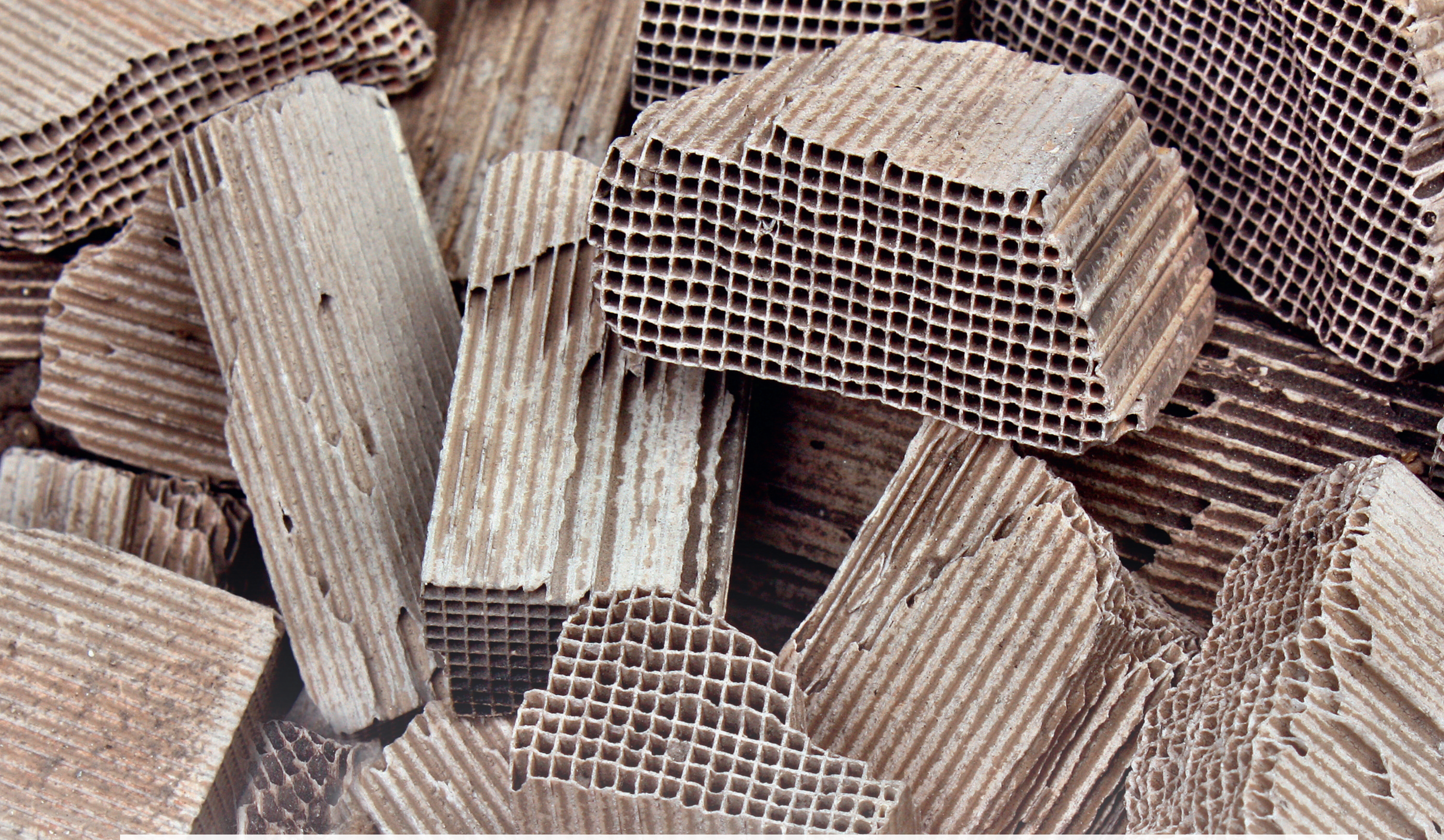


New processes to recover platinum group metals

Platinum Group Metals (PGMs) are in high demand across the world for use in a variety of different products, including cars, jewellery and electronic devices, yet the supply of these metals is not keeping pace with demand. Researchers in the PLATIRUS project are developing innovative, cost-efficient recovery processes, which it is hoped will provide the basis for a new PGM supply chain.

