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Study of foam generation mechanism at the pore scale

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Foam injection into the subsurface is generally performed to improve gas mobility control during enhanced-oil recovery (EOR) and contaminated site remediation (Lake et al., 1989; Hirasaki et al., 2000; Mulligan et al., 2006). Several experiments have been conducted to study the foam generation mechanism at both the pore and continuum scales (Kovscek et al., 1994; Kam et al., 2003; Gauteplass et al., 2015; Prigiobbe et al., 2016). Pore scale experiments allow to understand the mechanism of bubble formation with a potential to help formulating constitutive equations for foam flow models improving their accuracy of prediction. However, pore scale studies have not been used to formulate foam generation rate, yet. Here, we present an experimental and modeling work on foam generation mechanism with a porous medium chip. Systematic tests at different flow conditions were performed using various chemicals to stabilize the foam, such as the surfactant, nanoparticles, and a combination of them. The pressure drop and the foam texture were monitored continuously using a pressure transducer and a high-speed high-resolution camera. We observed that to generate a foam in the presence of nanoparticles requires larger energy than when the surfactant is used to stabilize the lamellae. Possibility due to the larger critical capillary pressure for bubble rupture (Pc*) that can be reached in the presence of nanoparticles. Upon image processing, the results show that the generation rate and, therefore, the total number of bubbles increase with the injection rate, creating a more uniform bubble size distribution. We observed that nearby the gas injection the controlling mechanism of the bubble formation is snap-off, while afar from that lamella division dominates.

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