

Hydrometallurgical recycling of Platinum Group Metals (PGM) from used catalytic converters

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Keywords: PGMs, recycling, hydrometallurgical treatment, sustainability, feasibility assessment

1. Introduction

Platinum (Pt), palladium (Pd) and rhodium (Rh) are widely used in automotive gas purification systems. As the consumption of these metals is constantly increasing and their natural resources are depleted, used automotive catalysts (UACs) with a PGMs content ranging from 1000 to 3000 g/t [1], are becoming their most important secondary source. The pyrometallurgical methods that currently dominate the industrial recovery of PGMs from UACs are associated with significant CO₂ and dust emissions and substantial technological limitations that make the application of hydrometallurgy in the recovery of PGMs advantageous. Among the various hydrometallurgical methods, leaching remains the simplest and most economic for the extraction of Pt, Pd and Rh from UACs, with the relevant systems based on halogens, cyanide and sulphur [1,2]. This research investigates the recovery of Pt, Pd and Rh from used automotive catalytic converters in a chloride leaching system with improvements in solutions recycling. Specifically, it studies the effect of critical process parameters, such as the content of oxidizing agent (H₂O₂), process temperature and time, acid solution (HCl) concentration and pulp density, on the efficiency of PGMs recovery. The recycling of the leaching solution is also considered.

2. Experimental / Methodology

The ceramic parts (cordierite monoliths) of two spent automotive catalytic converters provided by the company Johnson-Matthey PLC were used as raw materials in this work. These ceramic monoliths were crushed, ground and mixed to a homogeneous UAC sample used in the leaching experiments, with a particle size below 250 μm (D₅₀ = 18.2 μm). Cordierite was the only identified mineralogical phase (XRD method) in the UAC sample. The chemical analysis (XRF method) of the UAS shown the content of Pt = 308 g/kg, Pd = 3051 g/kg and Rh = 344 g/kg. It also contained SiO₂ = 28.69, Al₂O₃ = 39.59, MgO = 9.46 and ZrO₂ = 3.38 %wt., CeO₂ = 5.74 %wt. and La₂O₃ = 0.56 %wt. The leaching experiments were conducted in a 500 mL spherical glass reactor equipped with a thermal jacket, thermocouple and controller. In each test, 300 mL of leaching solution was added into the reactor and heated under stirring (500 rpm), until the solution temperature reached a pre-defined value. Then, the appropriate mass of the UAC sample was added to the reactor. The formed slurry was stirred for a pre-defined time and then, it was filtered, and the filtrate was analyzed for PGMs content by the XRF method.

3. Results and Discussion

As shown in Figure 1, the recovery of Pt was favoured in the chloride system, reaching 99% under optimum conditions. The Pd recovery was also high, reaching 87%, while the recovery of Rh was about half of that of the other two PGMs under all studied conditions, ranging from 38% to 58%. The recovery of Pt and Pd was slightly enhanced by the increase of temperature and HCl concentration, as shown in Figures 1(a) and 1(c), respectively, while the recovery of Rh was positively affected by all the studied parameters (Figure 1 (a) – (d)). Based on the experimental results of this work, lanthanum (La) cerium (Ce) and aluminium (Al) were co-extracted with Pt, Pd and Rh to about 70%, 40% and 50%, respectively, indicating dissociation of the alumina coating. In contrast, the leaching of silicon (Si) from the UAC sample was negligible (< 1.5%), indicating stability of the cordierite substrate.

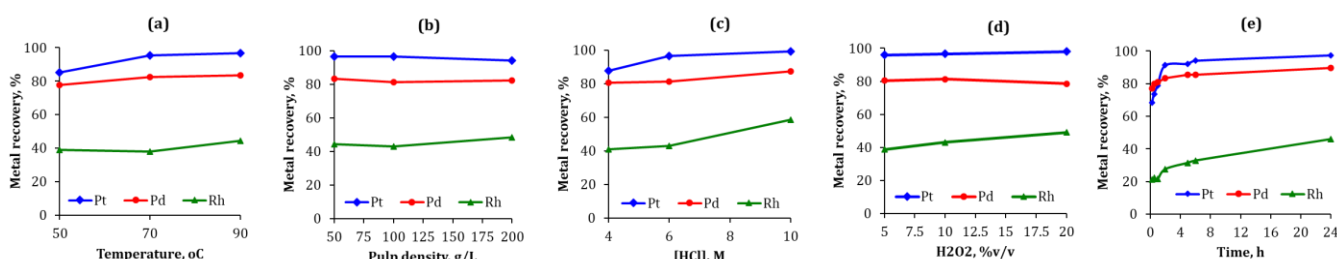


Figure 1. The recovery of Pt, Pd and Rh versus temperature (a); pulp density (b); concentration of HCl (c) and volumetric ratio of H₂O₂ (d) in leaching solution and time (e).

According to Figure 1(e), kinetics of the Pt and Pd leaching process was fast and the recovery of these metals was almost completed after 2 hours, reaching about 91% and 83%, respectively, with respective recovery rates of 45.5% and 41.5% per hour. In contrast, the Rh leaching had slower kinetics. Particularly, the recovery rate of Rh was about 14 % per hour in the first 2 hours and then decreased to a nearly constant rate of 1.4% per hour for the rest of the process. Following this rate, the recovery of Rh was around 46% after 24 hours.

4. Conclusions

Leaching of Pt and Pd is favoured in the HCl-H₂O₂ system, achieving 99% and 87% metal recovery, respectively. The leaching of Rh was inhibited by kinetic factors, resulted in 58% recovery after 24 hours, under optimum conditions. The dissociation of the alumina coating by the oxidizing agent and acidic solution, released the encapsulated PGMs, thus facilitating their leaching.

5. References

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Conference Proceedings

**9th International Conference
of the Hellenic Metallurgical Society**

3-4 November 2025

Thessaloniki, Greece

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