The six platinum group metals (ruthenium, rhodium, palladium, osmium, iridium and platinum - PGMs) are widely used in the commercial sector, for example in jewellery, electronics and automotive vehicles, and demand for these metals is forecast to grow further over the coming years. However, PGMs are among the least abundant of the earth's elements and current production and supply is not sufficient to meet global demand, prompting researchers to investigate alternative sources, such as developing processes to make better use of secondary raw materials.

PLATIRUS project

This is a topic at the heart of the PLATIRUS project, an ERC-backed initiative which brings together 11 partners from across Europe to develop an advanced process for recovering PGMs. The project consortium includes both academic and commercial partners, and by sharing their knowledge, skills and technical expertise, they aim to both develop innovative recovery processes and also move them towards practical application, in the process providing a more sustainable supply of PGMs.

The project's agenda encompasses research into several different processes and technologies around these wider objectives of developing different potential sources of PGMs, including an approach designed to recover raw materials from spent automotive catalysts. The conventional approach to recovering PGMs from these catalysts involves pyrometallurgical processes, essentially using thermal treatment to transform the material and extract the PGMs.

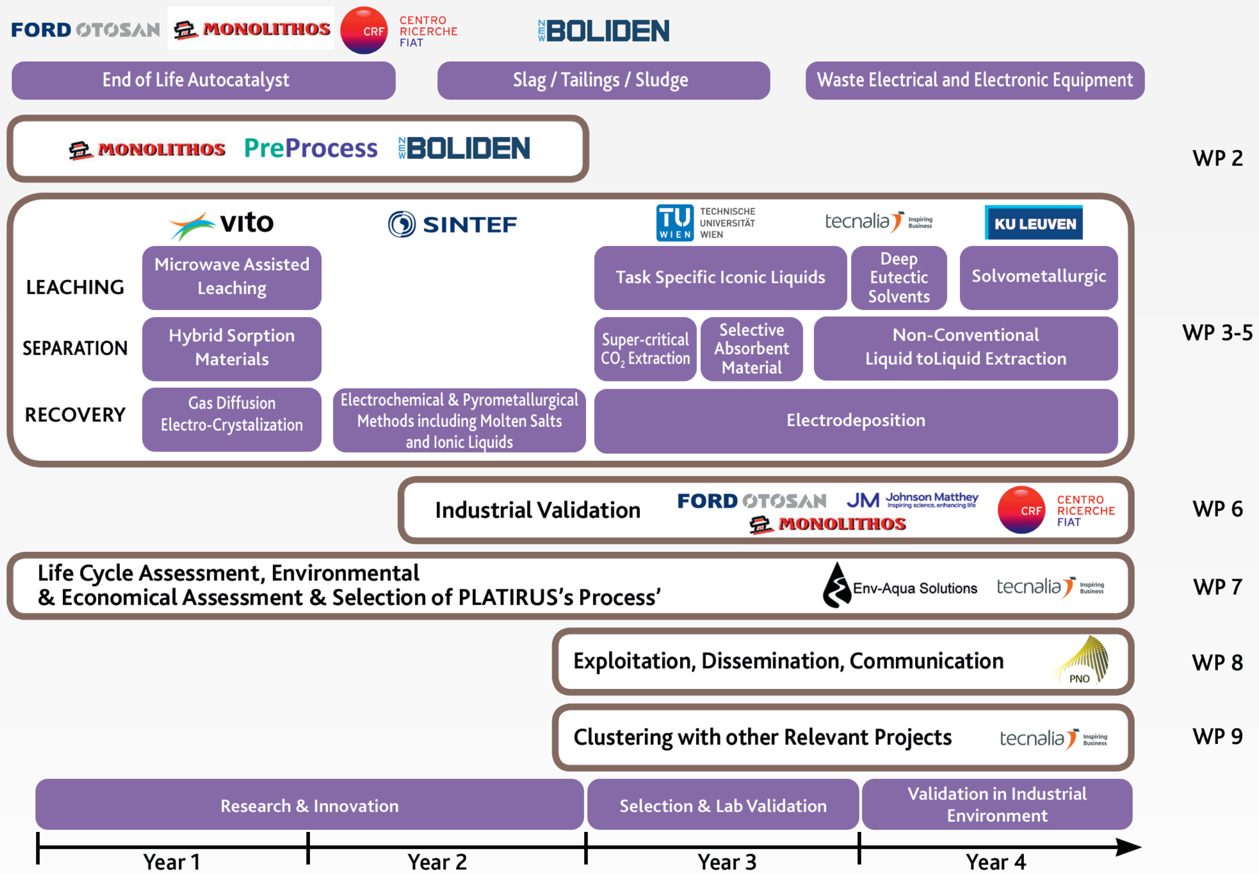
Current recycling processes are highly energy-intensive and require high capital investment, now researchers in the project have developed a two-step extraction process. Within the project, researchers are looking to assess the overall effectiveness of this approach and optimise the process.

