Measurement of the interfacial tension of the water-bitumen interface using an in-house developed novel microfluidic platform

Background: This project will contribute to a larger project sponsored by the oil sands company, Syncrude Canada Limited. After the froth treatment section in the processing of the oil sands from Athabasca, the product – diluted bitumen, still contains about 2 to 3 wt% of water. This water exists in the form of extremely fine droplets, which cannot be removed using the unit operations of inclined settling and centrifugation currently employed by Syncrude. The salts in the residual water have strong implications for bitumen upgradation, including the possibility of corrosion of equipment and poisoning of catalysts, both of which lead to significant downtimes. Thus, in the oil-sands industry, the presence of water in bitumen is highly undesirable. The retention of water can be attributed to asphaltenes and naphthenic acids, the surfactants indigenous to bitumen. Asphaltenes and naphthenic acids influence drop breakup processes that produce fine droplets and induce interfacial stability that inhibits coalescence. The parameter that is central to all of these processes is the interfacial tension (IFT) of the water-bitumen interface. Unfortunately, the dynamic interfacial behavior exhibited by this system has remained largely unexplored due to its complexity. In our group, we have developed a novel microfluidic platform, MEFD, to fill this gap by measuring the dynamic interfacial tension of the system.

We have already performed some preliminary IFT experiments with the water-bitumen system. Our experiments reveal that the interfacial tension is the result of a complex interplay between asphaltene self-association kinetics and asphaltene-naphthenic acid association kinetics. It turned out that the interfacial tension value measured using our microfluidic platform is much lower than the reported value in the literature for the water-bitumen system. This discrepancy may be ascribed to the fact that our measurement technique, MEFD, is one-of-a-kind and differs from the existing tensiometers in the following ways. Our measurement was carried out under flowing conditions, whereas previous studies were performed under stagnant conditions. Additionally, we examined the interfacial tension of water-in-oil emulsions, but previous studies measured the interfacial tension of an oil drop in water. Overall, this study, on the one hand, reveals many interesting things about the interfacial tension of the water-bitumen system, but on the other hand, raises very intriguing questions on its measurement techniques.

Objective and Deliverables: This project aims to explore the water-bitumen system further by performing the following IFT experiments using our microfluidic platform:
a) The interfacial tension of a reverse system (oil-in-water) will be measured.
b) Water drops will be first saturated in bitumen under stagnant conditions for different times then employed to measure the interfacial tension.
c) A water drop will be first saturated in bitumen under flowing conditions for different times then employed to measure the interfacial tension.

Along with experiments, you are expected to analyze and compile the experimental data.

Work Experience: Experience with experimental work in a research lab is desirable.

Work Load: Approximately an average of 20 hours per week for 8 months. The last two months will be used to compile the thesis and do additional experiments and analysis to complete the thesis.

The project start date is January 2018.

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