Innovative Scandium Refining Process from Secondary Raw Materials

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Introduction – MEAB Chemie Technik GmbH

Founded in 1970

Located in Aachen/Germany, near 3 borders

Active in hydrometallurgical field

Special interest: Solvent Extraction

Active role on research: SCALE, REDMUD, EURARE, etc.
Introduction – Scandium Sources

- Mainly produced as a **by-product**
  - Ni laterites
  - TiO₂ pigment
  - Uranium extraction
  - Bayer Process
Example Case: Bauxite Residue

Stockpiled all over the world
Currently 4 billion tonnes and growing
Varying compositions of Sc
Promising resource

In this case:
Greek Bauxite Residue
Contains 120ppm Sc
Example Case: Bauxite Residue

Why Slag Making?

- Removal of major part of bauxite residue
  - Concentrating Sc in slag
- Control of phases and crystallinity
  - Easier leaching

Innovative Leaching Method

- Si-gel problem
- Addition of $H_2O_2$
  - Oxidative Leaching Conditions
- >95% Leaching efficiency for Sc

Process:
- Bauxite Residue → Reduction → Pig Iron
- Reduction → Acid Leaching → Leach Residue
- Acid Leaching → Triple Stage Precipitation
- Triple Stage Precipitation → Impurity Hydroxides → ScPO$_4$ concentrate
- Triple Stage Precipitation → Ammonia Recovery
- Ammonia Recovery → Ca Residue → NH$_3$
- Process Water Return

NH$_4$HPO$_4$ → (NH$_4$)$_2$HPO$_4$ → ScPO$_4$ concentrate
### Example Case: Bauxite Residue

<table>
<thead>
<tr>
<th>Major Elements</th>
<th>g/L</th>
<th>Minor Elements</th>
<th>mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>18.6</td>
<td>Sc</td>
<td>16</td>
</tr>
<tr>
<td>Fe</td>
<td>1.7</td>
<td>Ce</td>
<td>16</td>
</tr>
<tr>
<td>Ti</td>
<td>3.1</td>
<td>Y</td>
<td>6</td>
</tr>
<tr>
<td>Ca</td>
<td>0.6</td>
<td>La</td>
<td>4</td>
</tr>
<tr>
<td>Si</td>
<td>0.3</td>
<td>Th</td>
<td>11</td>
</tr>
</tbody>
</table>

- High impurity removal rate
- Selective Sc precipitation
- Easy dissolution of Sc concentrate
- Easy further processing for further purification operations

**Diagram:**

- **1st Impurity Removal**
  - NH₃ → (NH₄)₂HPO₄ → ScPO₄ concentrate
- **2nd Impurity Removal**
  - NH₃ → Impurity Hydroxides (Sc containing)
- **Phosphate precipitation**
  - (NH₄)₂HPO₄
- **Ammonia Recovery**
  - Lime → Ca Residue
  - NH₃ → Process Water Return
Example Case: Bauxite Residue

**Extraction**
- High Sc Selectivity
- Low co-extraction

**Washing**
- Avoiding HF formation

**Stripping**
- Using NH4F
- Low impurity level
- Purification during precipitation
- Re-use of strip solution after precipitation

Diagram:
- **Extraction**
  - Strip Solution
  - Feed Solution
- **Stripping**
  - Stripped Org.
  - Raffinate
- **Washing**
  - Washed Org.
Significant Resource – Recovery from Alloys

- Expected increase in Sc usage
- Most important secondary resource of Sc
- Concentrated and already in metallic or oxide form
- Easy dissolution and processing
- Major impurities: Al, Zr, Mg, Mn
- Individual separation of each element
Significant Resource – Recovery from Alloys

Sc Source

- Milling & Sieving
- Acid Leaching
  - HCl $\rightarrow$ AlCl₃
- Solvent Extraction
  - Al $\rightarrow$ Al Product
- Sc/Zr Separation
  - Sc + Zr $\rightarrow$ Zr Product
  - Sc Product

- Al Recovery

- Fine Al-Sc Alloy powder (metallic)
  - Fast exothermic reaction
  - >99% dissolution of all metals
- Master alloy drosses (oxide)
  - Concentrated Sc in small particles
  - >95% leaching efficiency
  - Slow reaction due to stable oxides

Scandium-Inventory Workshop 2018, Berlin
Conclusions

- High focus of EU on Scandium production
  - Unreliable source and increase in demand
  - Active role in 3 Sc-related projects

- Bauxite residue is a promising resource
  - Huge stockpiled amount
  - Development of an effective process
  - Scale-up plans backed by EU H2020 RemovAL Project

- Best resource for future need will be Sc containing products
  - Recovery directly from Al-Sc alloys and SOFC
  - Highly efficient and feasible process
  - Flexible Sc product