Microfluidic Investigation of Foam Stability using Surfactant/Nanoparticle Systems at Reservoir Conditions

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ABSTRACT

Foam-assisted water alternating gas is one of the most promising recovery methods to overcome the gas mobility challenges into the reservoir. A surfactant solution and a gas phase are injected into the porous media, generating foams in-situ and creating barriers to the flow of the gas through the high permeability regions. However, surfactant-based foams generated with CO_2 are far from stable at harsh conditions of pressure and temperature. In this way, the addition of nanoparticles to the aqueous phase has been proposed to increase foam stability [1,2]. This work aimed to improve the understanding of the physical phenomena underlying foam generation/regeneration at pore scale for different injection flow rates and for different combinations of surfactant, nanoparticle and gas ratio systems. The aqueous solutions consisted in 0.5wt.% of a zwitterionic surfactant in brine, in the presence and absence of 0.01wt.% silica nanoparticles (SiO_2). The gas phase evaluated was either 100% sc-CO_2 or 40mol% sc-CO_2 and 60mol% N_2. The aqueous and the gas phases were co-injected at 50% foam quality through a glass micromodel at high pressure (1500 psi) and high temperature (60°C), and the fluid displacement was recorded on video. Results showed that a greater density of lamellae was formed when the fluids were co-injected at a higher flow rate. The microfluidic flooding also showed that the bubble lamellae were thicker when surfactant solutions containing silica nanoparticles were injected. Furthermore, the evolvement of the bubble size into dead-end pores due to Ostwald ripening effect was observed (Fig. 1).

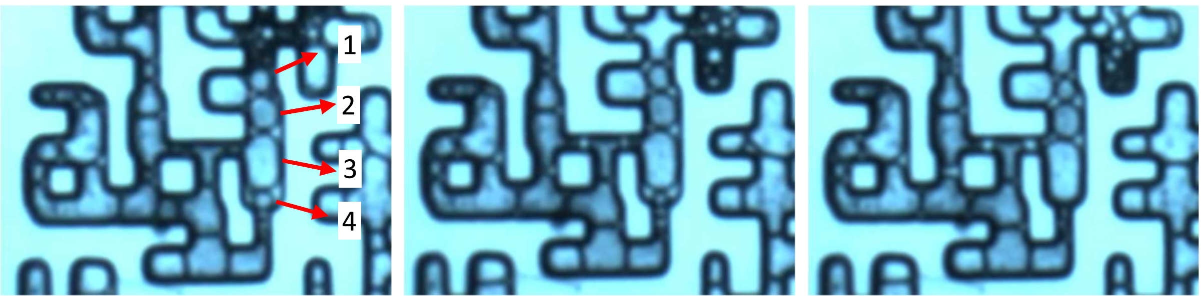

Figure 1: Bubble size evolvement into dead-end pores as a function of time (1-4: individual bubbles)

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