



Hydrometallurgical recovery of platinum-group metals from spent auto-catalysts – Focus on leaching and solvent extraction

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ABSTRACT

To ensure the supply of raw materials for products of extreme importance in strategic sectors, the recovery of critical metals from secondary sources becomes increasingly urgent. Platinum group metals (PGMs), being rare and very valuable, fall into this demand, and the catalytic converters that contain them are recognized as one of the main sources. Hydrometallurgical processes have been proposed as an alternative to pyrometallurgical ones, with leaching and separation by solvent extraction being core operations in this type of processing. This article investigates these two operations, seeking to optimize conditions and propose new arrangements to improve them. Two different catalyst samples were considered in the experimental work. Leaching was carried out involving concentrated HCl solutions (with H₂O₂ as oxidant) and low liquid/solid ratios, seeking to maximize PGMs recovery, guaranteeing their high concentration in leachates and minimizing aluminum co-dissolution. Cerium leaching was also followed since this is a rare-earth metal with potential interest. Temperature, HCl concentration, liquid/solid ratio (L/S), time and particle size factors were evaluated, and the optimized conditions found were 11.6 mol L⁻¹ HCl, 1%vol H₂O₂, 60 °C, L/S = 2 L kg⁻¹ and 3 h, leading to PGM yields of 90–98% Pt, 99% Pd and 70–96% Rh, and leachate compositions of 0.41–0.78 g L⁻¹ Pt, 1.6 g L⁻¹ Pd, 0.062–0.066 g L⁻¹ Rh, depending on the catalyst sample.

For solvent extraction (SX), several commercial extractants dissolved/diluted in toluene were checked, firstly with a model solution, and then applied to the real spent auto-catalyst (SAC) leachates produced *in-situ*. The overall results showed that the most promising SX systems among those tested were Cyanex® 471X and Cyphos® IL 101. Cyanex® 471X allowed the quantitative extraction of Pd(II) and Fe(III), but the latter was conveniently scrubbed by water prior to Pd(II) stripping by an acidic thiourea solution. Pt(IV) and Pd(II) extraction values by Cyphos® IL 101 were very encouraging, as only Fe(III) and Zn(II) were appreciably co-extracted, however, scrubbing of the contaminating metals, and Pd(II) and Pt(IV) stripping, did not work. Hence, investigation to find proper scrubbing/stripping agents for Cyphos® IL 101 SX system, to recover PGMs from recycled SACs, is further needed.

1. Introduction

The sustainability of the planet and the maintenance of our day-to-day life require that spent devices that can no longer be reutilized should not be discarded to landfill when containing value-added materials. In addition, the environmental preservation of our “collective home” is increasingly urgent, the climate changes being the most visible danger sign. Accordingly, recycling practices applied to wastes containing those materials, particularly the so-called “critical materials”,

should constantly be encouraged and globally implemented by the joint efforts of scientists, engineers, industrials, and investors [1].

Metals occupy the main part of the lists of “critical raw materials” that have been published every three years since 2011 by the specialized European Union committees [2], and platinum-group metals (PGMs) have always been included in those lists. PGMs encompass platinum, palladium, rhodium, iridium, ruthenium, and osmium, but the latter has no significant technological applications and, hence, it is not considered in the above-mentioned lists. The specific physical–chemical properties

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