Metal Recovery and Recycling by Urban Mining

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Secondary sources and resource recovery

Technological requirement
- Processing urban mine (WEEE) materials with high metal content
- Processing landfill/tailings/legacy materials with low metal content

The case for urban mining

Focus on Waste Electronic and Electrical Equipment (WEEE)

- 1 tonne rock
- 1-5 g gold
- 1 tonne WEEE, e.g. smartphones
- 300 g gold

- EU-28 12% increase in WEEE 2013-20 (note: 98 and 145% in China and India)
- For Cu and Al 85-95% energy saving compared to mining and refining
- 12% of gold consumed by electronics industry
- Gold is the most valuable component of WEEE
- 40% of WEEE in uncontrolled landfill
- WEEE waste sites 100x more contaminated by heavy metals
Hydrometallurgy – energy and resource efficiency

Metal ore or other source → Leach → Pregnant Leach Solution → Separation & Concentration → Single Metal Solution → Reduction → Pure Metal
Chemical understanding of metal recovery processes

The Metal Recovery Group @ Edinburgh University

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We aim to:

• **Understand** the chemistry that underpins metal recovery from primary and secondary sources

• **Identify** molecular level solution structure using experiments, spectroscopy, and computation

• **Develop** new reagents for metal recovery by solvent extraction

For a brief overview see page 154: http://www.paneuropeannetworkspublications.com/GOV20/files/assets/basic-html/page-1.html
Chemical recognition of metals

Chemical knowledge underpins our understanding of metal recovery processes. For example, different solution structures are seen depending upon metals, leachate, extractant, and solvents.

Urban mining a smartphone

- Very high metal content: 38% ferrous, 16% non-ferrous
- Need highly selective recognition for single metals: 60 elements in a smartphone

2 M hydrochloric acid (HCl)
2.37 M copper; 0.61 M iron;
0.57 M aluminium; 0.28 M tin;
0.24 M nickel; 0.11 M zinc;
0.012 M gold
Gold recovery from WEEE

We have discovered a simple amide for the selective recovery of gold from waste electronics.

- Other metals in large excess compared with $[\text{Au}]$
- $1^\circ$ amide gets Au, and a lot less Fe/Sn
Gold recognition by protonated amide receptor

We have used slope analysis, EXAFS, mass spectrometry, and DFT/MD calculations to identify the mechanism of gold recovery by solvent extraction.
Low energy processes to high value products

We believe that chemists, in collaboration with biologists, engineers, and industry can generate more economically and environmentally efficient metal recovery processes.
Technological solutions for recycling from the urban mine

1. Recycling of valuable and toxic metals
   • Metal recycling from waste electronic and electrical equipment (WEEE)
   • Challenges: Leaching; selective separations; economy of scale

Dr Carole. A. Morrison
Prof. Jason B. Love

2. New materials from waste materials
   • Sustainable cement, waste materials embedded in cement mixes
   • Challenges: Impact of waste fillers on product; material consistency

Dr Caroline Kirk
Materials chemistry
Energy and environment
Formation of natural materials

3. Recycling of plastics
   • Depolymerisation and regrowth of aromatic and aliphatic polyesters
   • Challenges: Selectivity; plastic separation; transition of technology

Prof. Michael P. Shaver
Polymer synthesis
Ligand and catalyst design
ROP/radical polymerization
UoE Director SOFI
Conclusions

1. Waste electronic and electrical equipment is a valuable resource
2. Chemistry is integral to metal recovery
3. Dynamic assembly can generate complexity from simple inputs
4. Collaboration between chemists, engineers, economists, and industry is essential

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Further Reading


