Cationically Grafted Natural Flocculant for Dewatering of Mature Fine Tailings

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Presentation for IOSTC 2018, December 12th
• Bitumen is extracted from oil sands using hot water and caustic.
• By-product waste slurry is called tailings.
• Recovery of 1 barrel (159 L) bitumen generates 3300 L tailings.
• Tailings ponds cover a footprint of ~175 km².
Background (2): Tailings Treatment Processes

- Consolidated Tailings
- Paste Technology
- Chemical Treatment
- Electrical Treatment
- Biological Treatment
- Pressure and Vacuum Filtration
- Freeze-thaw Technology

Process
• Natural polymers are made up of starch, cellulose, chitosan.

• They are biodegradable, safe to handle, easily available, and produce no secondary pollution.

• Chitosan can produce non-toxic sludge that could be used to stimulate growth in plants.
Objective and Approach

**Objective:**


**Approach:**

- Enhance the Solubility
- Cationic modification

**Measurable parameters:**

- Initial settling rate (Cylinder test)
- How fast sediments dewater (CST)
- Turbidity of supernatant
- Sediment solid content (SSC)
Experimental(1): Modification of Chitosan

Synthetic route of modification of chitosan via two steps: a) oxidation of chitosan; b) grafting/polymerizing PMATMAC onto oxidized chitosan.
Experimental (2): Flocculation Test

- Polymer addition and mixing
- Dewaterability measurement and mudline monitoring
- Supernatant Separation and solid content measurement

After 24 hours
Absence of C=C bond stretching of alkene at 1634 cm\(^{-1}\)

1478 cm\(^{-1}\) (C-H bending of quaternary amine cation), 1634 cm\(^{-1}\) (C=C bond stretching of alkene), 1713 cm\(^{-1}\) (C=O stretching of ester),

Asymmetrical stretching vibration of COO\(^{-}\) at 1394 cm\(^{-1}\) and the stretching of carboxylic acid O–H at 2356 cm\(^{-1}\)

1560 cm\(^{-1}\) (N–H bending of amine), 1651 cm\(^{-1}\) (N–H stretching of amine), 3350 cm\(^{-1}\) (O–H stretching)
Results & Discussion(2): ISR of Flocculated MFT
• Capillary suction time (CST) reflects the dewaterability of sediments.

• The instrument measures the time required by water to travel a certain radial distance.
Results & Discussion(4): Supernatant Turbidity & SSC
• The best flocculation performance of the flocculant in terms of ISR, CST, turbidity, and the solids content was observed at 6000 ppm.

• Effective MFT dewatering requires optimization of polymer architecture and operating conditions.

• In general, our results provide new insights into the development of novel green flocculants, which require further systematic research on scale-up synthesis.
Thank you!
Mature Fine Tailings (MFT): Composition, Physical Properties, and Theory

- MFT contains 30-35% solids (clays), 65-70% water, and 4-5% bitumen.
- MFT has pH 8-9, zeta potential -40 mV, and various ions (K⁺, Na⁺, Mg²⁺, Ca²⁺)

Why clays have negative charges?

Kaolin and illite clay structure

How charges can be neutralized?
The presence of the polymer on the particle surface can be described according to Equation (3).

\[ P_B = \theta(1 - \theta) \quad (3) \]

where \( P_B \) is the probability of polymer present on particle surface and \( \theta \) is the particle surface covered by the polymer. The probability of flocculation \((P_B)\) can be maximum when \( \theta \) is equal to 0.5, suggesting that a lower turbidity can be achieved when half of the particle surface is covered by the flocculant.
• Non-ionic polymers are rarely used as flocculants.
• Cationic polymers can neutralize the negative charges on clays and bridge them.
• Often, anionic polymers are used with divalent cations.
• Currently, acrylamide-based polymers are used in industry.
Polymerization Scheme