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Analytical analysis of wettability in hydrogen-rock-brine systems

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The energy transition efforts have given rise to the demand for energy storage. Due to its desirable characteristics, hydrogen is a favorable medium for storing the excess low-carbon electricity. Subsurface porous formations provide the solution for large storage capacities required to facilitate the energy transition. A successful storage project requires accurate modeling of the hydrogen movement and extent of its trapping, which is partially determined by the wetting properties of the hydrogen/water/rock system. The three-phase contact angle is an indirect means of quantifying wettability. Wettability and the resulting three-phase contact angles can be calculated using the surface force analysis. The interplay between the surface forces active in the contact region (namely, van der Waals (vdW), electrostatic, and structural/hydration forces) determine the film stability and the wetting behavior of the multi-phase systems.

In this study, we conduct a surface force analysis to investigate the wetting behavior of hydrogen in the presence of water and rock relevant for the underground storage systems. In light of surface forces, different parameters such as dielectric properties of the phases (water, hydrogen, rock), medium properties (water salinity and pH), and interface (water-rock and water-hydrogen) potentials/charge densities affect the magnitude of the vdW, electrostatic, and structural forces. The hydrogen contact angles for smooth surface can be calculated once the surface forces are quantified. Equilibrium and meniscus contact angles can be determined by means of the calculated total active force, the equilibrated film thickness, and capillary properties. An extensive sensitivity analysis on the model parameters controlling the wetting state of the considered system has been performed and critical parameters have been identified.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Online

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