Leaching efficiency

The aim with this approach is to both improve the yield of extracted metal and reduce processing time, which will help bridge the existing supply gap and reduce Europe's dependence on imports. Researchers have been investigating the potential of using microwave (MW) technologies to improve PGM extraction efficiencies from waste automotive catalysts, while also minimising the environmental impact.

One such technology was sulfation roasting of the waste catalysts, where microwaves were used instead of traditional thermal heating. The advantages of this are similar to the advantages of heating up a frozen meal in a microwave oven instead of a traditional kitchen oven: the heating will be faster and less energy (heat) is lost.

To do so, the waste catalysts were mixed with a sulfate source, such as potassium bisulfate ($KHSO_4$) or sodium bisulfate



monohydrate ($NaHSO_4{\cdot}H_2O$), and heated in a microwave oven that can reach high temperatures. The sulfate source reacts with, amongst others, the PGMs in the waste catalyst and transforms them into more soluble species. Once the roasting process finished, the material was brought in an aqueous solution in which the PGMs can dissolve and then be extracted from the catalyst material. This is the leaching step.

The relative costs of the two sulfate sources are of course a major consideration in terms of potential application, so it's important to note that $NaHSO_4{\cdot}H_2O$ is cheaper than $KHSO_4$. The ratio between the salt mixture and the catalyst is also an important factor in terms of the economics of the roasting process, as when less salt is used for roasting, less leachate is created with respect to the catalyst, with a higher concentration of leached metals.

The leachability of PGMs could be further improved by adding an oxidation agent, such as sodium chlorate ($NaClO_3$), during sulfating roasting. A detailed mineralogical study of the sulfation roasted materials provided further insights into the ongoing reactions during the microwave assisted roasting step.

Finally, the researchers improved the leaching step by introducing microwave heating and through the addition of a low concentration of acid (HCl). From this approach, researchers obtained leachabilites of 96 percent (+/- 1%) for palladium (Pd), 85 percent (+/- 5%) for platinum (Pt) and in excess of 96 percent for Rhodium (Rh).

Highly concentrated salt solutions

The project's work also included research into the use of concentrated acidic salt solutions to dissolve PGMs. A concentrated mixture of $AlCl_3{\cdot}6H_2O$ and $Al(NO_3)_3{\cdot}9H_2O$ was investigated for its potential use as a leaching agent, and tested on both metal wires and a real matrix comprised of spent automotive catalysts.

