

Improved Oil Recovery by Low Salinity Waterflooding: Surface Chemistry and SCAL Studies - Improved Oil Recovery by Low Salinity Waterflooding: Surface Chemistry and SCAL Studies

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The report contains the main objectives, final status and proposed future work plans of the project. Three publications have been resulted so far from this research project and another three are under preparation.

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SUMMARY

The objective of this project was to investigate the scopes of low salinity water injection (LSW) as an improved oil recovery method by SCAL studies and its linkage to the surface chemistry of reservoir rocks. The combination of SCAL and surface chemistry can provide an improved understanding of possible mechanisms of oil recovery during LSW. This information can also be useful while addressing the challenges during modelling of LSW process. The SCAL experimental studies were divided into following three tasks:

1. Investigation of LSW as secondary and tertiary recovery methods using various model oils.
2. Studies on effect of initial wettability conditions on performance of LSW.
3. Influence of various crude oil components such as acids, bases, and asphaltene on the recovery performance of LSW and its linkage with surface chemistry.

From the experimental results of Task 1, it was found that initial wettability of the rock has great influence on the final recovery by LSW as a secondary recovery method. The initial neutral-wet condition provides the highest recovery for both high and low salinity

waterflooding of Berea plugs. From Task 2, it was found that the initial water-wet condition is not favorable for LSW. Experiments were performed on Berea plugs with low and high clay content under same experimental conditions. The initial and final wettabilities were measured for representative plugs. It was found that there was negligible change in the wettabilities after LSW which supported poor response by LSW. In Task 3, coreflooding experiments were performed on several Berea plugs with considerable clay contents. Different variations of the Heidrun crude oil such as acid free, base free, and asphaltene free Heidrun crude oils were used to study the effects of various polar components of crude oil on the performance of LSW. It was found that the plug with base free crude oil provided highest whereas that with acid free crude oil provided the lowest oil recovery. The improved oil recoveries with LSW were found to be negligible. This can be attributed to the initial fairly water-wet conditions of the core plugs.

The further interpretation of the results of Task 3 is continued using surface chemistry analysis reported in the Ph.D. thesis of Dr. Umer Farooq. Few coreflooding experiments have also been planned to further investigate the adsorption/desorption characteristics during low salinity waterflooding.

CONCLUSIONS AND PLAN FOR FURTHER WORK

There were no major changes in the plans that were proposed in the original project proposal. The targeted goals were achieved at the end of the project, even though identification of the sufficient conditions for salinity effects still remains as a challenge for the research community. New research projects in cooperation with the oil industry and the Research Council are therefore planned to improve our understanding of the effect of water chemistry on oil recovery. Based on the results from the present project we intend, if project funding is made available, to do the following:

- Characterize the effluent crude oil in the experiments in terms of total acid number (TAN) and total base number (TBN) to study the adsorption/desorption phenomena and interaction of polar components with the rock surface under different salinity environments.
- In Task 2 of the present study, the initial wettability conditions of all the plugs were found to be moderately or strongly water-wet. Hence, in-depth investigation on the phenomenon of wettability alterations could not be made. Hence, in the following we will investigate this phenomenon on the core plugs that are initially neutral- or oil- wet.
- Various mechanisms have been proposed to explain the improved oil recovery by LSW. However, there is a lack of clear understanding of the working mechanism or mechanisms responsible for improved oil recovery with LSW. We therefore plan to do a systematic experimental study with different formation brine and injection brine combinations.

Four master theses and two conference publications has been the result so far from the present VISTA project. Three other journal manuscripts are under preparatory stage.

It is worth to mention that as a post-doctoral research fellow, Dr. Hadia was involved in the guidance and mentoring of master theses on low salinity waterflooding projects. There were another three master theses on low salinity project for Frøy field, apart from VISTA project, that Dr. Hadia has supervised. This also resulted into one SPE conference publication.

PUBLICATIONS

1. Ashraf, A., Hadia, N. J., Torsæter, O., and Tweheyo, M. T.: “Laboratory Investigation of Low Salinity Waterflooding as Secondary Recovery Process: Effect of Wettability”, Paper SPE 129012 presented at Oil Gas India Conference, Mumbai, India. 20-22 January, 2010.
2. Hadia, N. J., Torsæter, O, and Tweheyo, M. T. “Laboratory Investigation of Wettability Alteration: Impact on Low Salinity Waterflooding Performance”, 16th European Symposium on Improved Oil Recovery, Cambridge, UK, 12-14 April, 2011.
3. Hadia, N., Heldal Lehne, H., Kumar, K. G., Selboe, K., Stensen, J. Å. and Torsæter, O.: “Laboratory Investigation of Low Salinity Waterflooding on Reservoir Rock Samples from the Frøy Field”, Paper SPE 141114 accepted for presentation at the SPE Middle East Oil and Gas Show and Conference to be held in Manama, Bahrain, 25-28 Sept. 2011.
4. Hadia, N. J., Ashraf, A., Torsæter, O., and Tweheyo, M. T.: “Laboratory investigation on effects of initial wettability on performance of low salinity waterflooding”, Manuscript in preparation.
5. Hadia, N. J., Kalvik, S., Tweheyo, M. T., and Torsæter, O.: “Low salinity waterflooding and wettability alterations”, Manuscript in preparation.
6. Hadia, N. J., Hansen, T., Tweheyo, M. T., and Torsæter, O.: “Influence of polar components of crude oil on the performance of low salinity waterflooding”, Manuscript in preparation.