Mining Solutions
BASF Innovation Day
EIT Raw Materials

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**Hydrometallurgy**

**Definition**
Method by which a pure metal or metal salt is obtained from an impure metal source involving the use of an aqueous system for extraction

**Leaching**
- Feedstock containing metal is leached
- Aqueous conditions often harshly acidic, basic, oxidative or reductive

**Solvent Extraction**
- Highly or moderately selective extractants used to extract metals into the organic phase
- Optimized systems to ensure economic viability

**Purification**
- Final products can be salts or high purity metals
- Electrowinning often used when metal purity must be in excess of 99.99%
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Metal Feedstocks
Industry Challenges and Trends

- Environmental Pressure
- High Energy Consumption
- Public Opinion
- Geopolitical Stability in Source Countries

Impact on Metals:
- Lower Availability
- Higher Costs

- Lower grade ores requiring new leaching processes
- Evolution to more complex difficult to treat ores
- Secondary metal Recycle
- Pyrometallurgical Environmental Pressure
- Resource Nationalism

Dramatic Increase in Metal Demand Forecasted
End Users: Automotive Industry Example

Increasing Demand for Specialty Metals

Due to advances in technology, specialty metals are of more interest than the base metals used previously. Rare earth, platinum group metals, scandium, germanium, gallium, cobalt, lithium, etc., increasingly used...
Leaching Innovation

Leaching metals is the most costly part of the hydrometallurgy process.

**In-Situ Mining** could revolutionize mining – would remove the need for blasting, hauling, and comminution.

**Catalyst Recovery** to create a sustainable cycle for metal use.

**Urban Mining** to obtain precious metals from non-commercial waste.

Improved interstitial lixiviant flow through the ore, increases the rate of copper recovery.

Deeper intra particle permeation, significantly increases diffusion of copper from the particle.
Leaching solutions becoming more aggressive which require more stable extractants
Development of more selective extractants necessary
Global extractant portfolio decreasing due to low volumes necessary for applications
Solvent extraction systems have not been optimized using new mixing techniques from other industries

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Solvent Extraction Innovation

- Depth of Copper Ore Body
  - Oxide Cap (~10%)
  - Secondary Sulfides (~23%)
  - Primary Sulfides (~67%)

Hydrometallurgy Route
- Direct leach, heap leach or bio-leach route followed by SX / EW

Pyrometallurgy Route
- Well established smelting technology. Leaching is difficult as the ore “passivates” in normal leaching conditions

Concentrate Leaching Processes
- Leaching primary sulfides is new and requires high temp / pressure. Technology exists, but high temp leach solutions degrade existing SX reagents.

CAPTIVA HT SX Reagents

New Technology
High Purity > 99.9% is the typical target

Providing metals or metal salts in the appropriate form for end users

Depending on the metal, electrowinning processes require selective stripping of extractants

BASF internal battery production Li/Ni/Co recovery

Currently under development
**Need For Innovation**

**Resistance to Change**

**Industry Approach**
- Conservative to change and hence methods have not changed since metals were bountiful
- Internal Innovation budgets reduced for short term budget gain
- Traditionally skeptical of external innovation and reluctant to invest CAPEX due to scale of operations
- Mining cycle shortening driven by fluctuations in metals prices

**Need For Change**

**Future Requirements**
- Well understood by all stakeholders that the current status quo is not sustainable
- Broader metal portfolio due to innovations in high tech fields such as electronics, batteries, e-mobility innovative methods to obtain less abundant metals
- Cooperative innovation in the form of partnerships, could be the key to acceptance by industry
Innovative Cooperation

- Partner with an Engineering company with extraction technology
- BASF to provide chemistry input for leaching, SX and EW
- Partner with mining research groups focused on solving industry pain points
- Partner directly with customers to jointly develop hydrometallurgy processing solutions
- Partner with Technology owners to drive innovation and increase the speed to market

Innovative cooperation offers the highest probability of success