Recycling of Precious Metals from the Urban Mine

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Agenda

Umicore & precious metals
Key concepts
In practice
Closing remarks
Umicore & precious metals
The Umicore Group
Manufacturing and recycling for a wide range of P(G)M applications
Umicore in North America

- **Umicore Canada (CSM)**
  - Location: Fort Saskatchewan, Alberta

- **Autocat Canada**
  - Location: Burlington, Ontario

- **Autocat USA**
  - Location: Auburn Hills, MI

- **Optical Materials**
  - Location: Quapaw, OK

- **Palm (CSM)**
  - Location: Nashville, TN

- **CSM**
  - Location: Arab, AL

- **Technical Materials**
  - Location: Attleboro, MA
  - Location: Glens Falls, NY

- **Thin Film**
  - Location: Providence, RI

- **Precious Metals Management**
  - Location: South Plainfield, NJ

- **Government Affairs**
  - Location: Washington, D.C.

- **Building Products**
  - Location: Raleigh, NC

- **Zinc Chemicals**
  - Location: Raleigh, NC

- **Umicore USA + UMS**
  - Location: Raleigh, NC

- **UAR + UBR Recycling**
  - Location: Maxton, NC

- **Platoro**
  - Location: Platoro, CO

- **Energy Materials**

- **Performance Materials**

- **Catalysis**

- **Recycling**
Umicore in the product life cycle
Closing the loop for key functional materials

Automotive catalysts  Industrial catalysts  Fuel cells

Substrate manufacturer  umicore  Fuel cell stack manufacturer
Cannister  umicore  Catalyst user
Car/engine manufacturer  umicore  End consumer

Other examples: electronics, rechargeable batteries, photovoltaic, …
Umicore’s strength in recycling

The result of a strategic transformation in Hoboken (Belgium)

1887
Start of a lead de-silvering operation in Hoboken

1995
Start of major investment program to re-engineer flowsheet

2013
Announced expansion to 500 kt/y treatment capacity

Recovery of 17 different metals from complex, precious metal bearing feed materials

A significant above-ground PGM mine in Europe with ~1.75 Mtoz PGM capacity
Key concepts in (precious) metal recovery
Recycling occurs throughout the life cycle

Based on: C.E.M. Meskers: *Coated magnesium, designed for sustainability?*  
PhD thesis Delft University of Technology, 2008
Benefits of recycling

Significant environmental advantages, especially for PMs

Recycling:

- Lowers the CO₂ footprint for majority of metals
  - Example of Umicore Hoboken: ~1 Mt CO₂ saved vs. equivalent metal production from ore*
- Mitigates environmental impacts of mining
- Prevents impact from non-recycling (i.e. landfill)

Capturing these benefits, however, requires the use of state-of-the-art processes that avoid harmful emissions:

- From the product itself
- From substandard processes
- From reagents used in the recycling process

*Source: Ecoinvent 2.0, EMPA/ETH-Zürich, 2007
Industrial By-products

Critical mineral recovery occurs through a global network

- The production of critical minerals from ores requires the **efficient treatment of by-products**

- Many critical minerals are produced from the **global non-ferrous metallurgical network**

- Declining ore grades and increasing complexity leads to more by-products
Recycling is a funnel

*Materials are concentrated towards specialized end-processors*

Electronic scrap → Use → Collection (WEEE) → Pre-processing (Dismantling, Shredding, Sorting) → End-processing (Smelting, Leaching, Refining)

- **Electronic scrap**
  - # of actors worldwide: 1,000,000,000’s
- **Use**
  - 100,000’s
- **Collection**
  - 1,000’s
- **Pre-processing**
  - ~10
- **End-processing**
  - Pd, Au, Ag, Cu

**Example: Laptops**
- 200M adults (5y life, 50% ownership*)
- 20M units (PWB = 500 g)
- 10,000 mt PWB (Au = 100 ppm)
- 1 mt Au

A large population can be served by 100’s of pre-processors supplying 1 end-processor

Recycling is a chain

Efficient recycling depends on a strong chain of actors

**Collection**
- **Loss** during destructive use
- **ELV Collection**
- **Autocat Removal**

**Pre-processing**
- **Loss** as a result of dubious and unethical practices
- **Smelting Leaching Refining**

**End-processing**
- **Pt Pd Rh**

**Autocats**
- **Use**
- **Export** to area of lower recycling performance

**Electronic scrap**
- **Use**
- **WEEE Collection**
- **Disposal in household waste**
- **Dismantling Shredding Sorting**
- **Loss** to other streams in mechanical treatment
- **Smelting Leaching Refining**
- **Pd Au Ag Cu**

