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A quantitative study of oil mobilization induced by water diffusion in n-alkane phases: from pore-scale experiments to molecular dynamic simulation

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Low-salinity water flooding is a promising technique for enhanced oil recovery in sandstone and carbonate reservoirs. Numerous mechanisms have been proposed to untangle the effect of a low concentration of dissolved salts in the flooding medium. Among the mechanisms, it is suggested osmosis may explain the observed remobilization of residual oil. However, the process of water transport through the oil phase, due to a salinity contrast, and its contribution to oil remobilization is not fully understood. In our study, we used three aqueous solutions and two alkanes in a series of microfluidic experiments with hydrophobically coated glass micro-chips for mimicking the low-salinity waterflooding process in an oil-wet rock formation. With three steps of liquid injection, we created multiple systems of low-salinity water/alkane/high-salinity water in the porous micromodel, and, afterward, continuously monitored the domain for 70 hours. The acquired images gave a direct pore-scale observation of the dynamic expansion in the trapped high-salinity water regions and its influence on the oil movements. Through the quantitative approximation, we noted that ionic strength and the hydrocarbon chain length both played important roles in water diffusion. A salinity contrast of 1.7 g/L-17 g/L caused higher water flow rates than 50 g/L-17 g/L for both alkanes. The difference in water flow rates between the case of 1.7 g/L- 17 g/L and the case of 50 g/L-17 g/L were not proportional to the salinity contrast during the experimental period. There was no a simple relationship between the chain length of hydrocarbon and water flow rate.. Moreover, to investigate the effect of salinity on water behavior in heptane, we conducted molecular dynamic (MD) simulations by considering three different concentrations in the high-salinity water region featuring our experiments. The results indicated that high salinity limited the diffusion of water from the high salinity region into the oil phase and reduced the possibility of water entering the heptane phase. Therefore, the net flux of water from the pure water side to the salty waterside was enhanced. MD simulations thus provided a better understanding of how water diffuses through an alkane phase due to the solubility difference and helped us explain the expansion of high-salinity water in microfluidic experiments.

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References

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Unsure

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