Wettability in carbonates: the effect of water-soluble carboxylic acids in crude oil

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Acidic components in crude oil influence wetting condition through their effect on electrostatic interactions with the mineral surfaces. In this paper, we have extracted water-soluble acids from a crude oil with high AN to study the effect of these acidic materials on the wetting condition. The biodegraded Heidrun crude oil with AN=2.82 and BN=1.13 mgKOH/g was used as the base crude oil, which was sampled from a new well during a well-test. The original test-oil termed (O.O) was made by diluting the base oil, Heidrun crude oil, with 40 vol% heptane. After extracting water-soluble acidic materials from the Heidrun oil, it was also diluted 40 vol% with heptane, and the oil was termed treated oil (T.O). Both crude oils were centrifuged and filtered through a 5 µm Millipore filter. The acid number for the original oil was 1.8 mgKOH/g while the acid number for the oil depleted in water-soluble acids was 1.5 mgKOH/g. Two crude oils have been studied by chromatographic wettability test and spontaneous imbibition using seawater as imbibing fluid to determine the differences in the wetting condition and oil recovery. In a spontaneous imbibition process at 110 °C, both the imbibition rate and ultimate recovery were higher in the cores saturated with the oil depleted in water-soluble acids, Fig.1. The difference in the imbibition rate and also ultimate recovery indicates that the carboxylic material from the oil depleted in water-soluble acids can be displaced easily compared to the original oil.

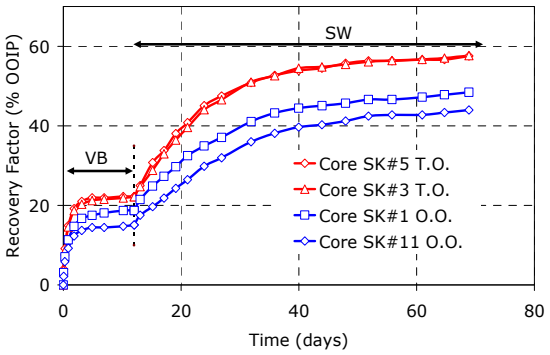

Fig. 1. Spontaneous imbibition into chalk cores saturated with different crude oils, original oil and treated oil. Spontaneous imbibition was performed by formation brine, VB, followed by seawater, SW, as the imbibing fluid at 110 ºC, S_{wi}=10%

The difference in wetting properties was also confirmed by chromatographic wettability tests. The water wetness appeared to be lower for the original oil compared to that for the treated oil. The initial chromatographic separation area between the tracer and sulfate curves for the original oil and the treated oil was 0.083 and 0.098 and the corresponding initial water–wet fractions were calculated to be 0.53 and 0.63, respectively. This is in line with the observed difference in spontaneous imbibition using formation water as initial imbibing fluid, i.e. the original oil made the chalk less water-wet than the treated oil. The wetting properties of the cores after spontaneous imbibition with formation water and seawater at 110 °C were determined as well. The area between the tracer and the sulfate elution curves for the core containing the original and treated oil was 0.120 and 0.148, and the corresponding water-wet fractions after wettability alteration were determined to be 0.77 and 0.95, respectively. In line with the spontaneous imbibition data, the water-wet area increased by 32% for the core containing the treated oil depleted in water-soluble acidic material compared to an increase of 24% for the core containing the original oil. These crude oils were also investigated with respect to interfacial intension. The IFT-value between the Heidrun oil (base oil) and seawater and both of the diluted oils, original oil and treated oil, appeared to converge to the same value as the flow rate decreased, ≈ 11 mN/m, using drop volume tensiometer.

As pointed out by Barth et al.[1], the amount of extractable acids is greater for biodegraded oils compared to that for non-biodegraded oils. It was also confirmed that the average molecular weight of the extractable acids from biodegraded oils was significantly lower than that of non-biodegraded oils.

Even though the strength of the bonding of carboxylic material onto the calcite surface is mostly dictated by the carboxylic group, the organic structure of the carboxylic material will have influence on the wettability alteration process as well.

References

[1] Barth, T., et al. (2004) *Acidic compounds in biodegraded petroleum.* Organic Geochemistry, 2004. **35**: p. 1513-1525.