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Pore-scale investigation of the influence of gas mixing on He/brine and CO₂/brine wettability using Microfluidics: Implications for CO₂ and H₂ geo-storage

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Geological storage of hydrogen (H₂) and carbon dioxide (CO₂) is pivotal for a successful energy transition toward a diversified low-carbon economy and a net-zero emission future. The wettability of reservoir rocks in the presence of formation fluids and H₂ or CO₂ is a controlling factor of gas mobility, residual trapping, and efficient storage. However, the influence of different brine types (salt type and concentration) and gas contamination on wettability is rarely reported in the literature.

Therefore, we present the results of a set of experiments using a microfluidic chip of different diameters (50, 70, 90, 110, and 130 μm) measuring CO₂/brine, N₂/brine, and He/brine advancing, receding, and static contact angles for the same brine type and mixing ratios (20%, 50%, and 80%) at constant conditions ($P=14.7$ atm and $T=22$ °C). The helium was used as an analogy for hydrogen to avoid any safety complications. The experiments were conducted using a constant brine rate at 0.1 $\mu\text{L}/\text{min}$ during imbibition. A sophisticated Matlab code was built to measure contact angles from live videos of the microchips, allowing the generation of multiple data points with controlled upscaling.

The measurements indicate the channels are strongly water-wet for all gases with CO₂ being the highest water-wet. All the dynamic contact angles decreased with increasing channel diameter from 50 to 130 μm . The measurements were validated with similar experimental approach in the literature. The CO₂, N₂, and He contact angles increased with increasing the mixing ratios from 10% to 50%. Higher hysteresis was observed with a higher mixing ratio, indicating a significant impact of contamination on the storage process.

The presented experimental approach depicts a time-effective technique to investigate crucial influencing parameters using microfluidic chips for effective and successful underground H₂ and CO₂ sequestration.

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References

Conference Proceedings

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