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CO_2 Utilization with Complexation of Polyelectrolyte Complex Nanoparticles and Surfactants for Environmentally Friendly Unconventional Hydrocarbon Recovery: Mechanistic Study, Recovery and Multiscale Visualization

Abstract

Hydraulic fracturing process suffers from large dependency on water resources with reported negative environmental impacts. Employing high internal phase emulsions to reduce freshwater consumption in unconventional oil recovery is a promising approach to protect drinking water resources and enhance ground and surface water quality to avoid large water disposal which may lead to seismic activities. As an alternative to fresh water, the mixture of produced water and compressed CO_2 in supercritical state are stabilized to form homogenous $scCO_2$ foam. The hydrocarbon recovery is directly related to physiochemical properties of foam and subsurface multiphase transport. The main objective of this work is to generate, stabilize and to study the texture of $scCO_2$ foam and foam-oil interaction with multiscale observation to establish a correlation between foam microstructure, stability and recovery performance in environmentally friendly unconventional oil recovery process.

Two oppositely charged polyelectrolytes are investigated to generate a stable lamella between the aqueous phase and the $scCO_2$ while degrading in the presence of crude oil. The foam system improves fracture propagation, proppant transport and fracture cleanup compared to the base case foam system with no PECNP.

Enhanced bulk viscosity and improved foam quality as a result of complexation at the interface was identified with rheometry in addition to sand pack experiments with PECNP-surfactant ratios of 1:9 and 4:6, in 33.3 kppm and 66.7 kppm salinity brine systems, respectively. Formation damage was controlled by the newly introduced mixtures as fluid loss volume decreased across the tight Kentucky sandstone cores by up to 78% and 35% for $scCO_2$ foams made with PECNP-WLMs in 33.3 and 66.7 kppm salinity brine. The formation of PEC-surfactant nanoparticles was verified via dynamic light scattering and transmission electron microscopy (TEM). A Raman spectroscopic model was developed to realize the structural changes associated with complexation. The possibility of molecular complexation for lamella stabilization was also explored for EOR application. Ionic complex containing PECNP and N-120 ethoxylated surfactant was employed to enhance $scCO_2$ foams made with the thin film of high salinity brine formed between $scCO_2$ bubbles and the complex improved DLVO forces in aqueous polyelectrolytes for carbonate surfaces. Millimetric view cell observation was coupled with micrometric fluidic visualization to shed light on multi scale observation of physical structure, geometry, dynamic and stability of electrostatically enhanced $scCO_2$ foam. Multiphase flow in fractured medium was emulated using micromodels. Wet etching technique on glass was performed via UV photolithography and thermal bonding, whereas dry etching was conducted with selective laser etching (SLE) inside the glass bulk. Lamella stability as a result of complexation of two oppositely charged polyelectrolytes with zwitterionic surfactant was investigated in view cell and glass microchips.

Date:

Tuesday, Dec 15th, 2020

Time:

Starts @ 1:00PM

Zoom Meeting Details:

HYPERLINK

Meeting ID: 842 3787 3899

Password: 665753

Committee Chair:

Associate Professor Reza Barati