6 June 2025

#EU GREEN WEEK

EU Green Week Partner Event

GDEx: A selective electrochemical route for recovering precious metals and other critical raw materials

Omar Martinez Mora (PhD)

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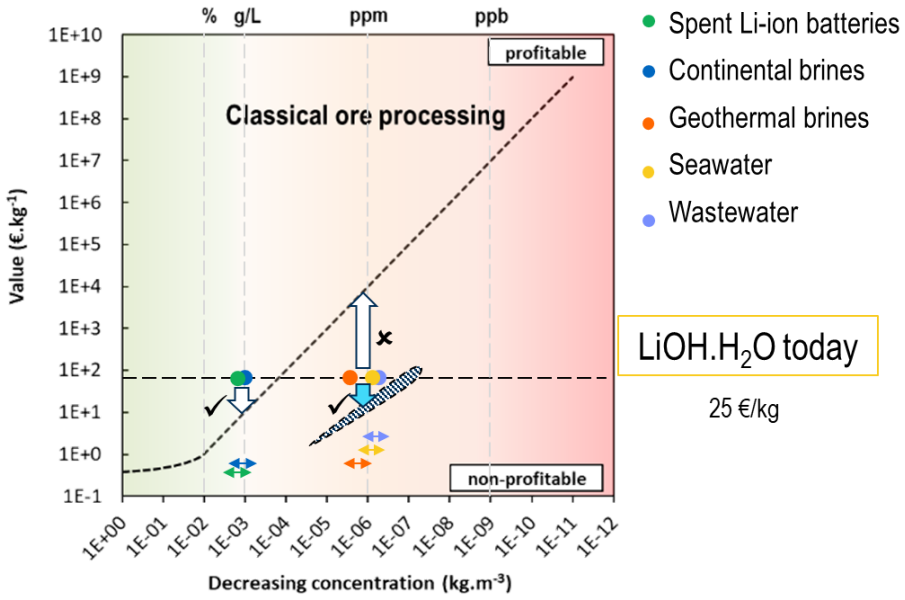
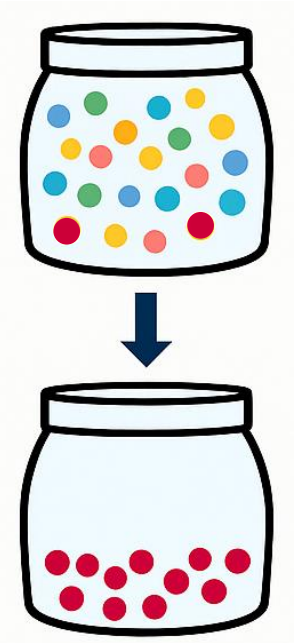
The challenges of recovering metals of diluted sources

Sherwood plot



Processing costs need to reduce significantly to make recovery from dilute matrices profitable

A jar of full of marbles



Can we recover just the red sustainably…and economically?

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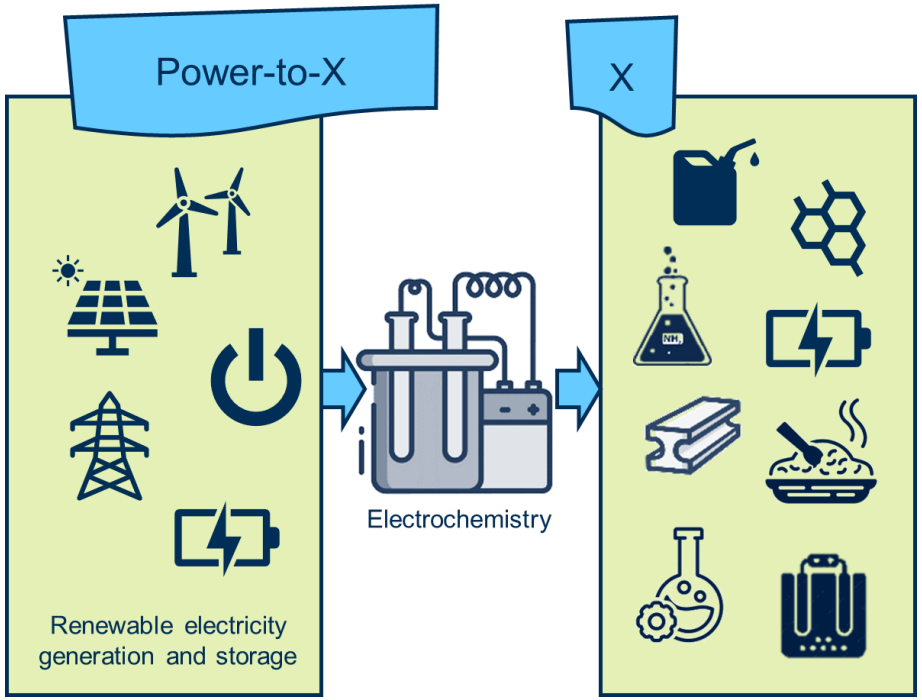
At VITO's ELEC team we believe that electrochemistry...

...is the solution



Our expertise:

- **Design and build of electrochemical components**
  - Electrodes, electrocatalysts, membranes, etc..
- **Electrochemical processes development**
  - Hydrogen production
  - CO_2 capture and conversion
  - Organic electrosynthesis
  - Critical raw material recovery
    - GDEx

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What is GDEx?

