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Investigating Hydrogen Storage in Pore Media of Saline Aquifers: A Numerical Study on Wettability and Pore Structure Impact

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Hydrogen, as a promising clean energy source, holds significant potential for energy transition and the efficient utilization of clean energy. However, large-scale hydrogen storage poses a limitation to its large-scale utilization and further development. Saline aquifers, characterized by favorable pore space and temperature-pressure conditions, are considered promising candidates for large-scale hydrogen storage. Therefore, our study focuses on investigating the flow of hydrogen in porous sandstone media during the initial injection and extraction process.
Utilizing the volume of fluid method, we conducted direct numerical simulations of this process, scrutinizing the impact of wettability, capillary number, and pore structure on hydrogen flow, storage capacity, and loss rate. The result reveals that hydrogen flow in underground porous media is predominantly governed by capillary forces, with hydrogen primarily stored in larger pores and channels. Increasing hydrogen wettability enhances reservoir storage capacity but concurrently results in elevated residual hydrogen after the extraction process. Regardless of reservoir wettability, hydrogen losses during the initial injection and extraction process are significant. Reservoirs characterized by larger pore and throat radii exhibit higher effective hydrogen storage capacity. Additionally, reservoirs featuring higher coordination numbers and enhanced connectivity contribute to greater hydrogen storage capacity and improved recovery rates.

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