Researchers investigated the influence of several different factors on leaching efficiency, such as the salt-to-catalyst ratio, water content and the contact time. In terms of the latter, researchers found that it was not easy to fully dissolve all of the different PGMs, but palladium could be selectively leached by limiting the contact time to 30 minutes, while the highest level of platinum dissolution (around 64 percent) was achieved with a contact time of around four hours.

A further dimension of the project's research centers around investigating the recovery of palladium by the use of reductive precipitation with ascorbic acid, also known as vitamin C, a highly potent reducing and antioxidant agent. It was found that the amount of precipitated palladium was around 25 percent, a relatively low level, so further investigation is required to optimise this process and improve the recovery rate of PGMs.

The results of these tests so far are very encouraging, and bode well for the prospects of translating this research into practical benefits, as work continues into reducing the environmental impact of the automotive sector and improving the efficiency of resource use. While catalytic converters have had a significant impact in terms of reducing pollution levels, there is still scope to improve the efficiency of resource use through the recovery of PGMs from these devices, reducing the need to mine primary resources.

Circular economy

This is very much in line with wider objectives around reducing the use of primary resources and establishing a circular economy, where raw materials are re-used and brought back into circulation.

This represents a new economic model, moving away from the rapid disposal of products and materials towards a new emphasis on reducing or even eliminating waste, leading to both economic and environmental benefits.

The circular economy represents a potential route towards waste reduction, yet this must be built on effective engagement between procurers, service providers, consumers and recyclers, who all have important roles to play. It is extremely difficult to substitute PGMs with other materials, further reinforcing the importance of recycling and recovering them, which if achieved efficiently would close the gap between global supply and demand.

It has been calculated that an additional 29 tonnes of PGMs would be available on the global market if 100% of the PGMs available in end-of-life autocatalysts were recovered, a quantity which comfortably exceeds the current gap between supply and demand. Much of the current supply of PGMs is imported from geopolitically unstable areas, which makes the supply high-risk, and large amounts of CO2 are emitted during the process of mining primary reserves.

An efficient and reliable method of recovering these materials holds great potential in these terms, helping to reduce Europe's dependence on imports, now researchers are looking to bring the project's findings to wider attention. A team of researchers presented the project's findings at the 2020 Raw Materials summit, demonstrating the potential of the PLATIRUS technologies in terms of the development of the circular economy.

The project's research represents an important contribution to the wider goal of moving industry towards environmental sustainability, while also helping European companies maintain their position at the forefront of technical innovation.

With **demand for PGMs** particularly **high in Europe,** the European Commission has classified them as **critical raw materials,** underlining the importance of making better use of the secondary materials available in **spent automotive catalysts.**

PLATIRUS

PLATInum group metals Recovery Using Secondary raw materials

Project Objectives

Key target of the PLATIRUS project is to realise a significant contribution to bridge the supply gap of PGMs in Europe, by fostering the development of novel or improved secondary materials to PGM recovery supply chains from autocatalysts, mining and electronic wastes.

The PLATIRUS project tackles the challenge of boosting the availability and ensuring a stable supply of PGMs in Europe by:

- The upscaling to industrially relevant levels of a novel cost-efficient and miniaturised PGMs recovery and raw material production process.
- Selecting the best (combination of) recovery technologies and developing a PLATIRUS recovery process and Blueprint Process Design for the final upscaling step, before market introduction.
- Preparing and stimulating market introduction.

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Project Partners

- https://www.platirus.eu/consortium/

Contact Details

Project Coordinator,
Dr. Amal Siriwardana,
Tecnalia - coordinator
E: Amal.Siriwardana@tecnalia.com
E: info@platirus.eu
W: https://www.platirus.eu/


Dr. Amal Siriwardana

Dr. Amal Siriwardana, The head of waste valorisation department in TECNALIA [www.tecnalia.com]. PhD (2005) in Chemistry at the Tohoku University, Japan. He is a coordinator of several H2020 projects (e.g. PLATIRUS, CROCODILE and TARANTULA).
Dr. Siriwardana holds over 24 publications, 5 patents and 3 book chapters.

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