Removal of Fine Solids from Bitumen by Polymer Flocculants during Non-aqueous Extraction of Oil Sands

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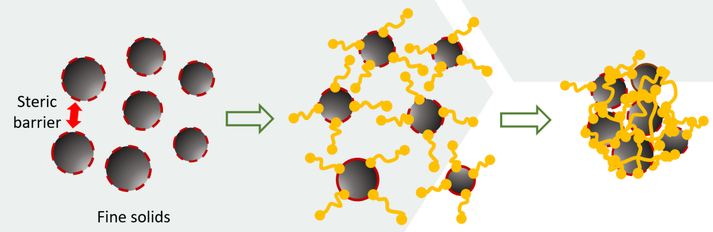
BACKGROUND

Non-aqueous extraction (NAE) of oil sands has been considered as an alternative technology to the conventional water-based extraction to decrease fresh water usage and avoid tailings issues. However, the significant amounts of fine solids left in the NAE bitumen make the product unsuitable for downstream operations. Surface characterization and surface force measurements demonstrate that the steric interaction among bitumen-adsorbed fine solids plays a dominant role in stabilizing these fine solids in the bitumen-solvent mixture. In this work, Polymer flocculants have been applied to bridge and flocculate the fine solids to clean up the NAE bitumen, via different interactions such as acid-base interactions, π-π stacking and intermolecular H-bonding attractions among polymers and solids coated with bitumen. This work provides useful information regarding the surface properties of the fine solids left in the bitumen from the NAE process and the development of feasible approaches for removal of these fine solids.

AIMS AND OBJECTIVES

The ***short-term*** objective of this research work is to investigate performances of polymer additives in flocculating and settling bitumen-coated fine solids in organic media, and to characterize interaction behaviors of polymeric flocculants with fine solids with coated bitumen in organic media in the NAE process.



The ***long-term*** objective is to explore suitable polymers to remove fine solids from NAE bitumen and ultimately resolve the challenging fine solids issue in the NAE process.

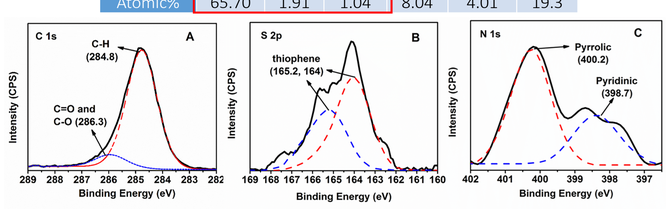
SURFACE PROPERTIES OF FINE SOLIDS

❖ Presence of adsorbed bitumen on fine solids

Chemical state of the outer-most surface of fine solids were detected. C was highly concentrated (65.7 %) on fine solids, assigned to carbon in aliphatic, aromatic C-H and C-O environments. The elements S and N are important heteroatoms in bitumen. XPS analysis indicated that bitumen was adsorbed on the surfaces of fine solids.

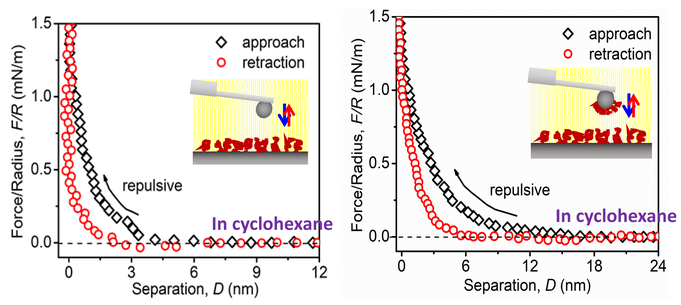
Atomic % of elements on fine solids characterized by XPS

Element	C 1s	S 2p	N 1s	Si 2p	Al 2p	O 1s
Atomic%	65.70	1.91	1.04	8.04	4.01	19.3



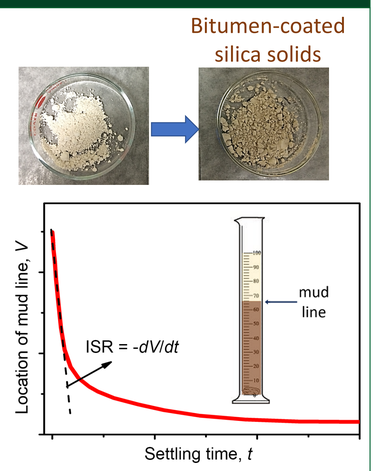
❖ Steric interaction among bitumen-coated fines

AFM force measurements in a model system revealed that the presence of adsorbed bitumen on fine solids introduced steric repulsion between two solids, leading to the long-time stable solids suspension in organic media and making it difficult to settle down and remove fine solids from bitumen-solvent mixture in NAE process.



