geoconvention
Calgary • Canada • May 15-17 2023

Improved Technology for Alkaline-Surfactant Polymer Flooding (ASP), Relevance for Canadian Reservoirs

Jeffrey G. Southwick (JSouth Energy), R. Matthew Dean, Nadeeka Upamali, Mina Fazelalavi, Upali Weerasooriya, Chris Britton (Ultimate EOR Services, LLC)

Summary

A review of alkaline-surfactant-polymer (ASP) field projects in Canadian heavy oil reservoirs (Delamaide et. al., 2014) concluded that significant increase in oil production was achieved, but severe operational issues occurred. The accumulation of silicate and carbonate scale in production wells caused frequent work overs and interruption of oil recovery. Sodium hydroxide alkali was used in these field projects. Sodium hydroxide is a strong base developing high pH in solution. This is advantageous for efficiently converting petroleum acids in heavy crude into soaps (lowering interfacial tension), but is deleterious in dissolving sandstone, forming soluble silicates. These silicates precipitate with Calcium and Magnesium cations in production wells as injection fluid mixes with reservoir brine. Silicate scale is difficult to treat since in contrast to carbonate scale it is not readily dissolved by acid.

The problem of scale in production wells is not limited to Canadian ASP projects. ASP floods in Russia (Volokiten et al. 2018) and India (Pandey et al. 2016) also comment on the deleterious effects of scale. Recent developments (Southwick et al. 2020, 2022) show that the organic alkali ethanolamine can be substituted for NaOH or Na_2CO_3 in ASP formulations with no loss in oil recovery, and with a lower tendency to form scale in producers. Silicate scale will not form as the combination of lower pH (relative to NaOH) and low temperature will not cause silica dissolution from reservoir sand. Moreover, carbonate scale will be reduced as the only carbonate anion that is formed is from a limited quantity of bicarbonate in the injection brine. This is a much lower amount than would be present from using sodium carbonate as alkali for the ASP flood. This new technology has been successfully piloted in Oman (Mahrouqi et al. 2021). Furthermore, ethanolamine shows less alkali consumption (on a molar basis) than NaOH or Na_2CO_3 and being a liquid affords more efficient mixing and field handling. Given all these advantages the economics of ASP flooding is improved with organic amines such as ethanolamine or dimethylaminoproylamine (DMAPA).

Theory / Method / Workflow

Chemical efficiency in reducing the interfacial tension between brine and oil was performed by standard phase behavior tests. Core floods were performed to quantify the extra oil production gained by use of chemical additives compared to polymer or waterflooding. Chemical consumption on reservoir rock was determined by titration of effluent.

Results, Observations, Conclusions

Organic alkali performs as well as sodium carbonate (the industry standard alkali for ASP formulations in oil recovery experiments. Figure 1 below shows two core floods with the same moles of alkali used.

Comparison of Sodium Carbonate and MEA as Alkalinity
SPE 200432-MS

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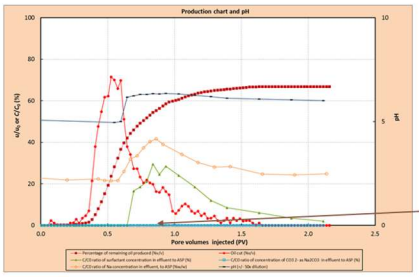
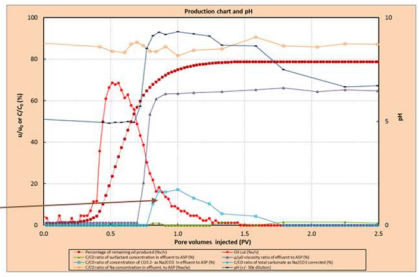
0.10 M Na2CO3 – 1.0%



0.10 M MEA – 0.6%



Oil Recovery equally good with MEA.

Much Better Alkali Propagation with MEA – Less Chemical Needed

Furthermore, much less alkali is consumed by reservoir rock than sodium carbonate. Due to this and the fact that the molecular weight of MEA is about ½ of sodium carbonate eight times less MEA is required for ASP floods. This combined with the fact that MEA is a liquid greatly improves logistics and field handling.

Table 4: MEA & Na_2CO_3 consumption

	MEA	Na_2CO_3
Injected alkali mole	1.9E-02 mol	4.4E-02 mol
Recovered alkali	1.7E-02 mol	3.3E-02 mol
Alkali consumed	2.5E-03 mol	1.2E-02 mol
Alkali consumed, mg	153	1230
% Consumed	12%	26%
mg. cons/g. rock	0.3	2.2

8 times less MEA is required for ACP/ASP floods! More than offsets price difference.

Finally, for specific surfactant structures liquid alkali-surfactant blends can be delivered to the oil field for direct injection into a polymer stream affording straightforward implementation of ASP.

Novel/Additive Information

New concept for alkaline surfactant polymer flooding. Lower cost and less complex implementation into the oilfiled. Few facilities required, and less tendency for production well scaling.

References

Delamide, E. et al "Chemical EOR for Heavy Oil: The Canadian Experience" SPE-169715-MS (2014).

Volokitin, Y., Shuster, M., Karpan, V. et al. 2018. Results of Alkaline-Surfactant-Polymer Flooding Pilot at West Salym Field. Paper presented at the SPE EOR Conference at Oil and Gas West Asia, Society of Petroleum Engineers, Muscat, Oman, 26–28 March. SPE-190382-MS. https://doi.org/10.2118/ 190382-MS.

Pandey, A., Koduru, N., Stantley, M., Pope, G.A., Weerasooriya, U.P., "Results of ASP Pilot in Mangala Field: A Success Story", (2016) SPE-179700, presented at Tulsa IOR/EOR Conference.

Southwick, J., Brewer, M., Batenburg, D. van. et al. 2020. Ethanolamine as Alkali for Alkali Surfactant Polymer Flooding - Development of a Low Complexity Field Implementation Concept. Paper presented at the SPE Improved Oil Recovery Conference, Virtual, 31 August–4 September. SPE 200432-MS. https://doi.org/10.2118/200432-MS.

Southwick, J.G., Upamali, N, Fazelalavi, M.,Weerasooriya, U., Britton, C., Dean, R.M.. "A New Logistically Simple Solution for Implementing Alkali-Surfactant-Polymer/ Alkali-Cosolvent-Polymer in Difficult Environments: Evaluation of Concept with High Total Acid Number Viscous Crude Oil", 2022 SPE Journal.

Al Mahrouqi, D. et al, "Advancement Towards the Full-Field Implementation of Marmul Alkaline-Surfactant-Polymer in the Sultanate of Oman" SPE-207250-MS (2021).