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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 ℃). 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 µL/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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