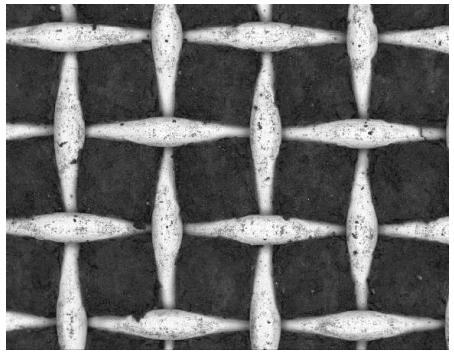
How does GDEx contribute to the sustainable recovery of critical raw materials?

Gas-diffusion electrocrystallisation (GDEx)

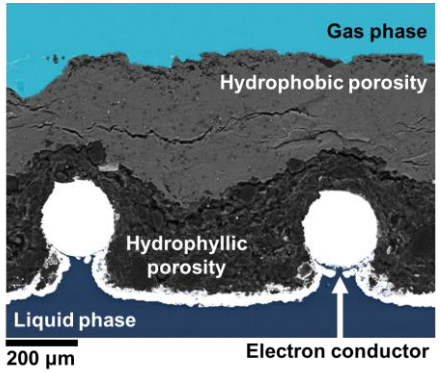
Process of reactive precipitation of metals in solution with oxidising or reducing agents produced *in situ* by the electrochemical reduction of a gas, in a gas-diffusion electrode.

Our journey starts with a gas-diffusion electrode

VITO CoRe®

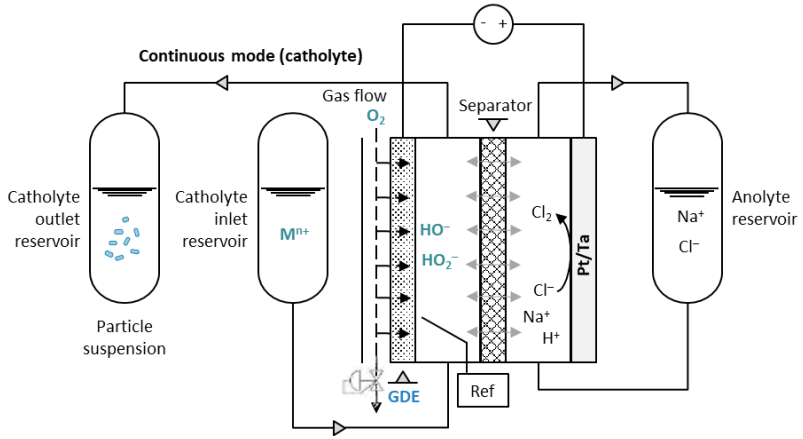


Front view



Cross section

Lab-scale GDEx reactor



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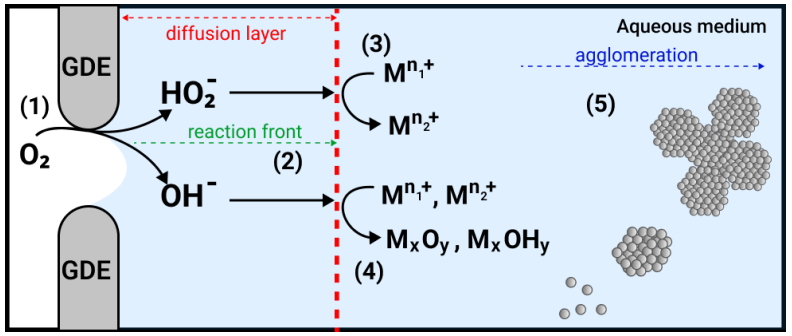
Gas-diffusion electrocrystallisation (GDEx)

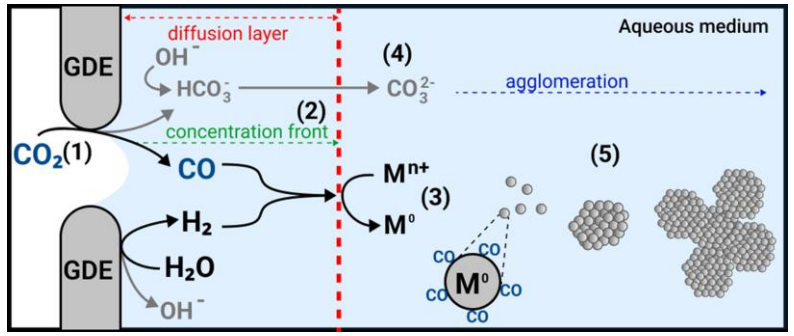
Process of reactive precipitation of metals in solution with oxidising or reducing agents produced *in situ* by the electrochemical reduction of a gas, in a gas-diffusion electrode.

O_2 as gas feed



Oxidation-assisted alkaline precipitation

CO_2 as gas feed



Reduction-assisted buffered precipitation

Recovery of metals from waste stream solutions

Synthesis of nanoparticles

- Metal (hydr)oxide nanoparticles
- Elemental nanoparticles

Dominguez-Benetton, X. et al. (2015) Patent EP32422963B1

Dominguez-Benetton, X. et al. (2021) A process for precipitating particles of platinum group metals. EP21165681.

