Obtaining Molecular Structure at Oil Interfaces and Applying it in Upstream Contexts

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Abstract

Most phenomena that are related to oil recovery are taking their root in the molecular layer that resides between either the oil and the brine or the oil and the rock. The liquid-liquid interactions determine the IFT which in turn impact the capillary forces. These are also directly influenced by the affinity of the liquid to the rock. The common denominator in most oilfield related chemical process steps is that they are aiming at impacting the interfacial molecular layer in one way or another. This most evidently pertains to challenges in enhanced oil recovery and (d)emulsification. To a large extent the research and development within these two topics is dominated by trial and error; primarily because the composition of the bulk (brine but particularly crude oil) is so incredibly complex that it is very difficult to draw any real chemical conclusions that can form the basis of educated operational input. With molecular-scale structural information on the composition at interfaces it would be possible to design chemical solutions tailored to specific problems and to specific crudes, brines and rocks. There is very little insight relating to molecular-level interfacial structure in oil and gas. This contribution describes our attempts to mitigate this situation. We propose two new strategies that complement each other to obtain interfacial structure. The first relies on the structure specific interaction of short laser pulses with molecules oriented at interfaces and the second strategy aims at performing a mass spectrometric analysis of the outermost layer of hanging or acoustically levitated drops, including those with a core-shell structure. The results are very promising. We have utilized the laser-based technology to reveal the orientation of the dodecylsulphate anion at an aqueous interface and how it is impacted by salinity changes. When it comes to the mass spectrometric approach (field ionization of droplets), we have investigated a series of crudes with varying viscosities and acid contents and found that it is indeed possible to assess the interfacial composition and processes even for mixtures that are as complex as crudes. The findings can for example guide towards what are the most surface-active materials in complex injection mixture or the crudes themselves and aid the rational development of new approaches to enhanced oil recovery.