-tolerant cyanogenic bacteria promote gold biorecovery," (in eng), *Bioresour Technol,* vol. 152, pp. 80-5, 2014.