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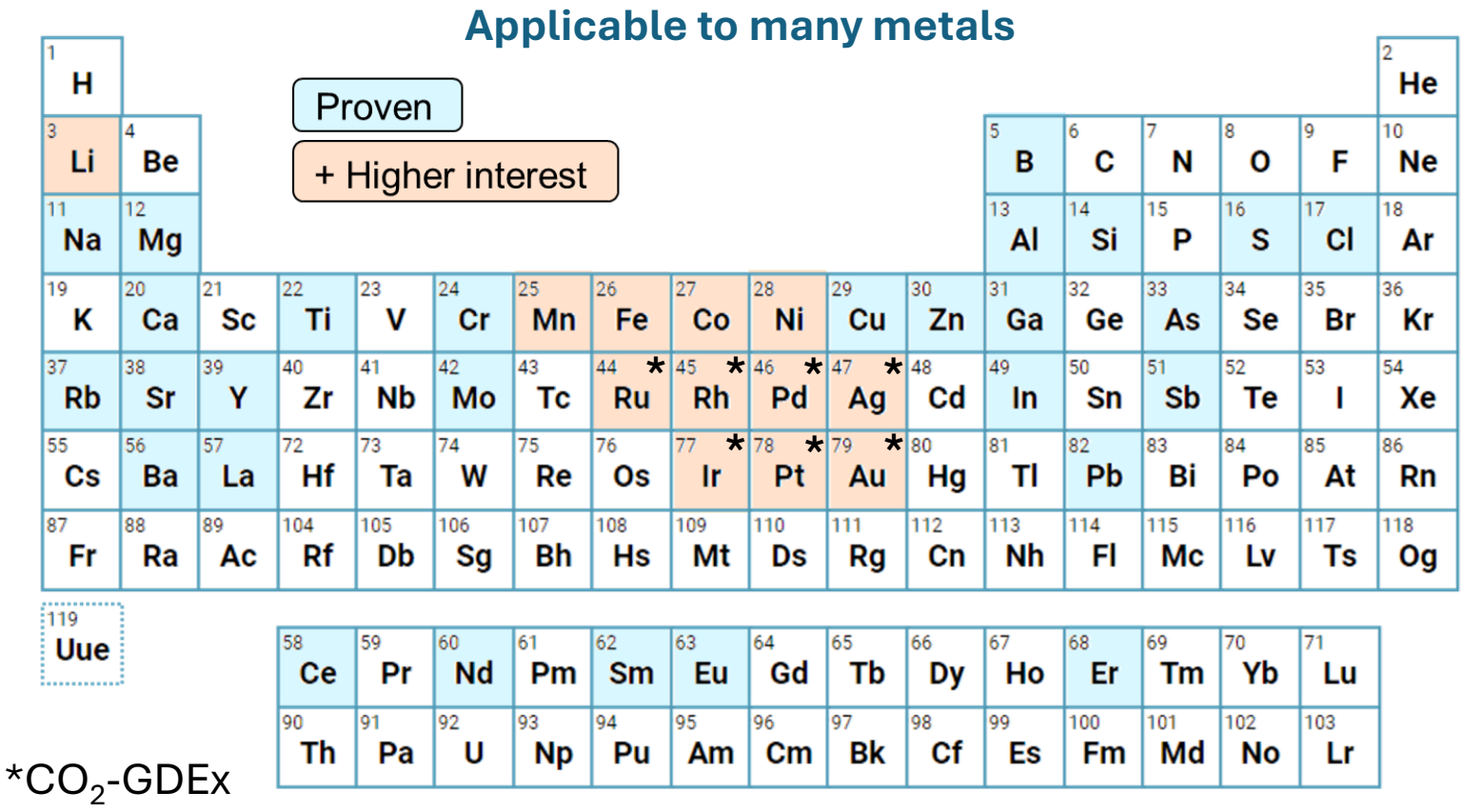
Gas-diffusion electrocrystallisation (GDEx)



*CO_2-GDEx

Funded by the European Union

Lithium recovery:

LiCORNE

CRM geothermal

Battery recycling (Mn, Ni, Co, Li)

RHINOCEROS

RESTORE

PGM + Au, Ag recovery:

