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Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):
Wang, T., Andersen, S. I., & Shapiro, A. (2021). *Coalescence of oil droplets in microchannels under brine flow*. Abstract from DHRTC Technology Conference 2021, Kolding, Denmark.

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Coalescence of oil droplets in microchannels under brine flow

Tian Wang, Simon Ivar Andersen, Alexander Shapiro

We use microfluidics technique to study the coalescence of model oil droplets in microchannels. Different stages of the coalescence: convergence of the droplets and liquid film drainage, collision, interfacial film rupture, and merging are captured by high-speed imaging. The coalescence time is studied, defined as the merging time for the droplets after physical contact. Adding salts into the water phase may slow down the coalescence process. Cations Na^+ , Ca^{2+} and Mg^{2+} do not significantly affect the coalescence time, while the presence of the anion SO_4^{2-} produces much longer times than of Cl^- . The presence of a surface-active component, stearic acid, increases the coalescence time, in a clear correlation with the interfacial tension. At higher pH stearic acid is deprotonated into stearate; correspondingly, the interfacial tension decreases further and the electrostatic repulsion of the head groups of fatty acids increases. The interface between droplets and water is thereby stabilized and the coalescence time increases. A pH value higher than the pKa of stearic acid induces highly stable plastic-like oil-water interfaces. We discuss the implications of our results on the applications in the petroleum industry concerning e.g. enhanced oil recovery under smart waterflooding.

Figure 1. Four stages of the coalescence process: (a) approaching; (b) collision; (c) rupture of interfacial film and (d) merging.