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A study on the CO2 displacement behavior at nanoscale considering rough surface

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CO2 displacement is considered as a potential method to enhance shale oil recovery. CO2 can reduce the viscosity and surface tension of crude oil, making it possible to recover crude oil in the nanopores. At the same time, the CO2 can also be partially stored underground, reducing the carbon footprint of the hydrocarbon extraction process. Therefore, understanding the CO2 displacement in nanometer pores of shale is critical for developing effective CO2 injection techniques. In this work, we applied direct numerical simulation to study the effect of rough surface on CO2 displacement in nanometer pores of shale. By quantifying the CO2 displacement in rough nanochannels, we aim to understand how surface roughness and morphology affect the displacement process. After considering the influence of slip effect, the CO2 displacement process in three channel models was studied (single channel, pore throat structure, nanoporous media). We found that in a single channel, the rough surface leads to the reduction of CO2 displacement paths, slowing down the displacement rate. In addition, the pinch-point effect of the rough nanochannel prevents the smooth progression of the interface contact line. The Periodic fluctuations at the interface further hinder CO2 displacement. The smoother the convex and convex transition of rough surface, the smaller the resistance effect of the pinch-point effect. In the pore throat structure model, the rough surface makes it easier for residual oil to remain in the pore. We also simulated CO2 displacement in rough nanoporous media and found that rough surfaces lead to a substantial reduction in CO2 displacement efficiency. Our simulation results show that the surface roughness of shale nanometer pore has nonnegligible effect on CO2 displacement.

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