Exploring the Potential Use of Monoethanolamine-Based Lixiviants for Lead Extraction from Zinc Calcine and Zinc Leaching Residue

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S. Shao et al. (2022) "A review on the removal of magnesium and fluoride in zinc hydrometallurgy".

[1]
For 1 ton of Zn produced → 0.5-0.9 ton of zinc leach residue (ZLR) generated

- ZLR is generally landfilled
- ZLR still contains valuable metals, e.g. Zn, Cu, Ag, Pb

Pb used: batteries, ammunition, radiation protection material.

Produced as a by-product of Zn processing → Pb as insoluble anglesite (PbSO₄).

What we study:
- Pb is extracted in the first step, directly from zinc calcine (ZC)
- The method is applied to extract Pb from ZLR
- Preventing the generation of strongly acidic ZLR
- Avoiding high lixiviant consumption

What we apply:
Alkaline lixiviant based on monoethanolamine (MEA)
MEA: a bifunctional solvent with amine and hydroxyl functional group

\[ \text{H}_2\text{N-CH}_2-\text{CH}_2-\text{OH} \]

Industrial application:
CO\(_2\) adsorber
Wood preservation
Surfactant

Application in metal extraction:
Recovery of Pb from waste battery scrap by leaching in mono-, di- and triethanolamine (MEA, DEA, TEA) in aqueous solution\(^2\)

\[
Pb\text{SO}_4 (s) + \text{TEA (aq)} \rightarrow Pb(\text{TEA})^{2+} \ \text{SO}_4^{2-} (\text{aq})
\]


\[ \begin{align*}
\text{M} & \quad \text{H}_2\text{N} \\
\text{C}_2\text{H}_4 & \quad \text{OH} \\
\text{NH}_2 & \quad \text{H}_4\text{C}_2\text{O}
\end{align*} \]

[3]  

[4]
### Elemental Composition (wt%)

<table>
<thead>
<tr>
<th></th>
<th>Zn</th>
<th>Pb</th>
<th>Fe</th>
<th>Si</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZC</td>
<td>53</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>ZLR</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

### Mineralogical Analysis

- **A** - Anglesite (PbSO₄)
- **F** - Franklinite (ZnFe₂O₄)
- **W** - Willemite (Zn₂SiO₄)
- **ZO** - Zn oxide (ZnO)
- **Gy** - Gypsum (CaSO₄·2H₂O)
- **P** - Plumbojarosite (Pb₀.₅Fe(SO₄)₂(OH)₆)

Relative Intensity (a.u) vs 2 theta (deg)
Preliminary Leaching Test

- Leaching in pure MEA is selective, but low LE
- The addition of ammonium salts increased the extraction of both Pb & Zn → higher LE, less selective

(T=25 °C; t=3 h; S/L ratio=1/10; stirring speed=500 rpm)
The minimum ammonium salt concentration and leaching time are required to achieve high LE.

- Pure MEA & MEA-(NH$_4$)$_2$SO$_4$ dissolved anglesite; zinc phases remained insoluble
<table>
<thead>
<tr>
<th>Leaching Treatment</th>
<th>Pb (%)</th>
<th>Zn (%)</th>
<th>Fe (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MW-Leaching</strong></td>
<td></td>
<td></td>
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<tr>
<td>MEA+(NH₄)₂SO₄; 120, 150 °C; 15, 30, 60 min</td>
<td>0.2 – 0.6</td>
<td>3.0 – 5.1</td>
<td>19.4 – 25.9</td>
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<td><strong>Water Bath Leaching</strong></td>
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<tr>
<td>MEA+(NH₄)₂SO₄; 100 °C; 4.5 h</td>
<td>0.1 ± 0.0</td>
<td>14.9 ± 0.6</td>
<td>21.1 ± 1.3</td>
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<td><strong>Room Temperature Leaching</strong></td>
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</tr>
<tr>
<td>MEA+(NH₄)₂SO₄; 25 °C; 3, 6, 12, 24 h</td>
<td>0.1-0.3</td>
<td>17.4-19.5</td>
<td>-</td>
</tr>
</tbody>
</table>
Negligible Pb yield due to reductive leaching → PbSO₄ is transformed into PbS.
- MEA-lixiviant can leach Pb from anglesite phases in zinc calcine
- ZLR leaching in the MW can destruct plumbojarosite phases
- MEA-lixiviant can not leach Pb from zinc leaching residue $\rightarrow$ reductive leaching to produce galena (PbS)
- On-going work: to understand reductive leaching of ZLR
Thank you

This project has received funding from the European Union’s EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 812580.