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# Ostwald Ripening Leads to Less Hysteresis during Hydrogen Injection and Withdrawal: A Pore-Scale Imaging Study

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Utilising depleted hydrocarbon reservoirs or aquifers for hydrogen storage shows promise due to their substantial storage capacity. Efficiently managing hydrogen storage requires careful consideration of hysteresis across multiple cycles. Hydrogen experiences both injection and production, usually on a seasonal basis, impacting both hydrogen recovery and pore space entrapment. Our study investigates the capillary pressure hysteresis induced by this cyclic injection and withdrawal process, employing X-ray tomography. This exploration holds potential for optimising subterranean hydrogen storage systems. Conducting experiments under dynamic conditions, we analysed gas and water distribution within distinct pore space geometries during drainage and imbibition cycles. We injected the gas phase into 6 cm long samples of Bentheimer sandstone at ambient temperature and 8 MPa pore pressure, followed by three water flooding cycles. Varied gas saturation levels—high, medium, and low—were achieved while maintaining a constant brine flow rate, allowing a comprehensive exploration of distribution dynamics. Throughout these cycles, our observations unveiled intriguing phenomena: (I) capillary pressure hysteresis and (ii) hydrogen migration through Ostwald ripening. Contrary to conventional models, our results suggest the possibility of surpassing the presumed residual gas saturation through further injection and withdrawal, challenging the assumed gas recovery limit. To further understand these phenomena, we analysed interfacial curvature and area, conducted wettability assessments, and performed pore occupancy analysis. These insights offer a pore-scale understanding of hydrogen storage dynamics, providing crucial image-based data essential for modelling multiphase flow properties in reservoir-scale simulations.

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