Application of nanoparticle-surfactant composites for the foam and emulsion stabilization

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Nanoparticle–surfactant composites represent a versatile and promising class of materials for regulating interfacial phenomena in dispersed systems. Their physicochemical behavior is governed by adsorption processes, electrostatic and hydrophobic interactions, and structural reorganization both at the interface and in the bulk. Surfactant molecules adsorbed on nanoparticle surfaces alter surface tension, rheological properties, and interfacial stability, while nanoparticles themselves influence micellization, aggregation, and the overall organization of surfactant assemblies.

A particular focus of this study is the role of silica nanoparticles combined with surfactants of different nature. Experimental results demonstrate that these composites significantly enhance foam stability by reinforcing interfacial films, reducing liquid drainage, and slowing coalescence. In emulsions, nanoparticles act as stabilizers via Pickering-type mechanisms, creating more robust and long-lasting structures. This dual ability to stabilize foams and emulsions highlights their multifunctional character.

From an application perspective, the stabilization effects of nanoparticle–surfactant composites are especially relevant for enhanced oil recovery (EOR). Improved foam stability enables better mobility control in porous media, while stronger emulsions facilitate more efficient displacement of residual oil. Beyond EOR, such systems hold promise in other industrial processes where interfacial control is critical, including detergency, food formulations, and environmental remediation.