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Pore-scale study of in-situ surfactant flooding with strong oil emulsification in sandstone based on X-ray microtomography

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Outline

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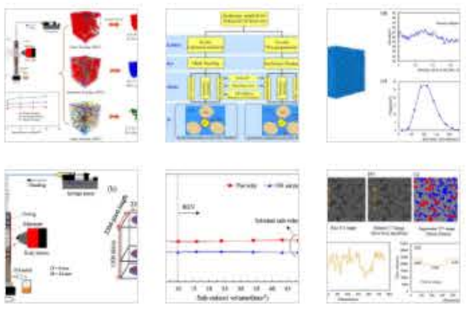

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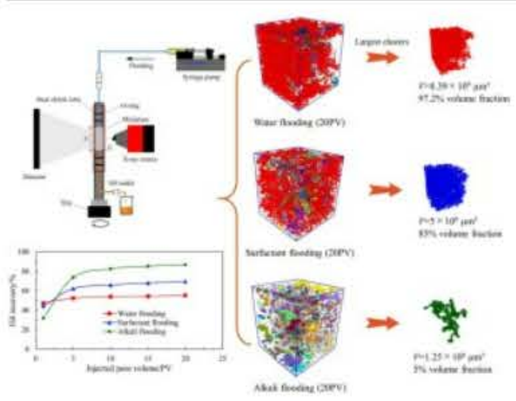
Highlights

- The dynamic displacement mechanisms during chemical flooding were confirmed at pore scale using X-ray microtomography.
- The dynamic evolution of oil cluster patterns was analyzed at various flooding stages.
- The emulsification mechanisms of ex-situ and in-situ surfactant were analyzed from interfacial activitis.
- Oil blebbing was found responsible for the strong oil emulsification in alkaline flooding.

Abstract

This study presented a pore-scale investigation on the dynamic displacement of oil subjected to ex-situ and in-situ surfactant flooding using X-ray microtomography. The ex-situ surfactant solution was pre-prepared, whereas the in-situ surfactant was generated directly with the chemical reaction inside porous media. The results showed that oil removal from the pore spaces relied on the combination of piston-like, pore-body filling and a weak emulsification mechanism in the ex-situ system, whereas the in-situ system was dominated by a strong emulsification process. The threshold capillary pressure was decreased significantly owing to interfacial tension reduction and wettability alteration, which enhanced the oil cluster mobilization. Therefore, the in-situ system produced the highest oil recovery efficiency of 86.9% compared with ex-situ system and water flooding. The emulsifying ability was evaluated through oil cluster size distributions and their dynamic evolution. The networks or branches disappeared and emulsified into small oil ganglia and singlets, thereby leading to a significant decrease in the average equivalent diameter. Finally, strong emulsification in the in-situ system was attributed to quick and precise surfactant aggregation at the oil–water interface that induced blebbing, whereas the ex-situ case was dominated by slow surfactant transport relying on advection and diffusion in the flow mainstream.

Graphical abstract



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Keywords

In-situ surfactant; Enhanced oil recovery; Emulsification; Chemical reaction; X-ray microtomography