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FIREFLY

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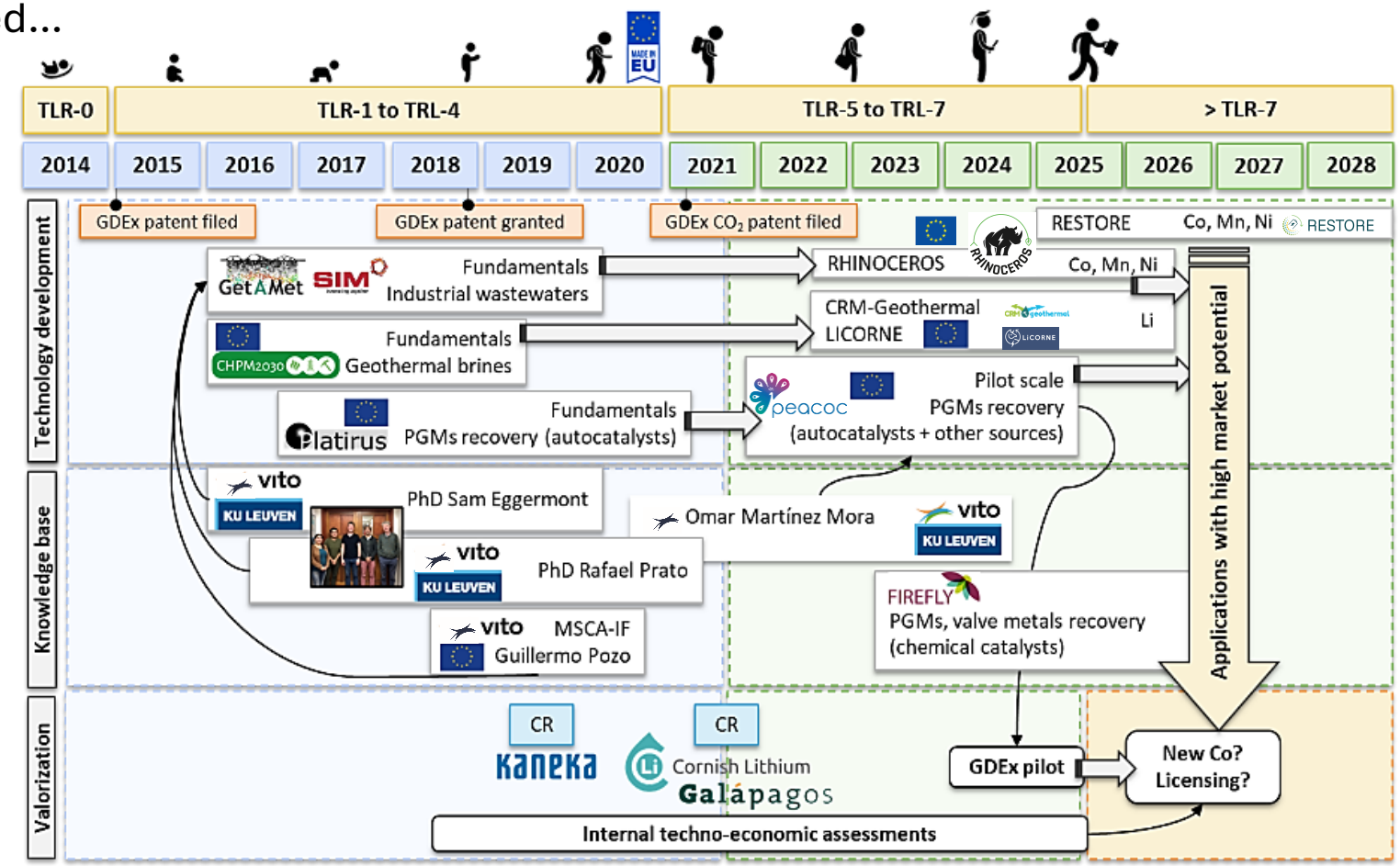
GDEx road map: from lab to real-world applications

