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Visualization and characterization of spreading and mixing at the pore-scale relevant for Geological Carbon Sequestration and Underground Hydrogen Storage

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Geological Carbon Sequestration and Underground Hydrogen Storage in porous reservoirs are promising strategies for transitioning to clean energy production. Gas dissolution in brine significantly influences flow and trapping behavior during both CO2 and H2 storage in porous reservoirs. Interestingly, for H2 storage, this effect was unexpected due to hydrogen's low solubility in brine. However, recent experiments have revealed rapid dissolved H2 transport that is not captured by current state-of-the-art models. To better understand the transport behavior of dissolved gasses in these systems, we conduct steady-state single-phase microfluidic experiments to visualize spreading and mixing at the pore scale. The experiments are carried out using two microfluidic chips with homogeneous and heterogeneous pore structures, each containing two inlets and two outlets. A pH indicator solution saturated with the gas is injected at one inlet, while a pH indicator solution without any dissolved gas is injected at the other, forming a mixing zone along the chip's center line (figure 1). The color change of the pH indicator solution reveals variations in dissolved gas concentration, visualizing the spreading and mixing of the dissolved gas. Experiments are conducted for both H2 and CO2 at atmospheric pressure and room temperature conditions across eight flow rates, covering advection- and diffusion-dominated transport regimes. The experimental results are compared to direct numerical simulation using the *interReactiveTransferFoam* module of the GeoChemFoam [1] solver package. Here the species transport of dissolved H2 and CO2 are solved with constant flow inlet and constant pressure outlet boundary conditions.

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References

[1] DOI:10.5281/zenodo.11354428

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