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Phase Interactions during Geological Carbon Storage in Depleted Hydrocarbon Reservoirs

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Carbon dioxide injection, as the final stage of carbon capture and geologic storage, has been proved to be a highly efficient process, particularly when applied to depleted hydrocarbon reservoirs after primary depletion, providing benefits for both enhanced oil recovery (EOR) and environmental concerns.
This experimental study investigates the impact of gas compositions, i.e. preexisting impurities in the injected gas phase, and the influence of CO_2 on oil behavior within the hydrocarbon reservoirs. The key mechanism, oil swelling, plays a crucial role in fluid mobilization, especially in microspores where CO_2 injection emerges as the sole efficient method for mobilizing trapped oil droplets within micro and dead-end pores. This process significantly contributes to increase sweep efficiency during the enhanced oil recovery (EOR) stage of geologic carbon storage.
To systematically explore these dynamics, a series of pressure decay experiments were conducted in a PVT cell. This involved utilizing a gas composition mixture containing methane and nitrogen. Another series of experiments using a binary mixture of CO_2 and nitrogen injection were carried out after the initial nitrogen flooding.
To replicate potential field conditions as realistic as possible, our study considered specific injection scenarios, incorporating factors such as soaking time (e.g., Huff and Puff techniques) and potential injection delays due to logistical factors. The noticeable increase in oil volume during multiple cycles of CO_2 injection due to prolonged exposure and interaction with CO_2 suggests a cumulative swelling effect associated with sequential injections.
This study investigates the complexities of field-relevant scenarios, including cyclic gas injection, and the results have implications for reservoir management and the optimization of CO_2 injection strategies, first for enhanced oil recovery and then for CO_2 retention in the reservoir for geologic storage.