Xóchitl Dominguez

How we started...



... and where we are

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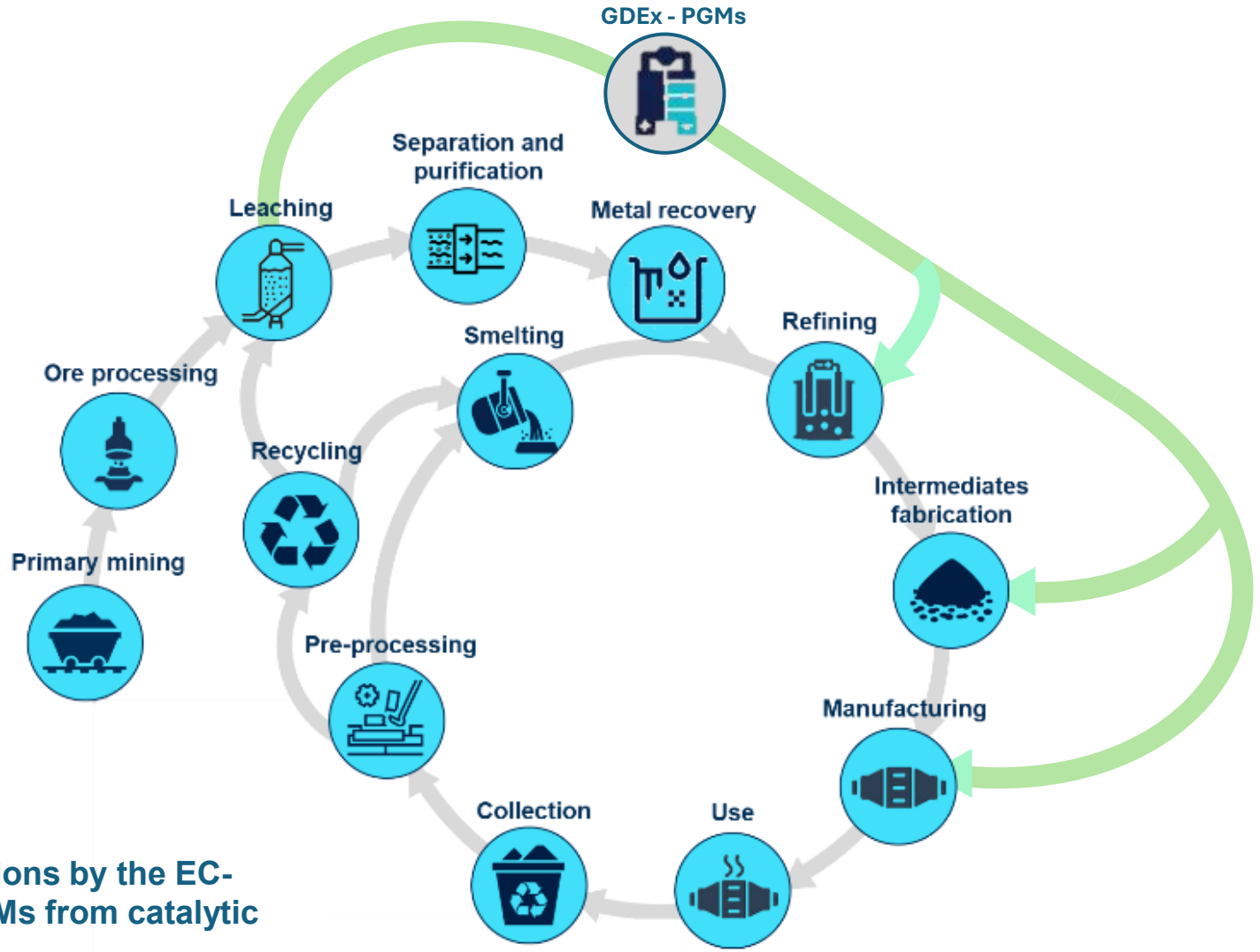
GDEx for PGM recovery

