Colloidal clay gelation: relevance to current oil sands operations

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– Colloidal Clay Gelation –
Relevance to Current Oil Sands Operations

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Settling Behaviour of Mature Fine Tailings (MFT)

before agitation

~3 wt% ultrafines

after agitation

Kotlyar, Sparks et al. (1992) AOSTRA J. Res. 8(1):55-61
Diluted MFT
Effect of using dispersing and flocculating agents
Reaction limited flocculation

Diffusion limited flocculation

Ultrafines suspensions settle to nearly same solids concentration (~3% wt%)

More rapid water release for recycle favoured by fast flocculation
in situ measurement of gelation rate
ultrafines concentration and water chemistry

Two conditions are necessary for an aqueous suspension to form a thixotropic gel:

-- critical amounts of ultrafines (3wt%) or clays (10-15wt%)

AND

-- sufficient concentrations of flocculating cations (Na, Ca, Mg)
Transmission Electron Microscopy of Ultrafines

mostly phyllosilicates
minors: $\text{TiO}_2$, pyrite $\text{FeS}_2$, etc.
XRD Measurements

Mercier et al. (2007) CSChE Congress, Edmonton

high intensities

ultra-fine-free clays

kaolinite 001

illite 001

total clays

ultra-fine clays

Intensity (Counts)
diffractometer angle 2θ (degrees)

Intensity (Counts)
diffractometer angle 2θ (degrees)
XRD-derived Marker combining Phyllosilicates Mineralogy and their Size Distributions

For a waste unit sample, this data representation showed that:

-- the illite/kaolinite XRD peak area ratio increases as average clay mineral thickness decreases (i.e., the clays in this oil sands are more-and-more illite-rich as the particle size gets smaller)

Mercier et al. (2007) CSChE Congress, Edmonton
XRD Analysis of Smallest Size-Fraction in a Waste Unit Sample

XRD patterns for delaminated illite and kaolinite calculated with Debye’s formula

The calculations assumed a particle with 6 nm diameter and a thickness $t$ comprising one composite layer.

Part 2

Application to current commercial operations
Segregation and non-segregation comparison

Water to oil sands ratio 0.7

0.5% ultra-fines
5.7% fines
12.2% bitumen

Water to oil sands ratio 2.0

1.8% ultra-fines
16.6% fines
8.7% bitumen

Segregation and non-segregation comparison
Effect of Ultrafines and Clays on GSV Performance

High ultra-fines and salt content (No bitumen separation)

Low ultra-fines and salt content (Bitumen can separate)

Conditioning (dispersion of clays)
Comparison of total solids content with ultrafines concentration in the middlings zone of BEU and Pilot tests

**2.9 wt% ultrafines**

**13 wt% fines**

**GOC = gel onset concentration**

(minimum conc. producing noticeable thickening of suspension)

Process failure required plant shutdown
Processability marker for ultrafines content in oil sands ore

ultrafines content of oil sand ores
not a simple function of fines content

anomalous samples
10 Regionally-Distributed Oil Sands Samples from Syncrude

- Estuarine (5 samples)
- Marine (5 samples)

Fines (wt.% of oil sands) vs. Bitumen (wt.% of oil sands)

- Poor Recovery
- Good Recovery
- Expectation
Clays content appears useful as potential processability marker. Although not enough clays are present to possibly cause gelation in GSV, the clays content might be sufficient to induce slurry thickening.

ultra-thin clay mineral content by XRD

ultra-fines concentration without time-consuming separation of this component

Summary

1) Earlier research on settling of MFT and ultrafine/clay suspensions revealed that:
   -- MFT always contains ~3wt% ultrafines
   -- aqueous suspensions with 3wt% ultrafines readily form gels if enough flocculating cations are present
   => Ultrafine gels can therefore account for 100% of the water holding capacity of MFT

2) Recent applications to current oil sands operations have demonstrated that:
   -- the ultrafines content of an ore may be responsible for reduced segregation of bitumen and solids in a GSV
   -- ultrafines content may therefore represent an indicator for both bitumen recovery and extent of MFT formation
   -- recent XRD developments for analyzing clay minerals in oil sands may make the determination of this parameter easier
Part 3: Concluding remarks

New regulation from Alberta ECRB Directive 074, effective September 2009, will impose future tailings performance criteria and requirements for oil sands mining schemes.

This regulation requires the reduction of fluid tailings and their conversion into trafficable deposits.

As such, the application of this directive will effectively place stringent limits on the amount of MFT which can be produced by oil sands operators.

In this light, we expect that predicting the extent of MFT formation will be important and achievable by monitoring the ultrafines content of ores.

Our recently developed XRD-based methodology shows potential to reach this objective.

Based on our earlier work in this field, we believe that the ultrafines content of an oil sands sample represents the ore property that is most relevant to explain MFT formation.

The physical limitations inherent to aqueous suspensions of ultrafines should therefore be taken into account in dealing with fluid tailings management.
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