The Role of the Non-ferrous Metals Industry in the Era of Sustainable Development Goals (SDGs)

Wednesday 23 October 2019
Altis Grand Hotel,
Lisbon, Portugal

JOINT STUDY GROUPS’ SEMINAR
“ADDRESSING THE CHALLENGE OF LOWER ORE GRADES AND RISING LEVELS OF IMPURITIES IN CONCENTRATES”

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Out line

• Introduction
• Accompany Metals in Natural Resources
• How to treat valuable metals in non-ferrous smelters
• How to treat harmful elements, Arsenic as an example
• Summary
What we have made from old time?
History of Artifacts
Human beings can’t live without artifacts
Old Non-Ferrous Metal Industrial Sectors

Present Non-Ferrous Metal Industrial Sectors

We have to stop the emissions of them

Keep green land, blue sky and sea and Keep a control of heavy metals

Non-Ferrous Metal Industrial Sectors make a strong contribution to keep beautiful environment of Earth

All resources become short or not?

- Energy Resources: oil, natural gas, coal
- Mineral Resources: Iron, Copper and other minor metals such as rare earth elements and PGMs
- Demands of Bi, Sb, Se and Te even increase: they are used for advanced materials which can contribute environmental issues

Enhance of Resource Efficiency both of Energy and Natural Resources

Create a Circular Society and achieve SDGs

Activity of Non-ferrous Industries in 3Rs
Main Targets from PCBs are Au, Ag, Cu and Pd. However, Pb and other harmful heavy metals should be recovered. And Halogens like Br has been still a problem during treatments.

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How can Metal Production be continued from Primary Resources

- Relationship between Annual Production Amounts and Clarke’s Numbers

![Graph showing the relationship between annual production amounts and Clarke’s Numbers](image)

- Chalcophile group I
- Siderophile group II
- Lithophile group III

$S = \frac{M}{T}$
- Group I: $T = 10^5 K$
  - $S = \frac{M}{T} = 30$ years
- Group II: $T = 10^4 K$
  - $S = \frac{M}{T} = 300$ years
- Group III: $T = 2.5 \times 10^2 K$
  - $S = \frac{M}{T} = 1.5 \times 10^4$ years

Good and Bad accompany metals in Copper Smelting for Natural Resources

Au, Ag, PGM, Bi, Te, Sb, Se, Cd, As, Hg, Mo
What is a Sustainability on Copper Industry?

• Developments of usages of copper
  We are living in an Electronics Society
  Electrical conductivity, strength and fabrication ability of Cu are so good, then no other materials like copper.
  many chemists have tried to develop new organic materials like copper but not succeeded.
• Keep copper resources Ore and Scrap
  Now copper contents in copper ore are less than 1.0% or 0.5%
  Copper scrap is increasing more in near future
• Keep an Environment in the production of copper including recycling

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Typical copper smelting process

Raw materials:
- Powder like resources into flush smelter
- Lamb type resources into converter

Precious metals like gold, silver and PGM are recovery after electrorefining of copper

Process flow of Toyo Plant, Sumitomo Metal Mining Co., Ltd.

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Summary of Methods for Bulk Removal and Disposal of Arsenic (1)

<table>
<thead>
<tr>
<th>Process</th>
<th>Commercial Operation</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Neutralization with lime-calcium arsenate/arsenite | Yes | • not effective at removing all arsenic from solution  
• residue not environmentally stable  
• easily carbonated by atmospheric carbon dioxide, releasing soluble arsenic |
| Neutralization with lime plus ferric iron – arsenical ferrhydride | Yes | • removes As down to <0.1 mg/L  
• residue stable if molar Fe/As >4  
• high iron requirement  
• high volume, high liquor retention residue  
• US EPA Best Developed Available technology (BDAT) |
| Neutralization with lime plus ferric plus base metals – base metal arsenical ferrhydrite | Yes | • removes As down to <0.1 mg/L  
• residue stable if molar Fe(+ base metals)/As >4 |
| Pressure oxidation – scorodite or Type I/Type II mineral | Yes | • stable arsenic mineral formed  
• requires polishing step for <0.1 mg/L As  
• minimum Fe requirements  
• requires autoclave  
• low volume, low liquor retention residue, easily filtered |
Summary of Methods for Bulk Removal and Disposal of Arsenic (2)

<table>
<thead>
<tr>
<th>Process</th>
<th>Commercial Operation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric scorodite</td>
<td>Pilot only</td>
<td>• stable arsenic mineral formed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• requires polishing step for &lt;0.1 mg/L As</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• minimum Fe requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• low volume, low liquor retention residue, easily filtered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• pressure vessel not required</td>
</tr>
<tr>
<td>Arsenic sulphide</td>
<td>Yes</td>
<td>• residue formed is unstable at pH &gt; 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• works best with As(III)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• elemental S formed with As(V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• melt with S to form glass</td>
</tr>
<tr>
<td>Copper arsenate</td>
<td>Yes</td>
<td>• specialized situations only, diminishing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• market required</td>
</tr>
<tr>
<td>Arsenic trioxide</td>
<td>Yes</td>
<td>• not environmentally stable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• market required</td>
</tr>
</tbody>
</table>

Basic research of new scorodite synthesis – collaboration Research with DOWA metal mining Co., Ltd

Process Flow Sheet of scorodite synthesis

Key point
Ferrous solution is used as starting materials

Prepared solution

0.7L of arsenic concentration 50g/L
Ferrous Sulfate 5-Hydrate
Fe/As molar ratio: 1.5

Reaction

Temperature: 95°C
Stirring rate: 1000 rpm
Oxidation: 0.2 gas
Gas volume: 1L/min
Reaction Time: 5, 60, 180, 420 min

Sampling

pH/ORP measurement at 60°C with stir

Pressure filtration

Pressure: 0.4 MPa
Pore size of membrane filter: 0.3 micron

Ferrous precipitate

Washing

Liquid/Solid (wet-cake) ratio: 10
Repurging with distilled water and filtration

Drying

18 hrs at 60°C

Solution

Scorodite

D.P., SEM, XRD
Particle size analyzer, BET
Leach Test

Characterization of Scorodite: SEM

- The precipitated sample at 5 minutes confirmed crystals somewhat irregular.
- The results also showed that large-sized crystal particles formed at 60 min.

Characterization of precipitates: XRD

- All precipitated samples including 5 minutes of reaction time were identified as scorodite
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Base Metals and Minor Metals recovered from Primary and Secondary Resources in Non-Ferrous Industry

More than 20 metals can be recovered except RE, W, Mo, V, Mn, Cr, Nb, Ta and Li
Summary
Necessity of Comprehensive Control of Impurity Elements

• To develop SDGs businesses utilizing non-ferrous extractive metallurgy and its fundamental technology, it is necessary to control by-products and impurities contained in the by-products within a comprehensive system.
• Impurities have been efficiently recovered by recycling them within each smelter and refinery for the extraction processes of non-ferrous metals—copper, zinc and lead.

Thank you for your attention

Pb  Ag  Au  Cu  Hg

Obrigada