Recovering Platinum group elements from spent car catalysts by combining bioleaching and electrodialysis

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Platinum-group elements (PGE) are precious metals, some of the scarcest elements in the Earth's crust. They are critical raw materials for catalysts, fuel cells, electronics, cancer therapies, and criminology applications. Mining PGE is expensive and has a massive environmental footprint (33.3 kg CO_2 eq per gram of platinum mined and refined). The dominance of South Africa and Russia in their supply, coupled with global conflicts disrupting trade, amplifies the need for alternative sources. Secondary resources of PGE, such as spent car catalysts, contain higher platinum concentrations than primary ores (0.2 to 0.3%, depending on the car's age and fuel burned), so there is a crucial need to recover those resources sustainably. It is estimated that processing 2 mg of spent car catalysts can prevent the mining of 150 kg of Pt ores (Fornalczyk & Saternus, 2009) with significant environmental benefits. However, current extraction methods—pyrometallurgy and hydrometallurgy—are energy-intensive, generate substantial waste, and struggle with mixed catalyst materials, limiting recycling capabilities.

In our study, we compare the effectiveness of combining bioleaching with electrodialysis (Gomes *et al*., 2020) with each technique by itself. We performed experiments in two-compartment electrodialytic cells using a cation exchange membrane (Membranes International CMI-7000S) as a separator. The experiments lasted 96 h, in triplicate, and were conducted at room temperature (20±0.5°C). In the electrodialytic setups, a low constant current of 5 mA was supplied by a DC power supply (SLS Flowgen PowerPro 3 AMP). In the bioleaching experiments, we used a pure culture of *Acidithiobacillus ferooxidans* (2 mL of inocula in 48 mL of 882 medium). The catholyte was a 0.01 M NaCl solution, and the electrodes were Ti-coated (Permascand type PSC101). Voltage, pH, and conductivity were measured daily, and samples were collected for metal analysis in ICP-MS (Thermo-Fisher Scientific iCAP-Q).

Results show an increase in platinum concentrations in the anolyte using bioleaching and electrodialysis 66.7±19.3% higher when compared with electrodialysis (Figure 1), and 92.8±0.9% when compared with bioleaching. A similar pattern was observed for palladium concentrations. When bioleaching and electrodialysis were combined, Pd concentrations were 39.9±12.5% higher than with only electrodialysis and 99.99± 0.01% compared to bioleaching. These findings demonstrate that the integration of different techniques can enhance PGE recovery from wastes. Further research is needed to optimise the process (liquid-to-solid ratio, mixing, duration of the experiments) and separate the metals of interest.

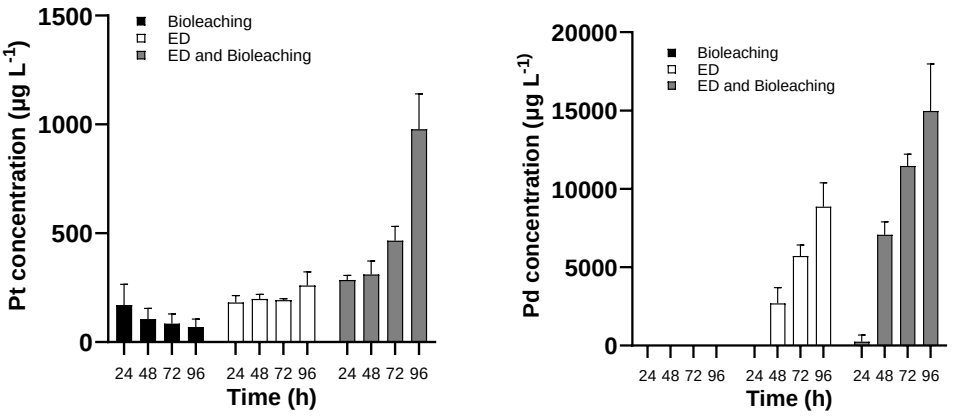

Figure 1. Concentrations of Pt and Pd in the anode compartment.

References

Fornalczyk, A.; Saternus, M. Removal of platinum group metals from the used auto catalytic converter. Metalurgija 2009, 48 (2), 133.

Gomes *et al.*, Enhanced electrodialytic bioleaching of fly ashes of municipal solid waste incineration for metal recovery. Electrochimica Acta 2020, 345.

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