What sets us apart

- **Low-grade precious metals**
  - Diluted streams
  - Selective recovery
- **Electrification**
  - Coupled with renewable energy
  - 2 kWh - 6 kWh per kg of recovered material
- **Upcycling**
  - Same or new applications



GDEx was awarded as one of the top 10% great innovations by the EC-Innovation Radar for its application in the recovery of PGMs from catalytic converters.

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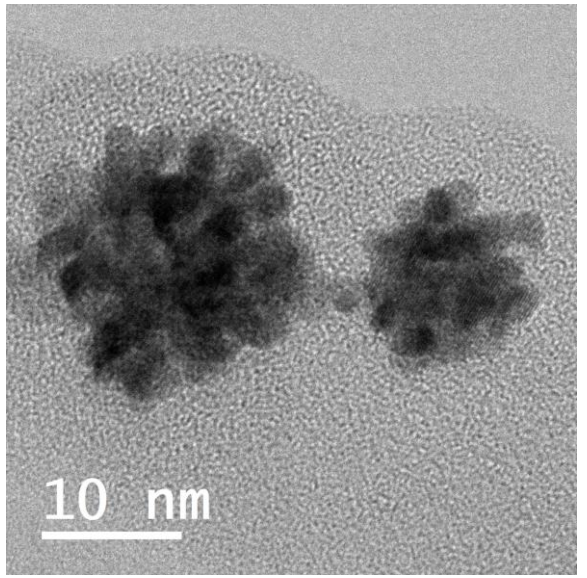
GDEx for PGM recovery

From synthetic solutions…



- In controlled conditions, GDEx enables the precipitation of PGMs as nanoparticles with controlled morphology and composition, which can be used in electrochemical energy applications.

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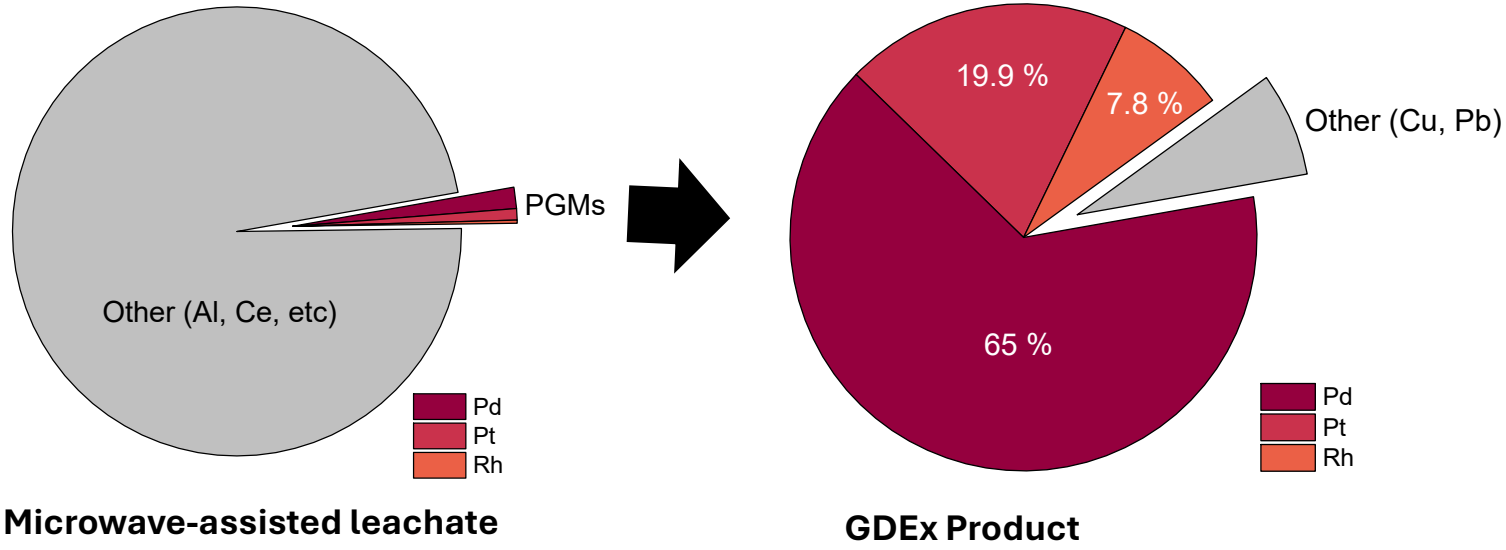
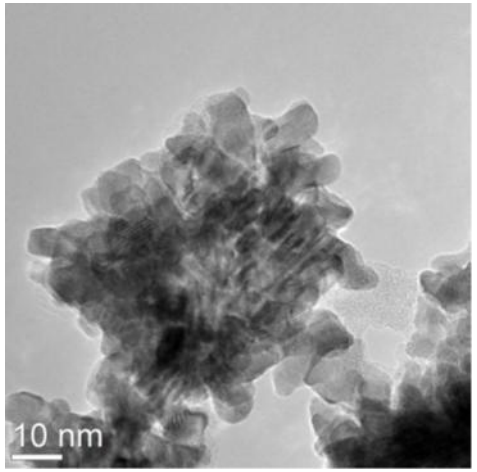
GDEx for PGM recovery

