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Pore-scale investigation of gas mixing, brine salinity, and salt type influence on the dynamic contact angle using Microfluidics for underground CO2 sequestration

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Geological storage of hydrogen (H_2) and carbon dioxide (CO_2) is pivotal for a successful energy transition toward a diversified low-carbon economy and a net-zero emission future. Wettability of reservoir rocks in the presence of formation fluids and H_2 or CO_2 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, this paper presents the results of a set of experiments using a microfluidic chip of different diameters (50, 70, 90, 110, and 130 μm) measuring CO_2/brine and N_2/brine advancing, receding, and static contact angles for different brine types and mixing ratios (10%, 30%, and 50%) at constant conditions (P=14.7 atm and T= 22 ℃). 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 the tested brine with CO_2. The advancing and receding contact angles vary from 9.5° to 38° and from 6.5° to 29°, respectively. The contact angles slightly increased with increasing brine salinity varying between the different types of salt (NaCl, MgCl, and KCl). The $MgCl_2$ demonstrated the highest values of contact angles. The contact angles increased with increasing the mixing ratios between CO_2 and N_2 from 10% to 50% and decreased with channel diameters. 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 CO_2 sequestration.

Participation

In-Person

References

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