



## Research Article

## Recovery of platinum from spent reforming catalysts by coupled leaching and solvent extraction using deep eutectic solvents



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## ARTICLE INFO

## Keywords:

Catalyst  
Deep eutectic solvent  
Leaching  
Platinum  
Solvent extraction

## ABSTRACT

Platinum recovery from spent reforming catalysts is both an economic imperative and an environmental necessity. In this study, we demonstrate a more sustainable alternative to conventional acid leaching by employing a choline chloride–ethylene glycol deep eutectic solvent (DES) system. Two Fractional Factorial Designs (FFD) were applied to screen and analyze the significant parameters for the leaching and solvent extraction (SX) processes. To identify the most influential parameters, statistical analyses were performed on the obtained results revealing that the choline chloride to ethylene glycol ratio plays a critical role by increasing the availability of chloride species for platinum complexation. Under optimized conditions, 10% w/w solids, a 1:1 choline chloride to ethylene glycol ratio, 25% w/w water, 90 °C, and 10% w/w nitric acid, over 92% platinum dissolution was achieved. To further refine the process, solvent extraction with trioctylamine (TOA) was employed, achieving 99.93% recovery of platinum under optimal conditions (10% v/v TOA in kerosene, a 1:1 M ratio of choline chloride to ethylene glycol, 25 °C, 5 min contact time). A key advantage is the inherent selectivity of the DES leach, which results in a significantly cleaner pregnant leach solution (~200× less iron, ~3× less aluminum) compared to conventional HCl leaching. This work establishes a combination of DES-SX as a highly effective method for the recovery and purification of platinum from spent catalysts, offering a scalable pathway toward more sustainable metallurgical practices.

## 1. Introduction

Platinum-group metals (PGMs) have consistently been included in the lists of “critical raw materials” being published by a specialized European Commission committees, every three years since 2011 [1,2]. PGMs which include platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), iridium (Ir), and osmium (Os) are widely used in industry due to their useful properties, such as catalytic activity, corrosion resistance, chemical inertness, and thermoelectric stability [3]. PGMs are quite scarce in the Earth’s crust, and the primary reserves of them are relatively small in comparison to those of other metals, that consequently gives PGMs a high commercial value. The relatively limited reserves of PGMs not only enhance their commercial value but also contribute to their designation as critical raw materials, which are characterized by high demand and low availability [4]. The smelting and refining processes of platinum ores often results in the release of

extremely dangerous fumes and large quantities of CO<sub>2</sub> [5]. In contrast, the recycling of Pt generates significantly lower CO<sub>2</sub> and SO<sub>2</sub> and consumes lower energy. Consequently, Pt recycling represents an efficacious and compelling approach to obtain Pt, both from the economic and environmental standpoint [6]. In addition, as a consequence of the depletion of natural PGM deposits rich in PGMs, the production of metals from secondary resources, such as spent catalysts, has become a necessity [7].

A review on the available literature indicates that hydrometallurgical and pyrometallurgical procedures are primarily used for the extraction of PGMs from secondary raw materials [8–10]. Hydrometallurgical treatment is possibly the most economically attractive method for the recovery of platinum. Valuable elements are leached using appropriate lixivants, and are subsequently, recovered from the pregnant leach solutions (PLS). Hydrometallurgical processing enables higher recovery rates compared to pyrometallurgy, with reduced energy

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<https://doi.org/10.1016/j.inoche.2025.115841>

Received 28 August 2025; Received in revised form 9 November 2025; Accepted 11 November 2025

Available online 13 November 2025

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