...to real waste streams



Microwave-assisted leachate **GDEx Product**



- **PGM precipitation: ~100% in all cases**
- ↑ Current densities promote precipitation but increase the charge consumed in the process (↑ power demand).
- ~90% PGM content in NPs formed (~10% Cu + Pb, rest: traces of Al + Si)
- Leachate reuse and regeneration feasible.

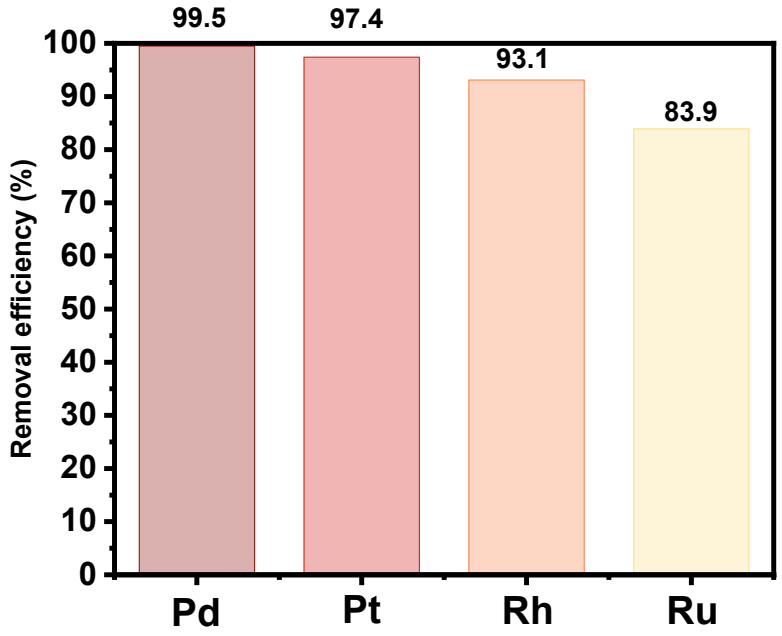
GDEx for PGM recovery

JM industrial streams

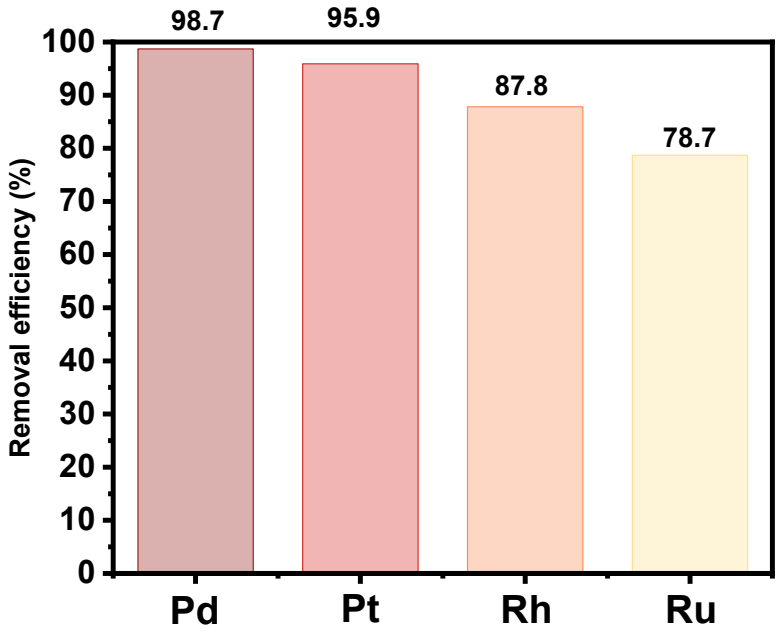
...to real waste streams

PGMs: 2-100 ppm

Batch mode



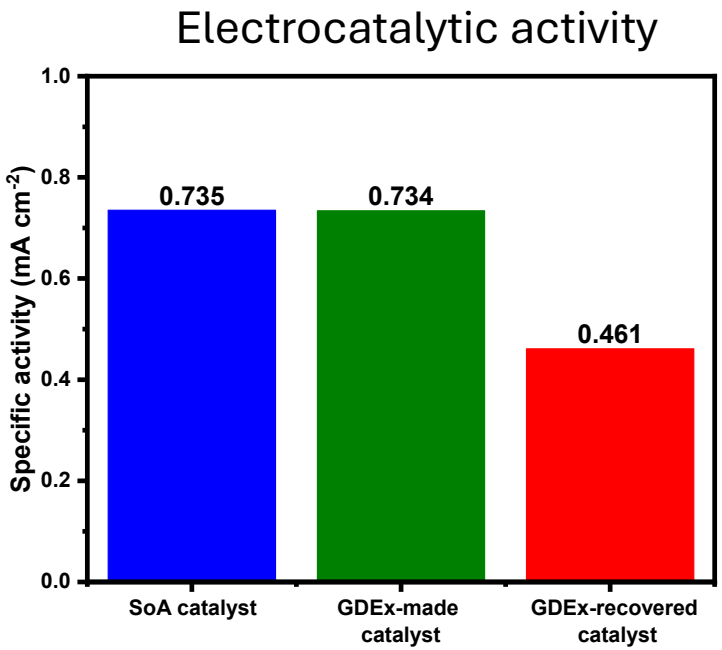
Continuous mode

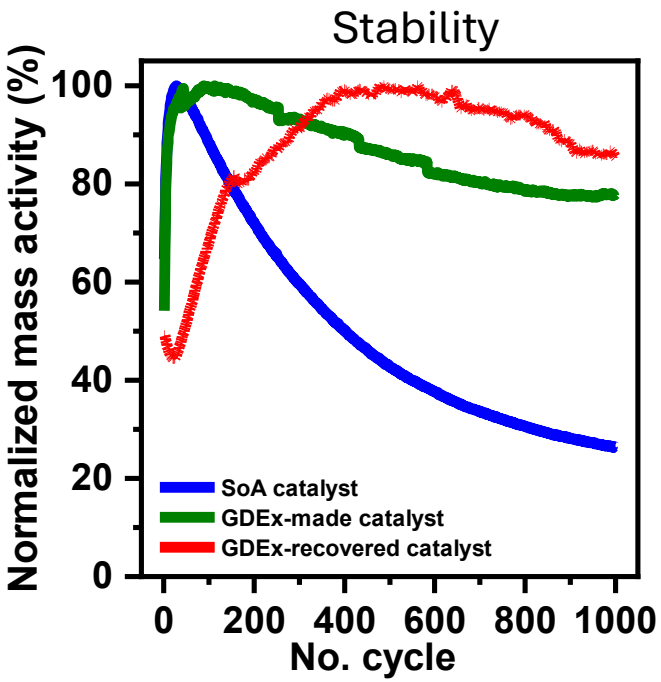


- High removal efficiency across all PGMs in batch mode
- Consistently high recovery in continuous operation
- The robustness of the GDEx process to recover PGMs from different matrices is demonstrated

Validating the use of recovered PGMs into electrocatalysts for energy applications

Electrochemical oxidation of methanol





- GDEx-made synthetic and recovered PGM-based nanomaterials show promising electrocatalytic performance vs. SoA materials opening the door the direct use of recovered materials as electrocatalysts for energy applications.

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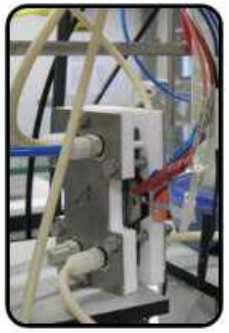
Scaling up: improving the reactor design

