

Adsorption of ethyl cellulose on asphaltene- or bitumen-coated hydrophilic silica surfaces

Shengqun Wang, Nataliya Segin, Ke Wang, Jacob H. Masliyah, Zhenghe Xu*

Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta T6G 2G6, Canada

*(*Corresponding author: zhenghe.xu@ualberta.ca)*

In our previous study [1], we demonstrated that ethyl cellulose (EC) is a biodegradable, greener demulsifier for water-in-diluted bitumen emulsions. The interfacial tension measurement showed a significant reduction of diluted bitumen-water interfacial tension with EC addition to organic phase. Micropipette experiments demonstrated flocculation and coalescence of water droplets in diluted bitumen solutions containing EC, depending on EC concentration. In this study, we intend to determine the molecular mechanism of EC demulsifiers using atomic force microscope (AFM) and quartz crystal microbalance (QCM).

After adsorption of asphaltenes and bitumen from toluene on a hydrophilic silica wafer as a substrate, the silica wafer was soaked in an EC-in-toluene solution for a varying period of time. The contact angle of a water droplet on the resultant surfaces was measured while the nano resolution morphology of the treated surface was determined by AFM. The EC was shown to gradually displace the asphaltenes or bitumen aggregates pre-adsorbed on hydrophilic silica wafer by pushing them into larger aggregates on the silica surface. The asphaltene/bitumen aggregates grew slowly, leading to a noticeable detachment of the aggregates from the silica surface.

Under the conditions of this study, the dynamic displacement process reached equilibrium in about 7 hours. At equilibrium, EC covers most of the silica surface with large asphaltene/bitumen aggregates sporadically scattered on the surface. The EC-dominated surface became more hydrophilic than asphaltene/bitumen-adsorbed surfaces.

The QCM study showed that the displacement of pre-adsorbed asphaltenes by EC is irreversible. It also showed that the interaction between EC and asphaltenes is not necessary for the displacement of asphaltene from silica surfaces by EC. The findings lead to the conclusion that the affinity of EC to hydrophilic silica surface is stronger than that of asphaltenes, most likely due to a much larger number of hydrogen bonds between EC and hydrophilic silica than between asphaltene and hydrophilic silica. This study provides further insights into demulsification mechanisms of EC for breaking w/o emulsions and demonstrates the potentials of EC in altering a solid from oil-wet to water-wet.

References

- [1] Feng, X. et al. (2010) *Langmuir*. 26, 3050-3057.