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Recent Advances in Surfactant EOR

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Abstract

Recent advances in surfactant EOR are reviewed. The addition of alkali to surfactant flooding in the 1980s reduced the amount of surfactant required and the process became known as alkaline surfactant polymer flooding (ASP). It was recently found that the adsorption of anionic surfactants on calcite and dolomite can also be significantly reduced with sodium carbonate as the alkali, thus making the process applicable for carbonate formations. The same chemicals are also capable of altering the wettability of carbonate formations from strongly oil-wet to preferentially water-wet. This wettability alteration in combination with ultra-low interfacial tension (IFT) makes it possible to displace oil from preferentially oil-wet carbonate matrix to fractures by oil-water gravity drainage.

The alkaline surfactant process co-injects alkali and synthetic surfactant. The alkali generates soap in situ by reaction between the alkali and naphthenic acids in the crude oil. It was recently recognized that the local ratio of soap/surfactant determines the local optimal salinity for minimum IFT. Recognition of this dependence makes it possible to design a strategy to maximize oil recovery with the least amount of surfactant and inject polymer with the surfactant without phase separation. An additional benefit of the presence of the soap component is that it generates an oil-rich colloidal dispersion which produces ultra-low IFT over a much wider range of salinity than in its absence.

It was once thought that a co-solvent such as alcohol was necessary to make a microemulsion without gel-like phases or a polymer-rich phase separating from the surfactant solution. An example of an alternative to the use of alcohol is to blend two dissimilar surfactants, a branched alkoxylated sulfate and a double-tailed, internal olefin sulfonate. The single phase region with NaCl or $CaCl_2$ is greater for the blend than for either surfactant alone. It is also possible to incorporate polymer into such aqueous surfactant solutions without phase separation under some conditions. The injected surfactant solution has under-optimum phase behavior with the crude oil. It becomes optimum only as it mixes with the in situ generated soap, which is generally more hydrophobic than the injected surfactant. However, some crude oils do not have a sufficiently high acid number for this approach to work.

Foam can be used for mobility control by alternating slugs of gas with slugs of surfactant solution. Besides effective oil displacement in a homogeneous sandpack, it demonstrated greatly improved sweep in a layered sandpack.