μ-flow cell
(10 cm^2)
~0.25 L/h

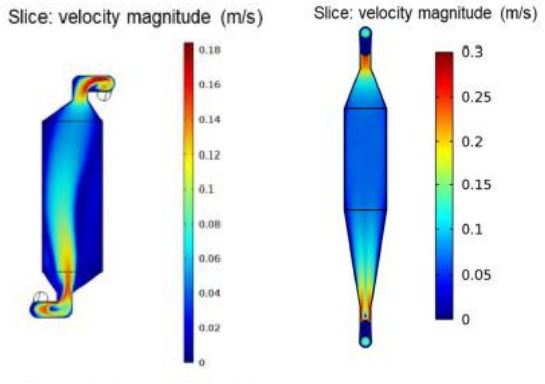


Syn Cell
(297 cm^2)
> 10 L/h

Lab-scale

Mid-scale

Reactor redesign



Pilot-scale

6-cell stack
325 cm^2/cell
100 L/h

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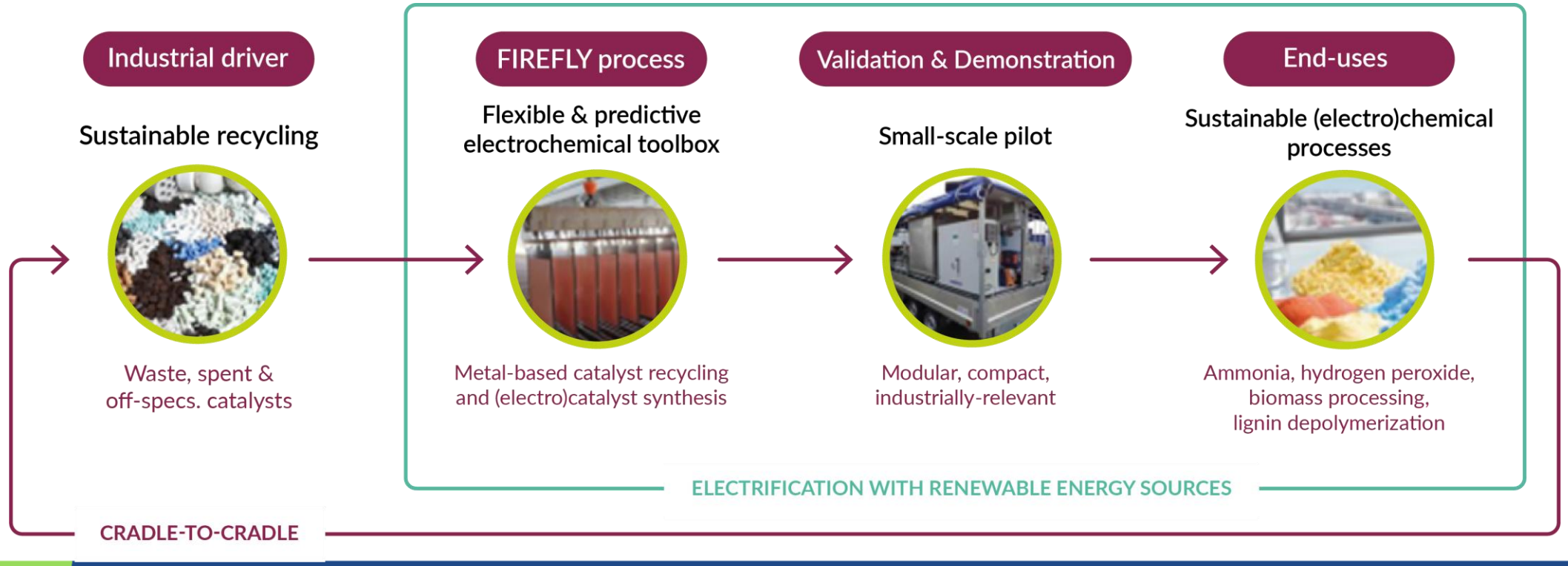
GDEx is part of a broader push to electrify the chemical industry: the FIREFLY project

The FIREFLY project aims to electrify a large part of the chemicals value chain in a sustainable way (environmental, economic, social): **POWER-TO-CATALYSTS AND CHEMICALS FOSTERED VIA ELECTROCHEMICAL RECYCLING.**



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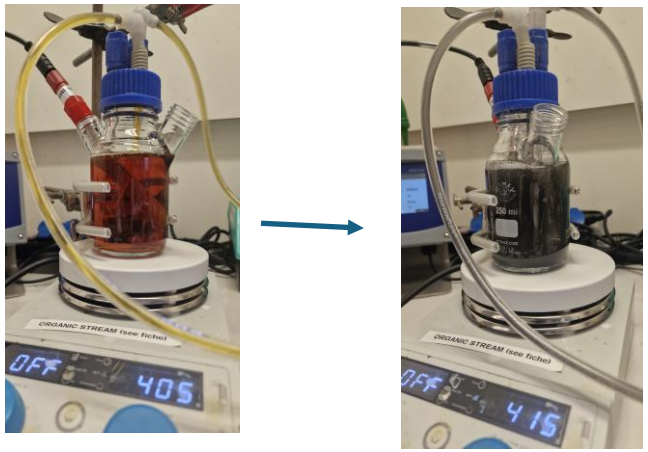
Pushing the limits: even in harsh conditions

From aqueous to organic solutions

Limitations to overcome

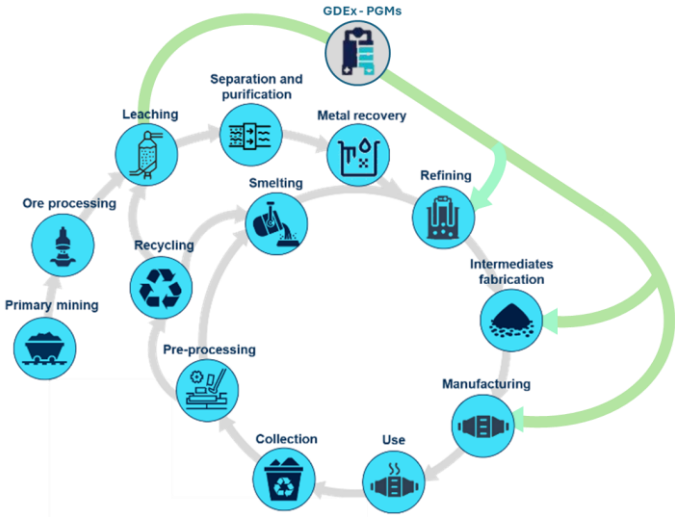
- Stream conductivity
- Solvent electrochemical window
- Reactor components stability



- GDEx can be used to recover **Pd** and **Rh** from streams based in polar solvents such as **methanol, acetonitrile and dimethyl formamide**.
- The recycled metals has been used to produce new catalysts for applications such as lignin depolymerisation or biomass conversion

Take away message

GDEx is a flexible electrochemical process that can be integrated into recycling value chains to enable the sustainable, cost-effective recovery of metals from waste, spent, and off-specification materials — transforming them into valuable resources for clean energy and technology.



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Thank you for your attention!

GDEx team

GDEx publications

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