POLYMER-FFT INTERACTIONS: FROM SURFACE CHEMISTRY TO RHEOLOGY

by

Mohammadhasan Sasar

Fluid fine tailings (FFTs) are generated in oil sands mining operations when the high water content processed ore is deposited into tailings containment ponds. FFTs are the main reason why tailings ponds cannot be reclaimed and returned to original landscape. Therefore, the development of innovative methods for addressing the problems caused by both legacy and new tailings is a pressing need for the industry.

This thesis presents the results of a multidisciplinary study of FFTs and their treatment using polymeric flocculation. Thermal (TGA/EGA) and spectroscopic (FTIR) analysis, methylene blue absorption and Dean-Stark extraction tests are used to characterize the FFTs and the residual bitumen. Additionally, a washing-based method is developed to investigate the partitioning of the organics in the FFTs.

The experimental work focuses on two contrasting FFT samples: one (FFT-1) from a pond that received waste from the bitumen extraction process; the second (FFT-2) originating from a more complex tailing pond with waste from both bitumen extraction and froth treatment processes. Thermal and spectroscopic analyses establish that compared to FFT-1, FFT-2 is characterized by higher concentration of residual organics, higher proportion of lower molecular mass organic substances, and a higher fraction of mineral associated organics. The compositional differences detected in the two FFTs are linked to observed differences in the flocculation, water release and rheology of the two materials. Therefore, the data establishes the uniqueness of FFTs and the necessity for the individual examination of these materials when designing a treatment plan.

Consistent and reproducible flocculation of the tailings is performed using both a conventional benchtop system, as well as a novel miniaturized setup that combines rheometer and polymer injection system to allow controlled delivery of the polymer directly into the rheometer cup. This enables rheological measurements during polymer injection, providing the means to study the flocculation process in quasi-real time.

Characterization of the mechanical properties of the FFTs both raw and after flocculation with a commercial anionic polyacrylamide (A3338) is conducted using a suite of rheological tests, designed to probe the response of these materials over a broad range of strains and shear rates. Large amplitude oscillation shear (LAOS) tests on FFT-1, performed in parallel with the injection of polymer in incremental doses up to and beyond the optimal water release dose, highlight unique behavioral features of the optimally dosed FFT, provide insight into the underlying structure, and identify rheological “indicators” that signal its formation.

Additional rheological tests on samples of optimally dosed/sheared flocculated FFT at different stages of dewatering show that successful flocculation leads to an improvement of the mechanical properties relative to the raw FFT at the same clay to water ratio. These effects are attributed to the percolated network formed as the polymer aggregates mineral particles, and further bridges these aggregates. This structure dominates the response of the material. Increasing disturbance causes rapid and irreversible degradation of the response, evidence of the sensitivity of the structure. The insights obtained from rheology are used to develop a model for the structure formed by polymer flocculation, its evolution with dewatering, and its sensitivity to disturbance.

This thesis also documents the release of free bitumen from both FFTs as a result of polymer addition.

<u>Thesis Committee:</u>

Professor M. Santagata – Purdue CE (co-Chair)

Professor C. Johnston – Purdue Agronomy and EAPS (co-Chair)

Professor A. Bobet – Purdue CE

Professor Heather Kaminsky – Northern Alberta Institute of Technology