Improvement of oil sands tailings treatment using enhanced flocculation process
Chemical Treatment of Fine Tailings

- Oil sand fine tailings are a stable suspension which is slow to settle

- Chemical flocculation remains a dominant approach
  - A part of many technologies in Tailings Management Plans proposed for Directive 085
  - Polyacrylamide (PAM) flocculants are an established technology

- Coagulation helps modify surface charge
  - Help clay capture, reduce polymer dose
  - Inorganic coagulants (Ca, Mg, Al, Fe)
  - Organic polymers (DADMAC)
Traditional Anionic PAM

- Copolymerization of acrylamide and sodium acrylate

- Initial optimization
  - Charge density
  - Polymer molecular weight

- Additional optimization
  - Linear vs. structured
  - Dual polymer systems
  - Bridging cations
Additional Approaches to PAM

- Combining more than 2 monomers
  - Addition of cationic functionality
  - Associative functionality

- Sequence of functional group
  Random: AABABBABAABB
  Alternating: ABABABABABA
  Block: AAAAAABBBBBAAAAAA

![Diagram of structures A and B with chemical formulas](image)

<table>
<thead>
<tr>
<th>Settling Bed Height</th>
<th>Time of Settling</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>45</td>
</tr>
</tbody>
</table>

Structure 1 | Structure 2
Objectives and Approach

- Further investigations into PAM beyond charge density and molecular weight

- Improve flocculation to achieve:
  - Faster, continued dewatering rates
  - Improved water quality for reuse (lower solids and bitumen content)

- Application of novel polymeric flocculants to determine their efficacy in treating MFT

- Study the effect of inorganic coagulants to enhance the overall flocculation process
Experimental

Materials
• MFT (10% solids) and process water from Alberta, Canada
• Comparison of conventional and novel flocculants
• Aluminum coagulants (Kemira)

Methods
• Coagulant followed by flocculant
• Observe settling rate

Results
• Turbidity: HACH DR/890
• Solid content: gravimetric analysis

<table>
<thead>
<tr>
<th>Polymeric Flocculant</th>
<th>Anionic Charge Density</th>
<th>Relative molecular weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional 1</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Conventional 2</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Novel 1</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Novel 2</td>
<td>Medium/Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Novel 3</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Results
Polymer Alone

Novel polymers 1 and 2 were successful in achieving higher settling rates while minimizing turbidity.

Decrease in settling rate for the Novel polymers follows a decrease in charge density.

- Novel 1 and 2 used for further testing in combination with aluminum coagulants.

Flocculant dosage: 500 ppm
Results

Addition of Aluminum Sulfate

The introduction of coagulant reduced the turbidity of the supernatant for both Novel polymers

Impact of coagulant addition on settling rate significantly different

Difference in settling rate potentially attributed to differences in sequencing of the functional groups
Results

Aluminum containing coagulants

Within aluminum containing coagulants, ALS showed best performance

Increasing Al content or basicity did not improve results beyond ALS

<table>
<thead>
<tr>
<th>Coagulant</th>
<th>Type</th>
<th>Al content (%)</th>
<th>Basicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALS</td>
<td>Aluminum sulphate</td>
<td>4.3</td>
<td>n/a</td>
</tr>
<tr>
<td>PAX-XL60</td>
<td>PAC</td>
<td>7.5</td>
<td>Medium</td>
</tr>
<tr>
<td>PAX-18</td>
<td>PAC</td>
<td>9.0</td>
<td>Medium</td>
</tr>
<tr>
<td>PAX-XL6</td>
<td>PAC</td>
<td>5.4</td>
<td>Medium</td>
</tr>
<tr>
<td>PAX-XL3919J</td>
<td>PAC</td>
<td>9.9</td>
<td>High</td>
</tr>
<tr>
<td>PASS-10</td>
<td>Polyaluminum sulphate</td>
<td>5.3</td>
<td>Medium</td>
</tr>
<tr>
<td>PAX-XL19</td>
<td>PAC</td>
<td>12.5</td>
<td>High</td>
</tr>
</tbody>
</table>

Al-coagulant dosage: 85 ppm; Flocculant dosage: 500 ppm
Undilute MFT
Initial investigations

- MFT: 33.5% solids, 0.32 CWR
- Centrifugation of flocculated MFT at 1090 rcf
- Novel polymer achieved similar performance at significantly lower dose
- Mapping performance in MFTs with various density and CWR
Conclusions

• Optimized novel polymers can enhance dewatering rates and recovered water turbidity levels

• Proposed polymers showed synergistic behavior with aluminum sulfate coagulant
  – Reduce turbidity further, potential to reduce polymer dosage

• In initial studies, some of the Novel polymers are showing a potential dose reduction in undiluted MFT conditions
Current and Future Work

Further investigate:

i. Additional aluminum-containing coagulants to compare efficiencies with the target flocculants.

ii. Enhanced flocculation with undiluted MFT

iii. Characterization of novel polymers to explain synergistic behavior with coagulants

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Thank you

Questions?

kemira
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