SETTLING TESTS

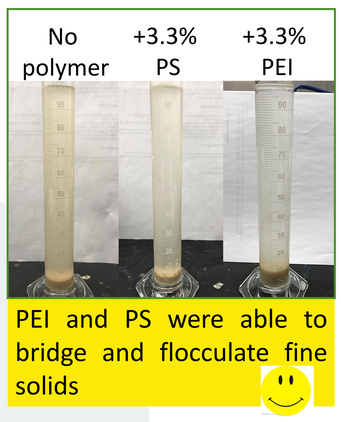
- bitumen-coated silica solids were first dispersed in cyclohexane.
- A small amount of polymer was added to the solids/cyclohexane dispersion.
- The mixture was transferred to 100ml cylinder and the location of mudline was recorded during the settling process.

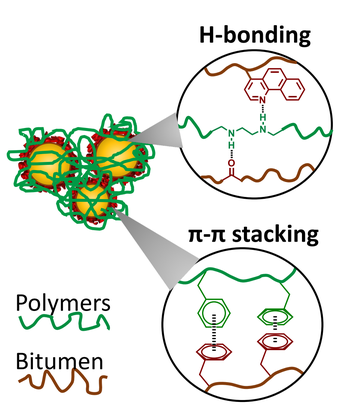


Schematic of settling tests and initial settling rate (ISR) calculation

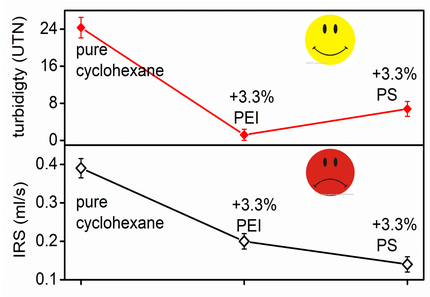
SETTLING TESTS WITH ADDITION OF POLYMERS

❖ After settling for 30min, the supernatant in 3.3% PEI and 3.3% PS cases exhibited relative higher clarity than that in No PEI case.

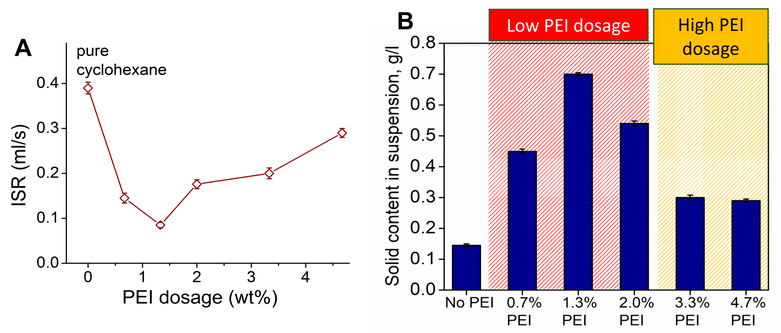




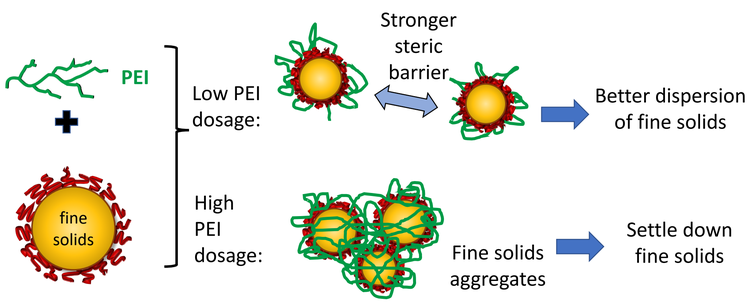
❖ With addition of PS or PEI, turbidity of supernatant became appreciably low, but ISR of fine solids was significantly decreased.



❖ Why polymer addition reduced ISR?—— (A) ISR of fine solids and (B) content of released supernatants after being dried as a function of PEI dosage



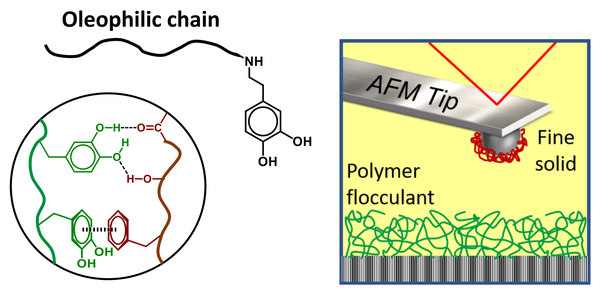
❖ Role of PEI in fine solids settling…



FUTURE PLANS

Aims: strengthen interactions between polymers and fine solids with coated bitumen, increase ISR of solids in cyclohexane and reduce content of polymers in released supernatant

Interested polymer::
Catechol-terminated polymers



Aims: characterize interaction behaviors of polymeric flocculants with fine solids with coated bitumen in organic media in the NAE process

Technique: Atomic Force Microscopy (AFM)

FES PROJECT OVERVIEW

T08-P02

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

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