- **Loss** as a result of informal treatment
- **Disposal** in household waste
- **Loss** as a result of dubious and unethical practices
- **Loss** during destructive use

Caffarey – ACS – Aug 2014
Recycling is dynamic
*Products are rapidly changing – example: electronics*

- Cloud
- Convergence of devices
- Unit weight decrease & miniaturization

These trends and others are already felt in the recycling industry and impact:
- Volumes & tonnages -> risk of capacity mismatch
- Material composition -> what’s in there?
- Recyclability -> which materials to focus on? need to rethink approaches?
Importance of sampling & assaying

Ethics, resources and skill are required

Sims investigates potential fraud at WEEE sites

An internal investigation has been launched into potential fraud at the WEEE recycling arm of scrap metal firm Sims Metal Management, after it emerged that the value of the company’s inventory had been overstated by around $60 million (£37m). (letsrecycle.com 2013)

Implats taking platinum recycler to US court

Impala Platinum (Implats) has initiated court proceedings against a US recycler for $182-million... In 2012, Implats took an impairment of R212-million against amounts allegedly owed by A-1. However, since then, A-1 has ceased deliveries of all material. (Mining Weekly, 2013)

Each material requires its own method

<table>
<thead>
<tr>
<th>Material</th>
<th>Method Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autocatalysts</td>
<td>Decanning &amp; sampling of ceramic converters</td>
</tr>
<tr>
<td>Electronic scrap</td>
<td>Three separate lines for shredded &amp; unshredded material</td>
</tr>
<tr>
<td>Metallic material</td>
<td>Sampling after remelting in induction or gas furnaces</td>
</tr>
<tr>
<td>Lumpy material</td>
<td>Sampling via crushing and milling</td>
</tr>
<tr>
<td>Liquid spent</td>
<td>Homogenization; increments from bulk flow, e.g. spent Rh catalyst</td>
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Precious metal recycling “in practice”
Our raw materials

- **Industrial By-products**
  e.g. slags from nickel, PGM & PM industry and slimes processing

- **Electronic Scrap**

- **Spent Industrial Catalysts**

- UPMR is an integrated smelter-refinery specialized in treating complex and precious metal-bearing materials from around the world

- All materials are treated at the Hoboken plant, though our autocat network provides local sampling in the USA, Brazil and Thailand
Our process

The UPMR flowsheet employs:
- unique and innovative technology,
- both pyro- and hydro-metallurgy, and
- advanced process control

…to efficiently recover 17 metals at the highest environmental standard and with minimal waste generated
Sampling
- Reducing several tonnes of material down to a representative few kilograms
- Dedicated processes for all raw materials, using material-specific procedures
- Secured area
- 190 people, +/- 8,000 lots/year

Assaying
- High accuracy determination of metal content down to parts per million
- Recognized leadership in the precious metals industry
- State-of-the-art analytical equipment
- 109 people, 55,000 samples/year
Investing in our future

**Capacity expansion**
€100m over 2014-2015 to expand treatment capacity by 40% to 500 kt/y

**Biological wastewater treatment**
€15m for an additional water treatment plant to further reduce metal emissions to water by 90% - operational 2014

**Sampling**
€25m to upgrade and expand the sampling facility to increase capacity and reduce throughput time – operational 2013

**R&D**
UPMR spends about 4% of its turnover on R&D, more than double the industry average
Our key strengths

- **Material compositions & complexity** – our flexible process allows us to treat the widest range of materials in the industry and respond to market conditions

- **Accuracy & transparency** – our robust process for determining customer return is trusted throughout the industry and is used to optimise processing

- **Efficiency & impurity management** – our unique and complex flowsheet enables a highly efficient recovery of PGMs from both primary and secondary sources

- **Technology & environment** – our focus on continuous optimisation and new process innovation opens doors to the recycling markets of tomorrow
Many pieces to the end-refining puzzle
Closing remarks
**Truly “value”-ing your precious metals**

*Let’s take recycling to the next level!*

| **Openness** | Transparency on material flows & transactions  
Reliable, accurate sampling & assaying |
|--------------|-----------------------------------------------------------------|
| **Innovation** | Continuously improving yields and reducing impacts  
Forward-looking solutions for the entire life cycle |
| **Teamwork** | Supply chain cooperation & stable business relationships  
Engaging emerging markets to improve recycling |
| **Respect** | For the environment, health and safety  
Close interaction with stakeholders |
| **Commitment** | Collaborative long-term approaches  
Strive as an industry toward high performance standards |
Thank you

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