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Electrochemical oxidation of copper(I) to make solvometallurgical recovery of PGMs circular

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Catalysts based on the Platinum Group Metals (PGMs) platinum, palladium and rhodium are widely used in clean technologies such as fuel cells or automobile catalysts. The high economical value of these PGMs makes them a prime target for recycling. Traditionally, hydrometallurgical as well as pyrometallurgical processes have been used to extract and purify PGMs from secondary raw materials. Whereas state-of-the-art metallurgical processes already employ non-toxic extraction conditions and circular recycling strategies, solvometallurgy might offer additional advantages such as higher reactivity and selectivity. Solvometallurgy strives to extract metals from all manner of sources, e.g. ores or waste streams, using non-aqueous solutions, as opposed to hydrometallurgy achieving metal extraction in aqueous media.[1]
The present study, within the framework of the FIREFLY project (https://www.firefly-project.eu/), focuses on combining solvometallurgy and electrochemistry to recover PGMs from spent catalysts. A previously established flowsheet[2] for selective solvoleaching of PGMs from end-of-life automobile catalysts shows that selective oxidative dissolution of PGMs can be performed in non-aqueous media and under more mild conditions. Current work focuses on the optimization of this flowsheet by investigating alternative solvents, that can be subsequently combined with a non-aqueous solvent extraction step. Ethylene glycol (EG) and dimethyl sulfoxide (DMSO) were chosen as solvents, where $CuCl_2$ and $FeCl_3$ can be used as oxidizing agents. As a next step, these oxidizing agents are regenerated and recycled via electrochemical oxidation, resulting in a environmentally friendlier and more compact flowsheet with closed loops. A spent catalyst was successfully leached using $CuCl_2$ in ethylene glycol (yield >85%), and selectively extracted by non-aqueous solvent extraction (NASX) afterwards. The remaining Cu(I) in the ethylene glycol phase was electrochemically oxidized to Cu(II) by using a divided cell, recovering the oxidizing agent and closing the loop. It is shown that several principles of circular hydrometallurgy, such as regenerating reagents and electrifying the processes wherever possible, can be applied also to the field of solvometallurgy, paving the way towards circular solvometallurgy.[3]

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(2) Nguyen, V. T.; Riaño, S.; Aktan, E.; Deferm, C.; Fransaer, J.; Binnemans, K. Solvometallurgical Recovery of Platinum Group Metals from Spent Automotive Catalysts. *ACS Sustain. Chem. Eng.* **2021**, *9*, 337–350. https://doi.org/10.1021/acssuschemeng.0c07355.
(3) Binnemans, K.; Jones, P. T. The Twelve Principles of Circular Hydrometallurgy. *J. Sustain. Metall.* **2023**, *9* (1), 1–25. https://doi.org/10.1007/S40831-022-00636-3.