Abstract

Canada has the world's third largest oil reserves, mostly located in Alberta region as the oil sands deposits. Alberta oil sands are the only one to make bitumen extraction feasible just using warm water in commercial scale, although oil sands deposits are found all over the world. The oil sands are a loose sand deposit containing a very viscous form of petroleum known as bitumen, coarse sand grains, fine minerals solids, clay and water. In the surface mining operation, the oil sands ore is mixed with warm water (35 - 80 °C) and caustic to produce a slurry. The slurry is then transported to the extraction plant by pipeline, where the bitumen froth is recovered by flotation. The bitumen froth is treated by adding organic solvents to remove remaining water and fine solids, and the final bitumen product is shipped to downstream for upgrading or refining process. While bitumen extraction using warm water is an economic recovery process, its disadvantage is high fresh water and energy consumption. The volumetric water/bitumen ratio in this process is approximately 19. The majority of the process water is recycled, but some of the water is trapped in the wet unsettled tailings, giving net consumption of 2 – 4.5 barrels of fresh water to produce 1 barrel of bitumen. The resulting wet tailings, a mixture of water, fine solids, and residual bitumen, require large tailings ponds, which had accumulated to about 1.18 billion m^3 by 2015. These large volumes of wet tailings are a risk to wildlife and a liability for future remediation. Over decades, numbers of technologies have been attempted to solve these issues but the challenges remain. New and emerging technologies to improve current oil sand industry's performance and to reduce the environmental compact are strongly demanded. In the seminars, I will present an overview of current bitumen extraction from oil sands industry and introduce new research directions undertaken in our research group, which consists of both fundamental understanding of the issues and new technologies development.

Presentation 1. Roles of Fine solids/Clays in Water Based Bitumen Extraction from Alberta Oil Sands

How to recover bitumen from the oil sands economically and efficiently is the ultimate goal of oil sands industry. One of major technical challenge in water based bitumen extraction is the ore processibility. It was found that the fine solids in ores have a detrimental effect on bitumen recovery, where ores with low fine content give good bitumen recovery (> 90%) while ores with high fine content yield low bitumen recovery (< 70%). In reality, the quality of ores varies from one mine location to another and within the same mine location, which affects the bitumen recovery adversely. It is generally acknowledged that the clay fraction (< 5 μm in size) is the key factor to influence the bitumen recovery, but the mechanism of the fine solids/clay affecting bitumen recovery is unclear. In this talk, I will summarize recent progress in fundamental understanding the interactions of fine solids/clay with bitumen using different techniques, and brief what the clay research gap in oil sands processing is.

Presentation 2. Dewatering and Consolidation of Oil Sands Mature Fine Tailings

The accumulation of oil sands tailings poses serious environmental issues in oil sands industry. In the tailings ponds, the fine clays and residual bitumen form the so-called mature fine tailings (MFT) which contain 30-40 wt% fine solid particles primarily below 44 μm in size (average 5-10 μm), 1-3 wt% residual bitumen with the balance water. Without any physical or chemical treatment, the MFT remains as a stable suspension in tailings ponds indefinitely. Traditional

wisdom is to add single polymer as process aids to accelerate fines flocculation and tailings dewatering/consolidation, but the results are not satisfactory. In this talk, I will present the recent results obtained by our research group in dewatering and consolidation of MFT. We found that 1) a two-stage polymer treatment (i.e., dual polymers treatment) has better dewatering performance than single polymer treated MFT in terms of capillary suction time (CST), filtration rate, and final solids content after filtration; 2) the large porous structure of treated MFT formed by the dual polymer treatment is believed to be the kay factor for water release of MFT; 3) the residual bitumen in MFT causes poor dewaterability of MFT and high dosage of polymers used for dewatering; and 4) geopolymerization of clays in MFT can be manipulated for MFT consolidation.

Presentation 3. Towards Understanding the Nature of Fine Solids in Non-aqueous Extraction of Bitumen

Non-aqueous extraction (NAE) of bitumen as a new technology and potential game-changer could significantly decrease the demand of fresh water in the extraction process and eliminate the challenging tailings and associated environmental issues. However, one of key challenges for NAE process is the product quality of NAE bitumen, where 0.5-15 wt% of residual fine solids suspended in NAE bitumen far exceeded the refinery feed requirement (< 0.03 wt% (300 ppm) fine solids content). A fundamental understanding of the properties and behavior of fine solids in NAE bitumen is crucial to seek efficient strategies to reduce the fine content in NAE bitumen. This talk will detail the characterization of fine solids in terms of wettability, mineralogy, composition and surface morphology. The mechanism of fine solids suspended in bitumen in terms of interaction forces and origin of those forces and the impact of these residual fine solids on solvent recovery will be discussed.

Brief Bio: Dr Xiaoli Tan is a colloid/polymer chemist with extensive experiences in the chemistry of many aspects of oil sands processing (extraction, bitumen froth treatment and cleaning, oil sands tailings treatment, and fundamental studies on asphaltene structures and aggregation). Currently Dr Tan is a research associate in Institute for Oil Sands Innovation (IOSI) at University of Alberta, where he is leading several research teams working on projects in the areas of oil sands non-aqueous extraction, bitumen upgrading, and oil sands tailings management. Prior to that time, Tan was a postdoctoral fellow to study the chemical structures and aggregation behavior of petroleum components in Department of Chemical and Materials Engineering, University of Alberta in 2005-2008. Tan obtained his Ph.D in Physical Chemistry with specialization in Colloid Chemistry from Technical Institute of Physics and Chemistry (Beijing), Chinese Academy of Sciences in 2005. He also holds a B.Sc degree of Applied Chemistry from Inner Mongolia University (2000). He has 35 publications in scientific peer-reviewed journals.