



ERA-MIN 2

RESEARCH & INNOVATION PROGRAMME  
ON RAW MATERIALS  
TO FOSTER CIRCULAR ECONOMY

**SUPERMET**  
PROJECT

# **SUPERMET - Recovery of Precious Metals from Spent Catalysts by Supercritical CO<sub>2</sub> Extraction Assisted by Polymers**

**Project coordinator:**

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**ERA-MIN 2 Final Conference and Final Seminar of Call 2017 projects  
18-19<sup>th</sup> November 2021**



Co-funded by the Horizon 2020 programme  
of the European Union





**SUPERMET**  
PROJECT

# Consortium

Main topic: 4. Recycling of End-of-Life products

Subtopic: 4.3. Recovery of raw materials from End-of-life products

Duration: 42 months  
(01/05/2018-31/10/2021)

**P2-National Institute of R&D for Optoelectronics - ICIA (Romania)**

Analytical Chemistry,  
Mass Spectrometry,  
Spectroscopy,  
Electrochemistry



Research organization  
TRL: 4 → 6

**P3-Innovation Fluides Supercritiques - IFS (France)**

Promotion of  
Supercritical Fluid  
Technologies,  
Networking, LCA



Association  
TRL: 3 → 4-5

Coordinator

**P1-Ecole Nationale Supérieure de Chimie de Montpellier - ENSCM (France)**

Polymer Chemistry, CO<sub>2</sub>-Soluble Macromolecular Extracting Agents



University  
TRL: 2-3 → 3-4

Total budget: 1497k€

Total funding: 1010k€ (67%)

**P4-HERAEUS (Germany)**

Precious Metals  
Recycling, Industrial end-user for Recycling Technology



Industry  
TRL: 1-3 → 3-4

**P5-Fraunhofer ICT (Germany)**

Chemical Engineering,  
Supercritical CO<sub>2</sub>  
Extraction



Research organization  
TRL: 2-3 → 4

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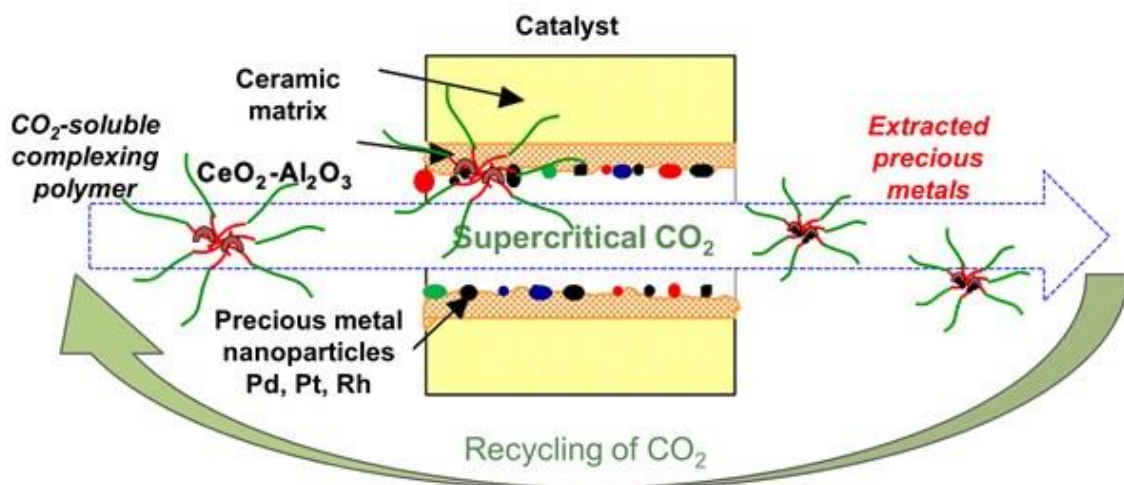




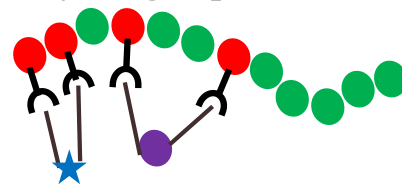
- Brief summary of the project objectives

## PROPOSED DISRUPTIVE RECYCLING PROCESS

SUPERMET project proposes to explore an eco-friendly disruptive technology for the recycling of precious metals, especially palladium (Pd) and platinum (Pt), from spent catalysts, e.g. from petrochemistry catalysts. The schematic presentation of the proposed recycling process of precious metal by supercritical CO<sub>2</sub> extraction assisted by polymers is shown in the following Figure:



Design of multifunctional macromolecular scCO<sub>2</sub>-soluble metal-complexing agents (gradient copolymers) for innovative recycling of precious metals



- scCO<sub>2</sub>-philic monomer unit
- metal complexing monomer unit
- ★ molecular ionic metallic species
- metallic nanoparticles
- Y complexing group
- ligand-metal interaction





## Economical Impact:

- Contribute to the **objectives of the Strategic Implementation Plan (SIP)** of the European Innovation Partnership (EIP) on Raw Materials: **improving resource efficiency by recycling**.
- **Serve the goal of the European Union to increase its independence from imports**. This is especially important since **PGMs are also used in other key technologies, such as polymer-electrolyte membrane fuel cells** (alternative power units for car, trucks, etc.). These growing technologies will also require PGM resources. Therefore the impact of the SUPERMET process might be much **beyond the targeted markets of chemical, petrochemical and automotive catalysts**.
- An additional aspect can be found by industrializing further the new SUPERMET process. Thereby an export technology is developed, meaning that **the process itself could be sold to other countries outside of Europe**.

## Societal Impact:

- Rely on soft chemistry, at low temperature ( $T < 100^{\circ}\text{C}$ ) and avoiding the generation of large amounts of toxic secondary effluents, being by that **more environmental friendly**.
- Show that the **chemical industry** is able to play a major role in the **preservation of the resources** by developing new clean recycling technologies.
- Demonstrate to the **general public** that **supercritical CO<sub>2</sub>-based processes** are economically feasible and environmentally advantageous for **waste recycling**.





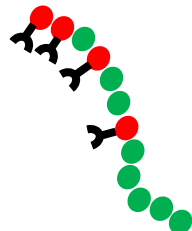
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- Catalysts delivered to partners and characterized
  - ✓ 3 Virgin, 6 virgin pre-treated, 5 spent catalysts, 6 spent pre-treated



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- Copolymers synthesized (42 fluorinated, 7 silicon-based, 33 hydrocarbon based), most being significantly soluble in supercritical CO<sub>2</sub>
  - ✓ With 5 types of metal complexing units
  - ✓ Able to interact with PGM or heavy metals



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- Supercritical CO<sub>2</sub> extraction tests performed
  - ✓ 2 different facilities
  - ✓ At lab-scale (up to 14 g of catalyst)
  - ✓ Mild-conditions (40 °C – 250 bars – 60 min)



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- Economical and Life Cycle Assessment (LCA)







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- Website <https://supermetproject.eu/>

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- Published articles
  - *Journal of CO<sub>2</sub> utilization*
  - *Materials*
  - *Molecules*

<https://www.enviscope.com/des-metaux-precieux-recuperes-grace-au-co2-supercritique/>

<https://www.lesechos.fr/pme-regions/auvergne-rhone-alpes/pourquoi-les-pme-du-recyclage-se-ruent-sur-les-metaux-rares-1357176>

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- Conferences, workshops, fares
  - *11 international oral communications*
  - *8 posters*
  - *1 video*





- Lessons learnt: visiotools have been extensively used for meetings due to COVID-19 but presential meetings remain essential for cohesion & team spirit
- No direct implementation by industry (premature due to pre- and post-treatment steps) although supercritical extraction by itself has proved to be powerful
- The project allowed each partner to reach higher TRLs in their respective fields (1-4 to 3-6)
- Optimization of analytical methods for metal determination
- The project permitted to popularize supercritical fluid processes in the general public
- SUPERMET results contribute to the priorities of the Strategic Implementation Plan of the EIP on Raw Materials by proposing a green recycling process of critical metals for improving resource efficiency







- The research results of the project will be utilized:
  - *Further R&D in partner organization/company*
  - *Other project participants will utilize the results*
  - *Other joint projects (PhD work on the recycling of critical metals from Li-ion batteries will start in 2021 at ICGM in relation with a French SME)*
- Fate of the consortium:
  - *The consortium will not continue after the end of the project but some partners wish to cooperate in the future*





# Acknowledgments



SUPERMET project partners thank ERA-MIN 2, the European Commission and the National Funding Organizations



Agence de l'Environnement et de la Maîtrise de l'Energie



Bundesministerium für Bildung und Forschung

To follow us : <https://supermetproject.eu/>  
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