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Visualized investigation of transport behaviors during CO2-EOR in multiscale porous medium

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Although CO2 injection into the geological formations is a promising option to enhance oil recovery, how multiscale pore structures within porous media affects multiphase transport remains poorly understood. This study fully exploits the unique advantages of real-time in-situ visualization of microfluidics to investigate the multiphase flow behavior within micro and nano-pores during both CO2 miscible and immiscible flooding process. Two types of porous media chips with network channel structures were designed–a micro-nano scale cross-scale chip with a fracture-matrix structure and a micro-scale chip with multiple pore-throat ratios. This study investigates the impact of cross-scale effects, Jamin effect, and network channel shapes on the flow patterns of CO2 and oil during the CO2 flooding process. The effects of these factors on the recovery rates throughout the entire CO2 flooding process are also discussed. In the cross-scale chip, micro-scale fracture channels expedite the process of achieving a 100% recovery rate in CO2 miscible flooding. Conversely, the micro-scale fracture channel, offering a "short circuit" pathway for CO2, results in the extensive entrapment of residual oil, leading to a substantial reduction in the recovery rate in CO2 immiscible flooding. In the micro-scale chip, the flow resistance induced by the Jamin effect increases with the increase of the pore-throat ratio porous media during CO2 immiscible flooding. The time required to achieve 100% recovery efficiency during CO2 miscible flooding is notably delayed with an increase in the pore-throat ratio. These results can significantly enhance our understanding of multiphase transport in CO2 enhanced oil recovery, facilitating the optimization of practical CO2-EOR schemes.

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