Pore-scale Investigation of the Effect of Surfactant on Storage Efficiency in CO_2 Geosequestration

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Geosequestration of carbon dioxide (CO_2) plays a crucial role in mitigating atmospheric CO_2 levels. Therefore, securing reservoirs for large-scale CO_2 storage is essential to achieve the greenhouse gas emission targets. Given the limitations of utilizing pore spaces in storage systems, enhancing pore space utilization becomes crucial in CO_2 geosequestration. Among the various proposed enhancing technologies, we here focus on the utilization of surfactant. Surfactants are used to reduce capillary forces between brine and CO_2 in geological media. With their hydrophilic heads and hydrophobic tails, surfactants effectively lower the CO_2-water interfacial tension (IFT). This study experimentally investigates the effect of surfactants on CO_2 flow and storage efficiency in a sandstone at pore-scale. Two-phase flow experiments were conducted under various pressure conditions (increased from 6MPa to 16MPa in stages). High-resolution three-dimensional images were obtained during the experiments using synchrotron-based X-ray microcomputed tomography. We compare microscale parameters such as interfacial curvature and contact angles. Through numerical simulations, we additionally assess mesoscale parameters including capillary pressure and relative permeabilities of CO_2.

The saturation of CO_2 has been observed to exhibit an increment due to the influence of surfactants in all experimental conditions. Analyzed parameters (e.g. relative permeability, curvature, IFT and capillary pressure) have demonstrated disparate behaviors due to the addition of surfactants. The influence of surfactants shows significant effect under low-pressure conditions, where CO_2 exists in gas phase. Considering the experimental results, surfactant would have considerable implications on both the storage capacity and CO_2 injectivity, particularly under low-pressure reservoir conditions such as depleted gas reservoirs. The observed increment in CO_2 saturation consequently causes corresponding increase in the overall storage capacity. Furthermore, alterations in fluid dynamics parameters would engender enhanced CO_2 injectivity at low pressures reservoirs.