BITUMEN RECOVERY AND CLEANING BY NONAQUEOUS EXTRACTION FROM SHALLOW DEPOSITS

BITUMEN-SOLVENT PRODUCT CLEANING

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BACKGROUND

Current bitumen extraction process from the Alberta oil sands is plagued by high fresh water use (4-5 bbl of fresh water per bbl of oil), high energy consumption (i.e., high GHG emission of 88 kg CO_2 per bbl of oil), and large tailings impoundment areas (>170 km^2 so far). All three problems are caused by the mobilization of the fine minerals (clays) in the oil sands by the caustic warm water, which combine with un-extracted residual bitumen to form a gel-structure that holds water indefinitely.

UAlberta has been working with Imperial Oil in the past 10 years to develop non-aqueous extraction (NAE) processes through the Institute for Oil Sands Innovation (IOSI). The NAE can operate at ambient temperature and generate dry stackable tailings, thus eliminate all the three problems above. Our vision of how the oil sands, as an energy source, fits in an energy system in the near future is as follows:

Oil sands mining → NAE → Cleaning / partial upgrading → Refinery

Oil sands in-situ (solvent/thermal) ↗

Theme 8 is on oil sands non-aqueous extraction. This project (Project T08-P02) is on product cleaning and partial upgrading.

SHORT-TERM OBJECTIVES

The short-term objective of this project (next 2-4 years) is to identify techniques that can remove the fine mineral solids from bitumen-solvent product to below 0.03 wt% through small-scale laboratory testing. Techniques that will be tested include: removal by bio-inspired polymers; by seasoned water droplets; by functionalized magnetic particles; by mild hydrothermal treatment and hot filtration. The possibility of combining bitumen cleaning with partial upgrading of the bitumen in the hydrothermal process will be explored. First, by using the clays as reactive surfaces, drawing on the catalytic properties inherent to the clays to change both clay and bitumen. Second, by understanding how non-aqueous extraction can best promote partial upgrading in tandem with extraction.

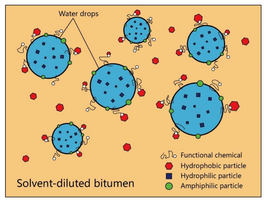
Ultimately, the identified technique(s) in an integrated NAE extraction and bitumen product cleaning circuit to assess the viability of the technique(s), and to deal with the separated fine solids streams. It is also anticipated that the product cleaning and partial upgrading can be accomplished in a single step if a mild hydrothermal treatment is used.

PROJECT OVERVIEW

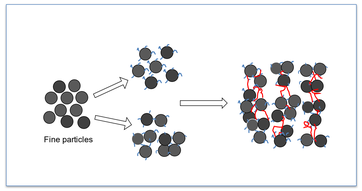
One of the challenges for a feasible NAE process is that the final extracted bitumen product is free of water and mineral and clay solids so that it can be used as refinery feed. This project is a systematic investigation of various physical and chemical methods aimed at cleaning up the NAE bitumen from oil sands to meet this target while maintaining high bitumen recovery.

The project T08-P02 will be carried out by five CO-PIs, Qi Liu, Arno de Klerk, Hongbo Zeng, Anthony Yeung, and Xiaoli Tan, from the Department of Chemical and Materials Engineering at the University of Alberta. **Qi Liu** oversees project management and execution, as well as works on hydrothermal NAE bitumen cleaning and using magnetic particles to clean NAE bitumen. **Hongbo Zeng** works on using bio-inspired polymers to clean NAE bitumen. **Arno de Klerk** works on hydrothermal partial upgrading of NAE bitumen and (clay) catalysts necessary for hydrothermal partial upgrading. Hydrothermal partial upgrading may be combined with hydrothermal NAE bitumen cleaning in the same process. **Tony Yeung** works on using seasoned water droplets to clean NAE bitumen. **Xiaoli Tan** works on hydrothermal NAE bitumen cleaning and magnetic particles to clean NAE bitumen. He also supports all research activities in this project.

Water droplets

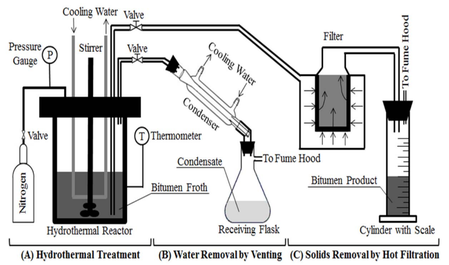


Polymers



Magnetic carriers and magnetic filtration

Hydrothermal treatment and filtration



THEME OVERVIEW

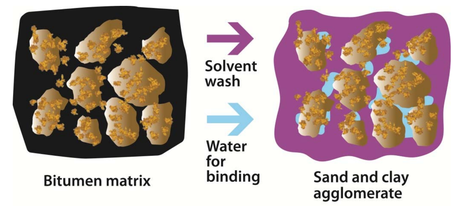
Heavy Oil - Non-Aqueous Recovery

Excessive freshwater use and its eventual capture in tailings ponds represent some of the most concerning elements of the oil sands industry. The requirement for water to be heated as part of the process is also a serious concern, as it demands the use of considerable energy as part of the extraction process. Developing a Non-Aqueous Extraction (NAE) method for recovering oil from the oil sands without the use of water could significantly reduce the environmental and carbon footprint of extracting these resources, and the fundamental science developed to support this process could enable significantly improved cleanup of oil sands sites.

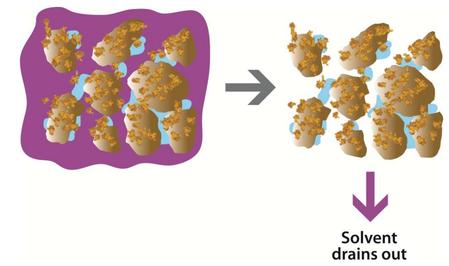
EXPECTED OUTCOMES

The outcome can be an identified bitumen-solvent product cleaning technique that is capable to remove suspended fine mineral solids to below 0.03 wt% so that the bitumen can be directly used as feed to refineries. It is also anticipated that the product cleaning and partial upgrading can be accomplished in a single step if a mild hydrothermal treatment is used.

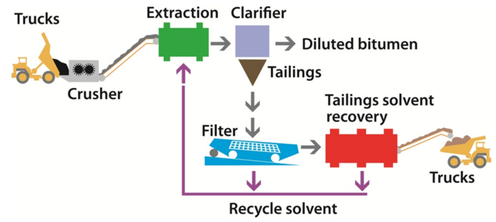
1. Solvent extraction



2. Solid-liquid separation



3. Overall NAE process



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