

sasol

ALFOTERRA SOLOTERRA

**Surfactants for chemical
enhanced oil recovery**

Sasol Chemicals





About us

We at Sasol Chemicals innovate for a better world and deliver long-term value to our customers, communities and society.

Our broad portfolio of high-value products plays an integral role in the creation of numerous solutions that benefit the lives of millions of people.

Thousands of companies around the world leverage our technology, world-class facilities, expertise and collaborative approach to tackle their challenges.



Sasol Chemicals has production sites for surfactants and their feedstocks everywhere in the world.

Our global presence ensures supply chain security for your project.

ALFOTERRA & SOLOTERRA

Surfactants for chemical enhanced oil recovery

Sasol offers a range of surfactants for various types of chemical enhanced oil recovery (EOR). We select or design our products to match the specific conditions of your reservoir.

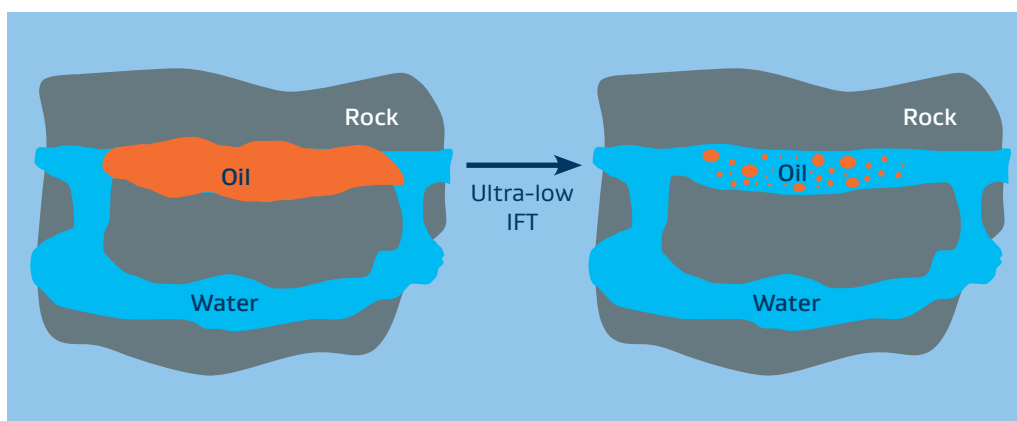
Surfactants are main components of (alkaline) surfactant polymer ([A]SP) flooding, but they can also improve other enhanced recovery techniques such as gas injection (miscible CO₂ flooding, foam assisted water alternating gas [WAG]), thermal (steam foam, steam-assisted gravity drainage [SAGD]) or wettability alteration.

(A)SP flooding – how surfactants work

Surfactants have the ability to lower the interfacial tension between floodwater and oil and thereby mobilise and solubilise crude trapped in rock pores. Ultra-low interfacial tension (IFT) is found in so-called 'Winsor Type III microemulsion phases'. To form these microemulsions, the surfactant needs to be exactly balanced in its affinity to the water and the oil phase. The phase behaviour is highly dependent on the chemical composition of the oil, the reservoir temperature, the salinity, the hardness of the formation water and the injection fluid as well as on the nature and composition of the surfactant package. Since for any given reservoir only the last two parameters can be influenced from the outside in any given reservoir, the selection of the right surfactant or surfactant formulation for any specific reservoir is essential.

Surfactant selection studies typically include the assessment of the solubility in the reservoir brine, rock adsorption, thermal stability, polymer compatibility, IFT measurements, and phase behaviour studies, followed by core flood tests of the most promising candidates.

Oil trapped in rock pores is mobilised by ultra-low oil/brine interfacial tensions.



Surfactant portfolio for chemical flooding

The right choice for all reservoir conditions

Different reservoir conditions result in different requirements for the materials to be used. High salinities – especially in conjunction with high water hardness – pose solubility issues for a lot of materials, while high temperatures over extended periods of time challenge the chemical stability of the surfactants. With these challenges in mind Sasol has developed a range of different chemistries suitable for all kinds of reservoir conditions.

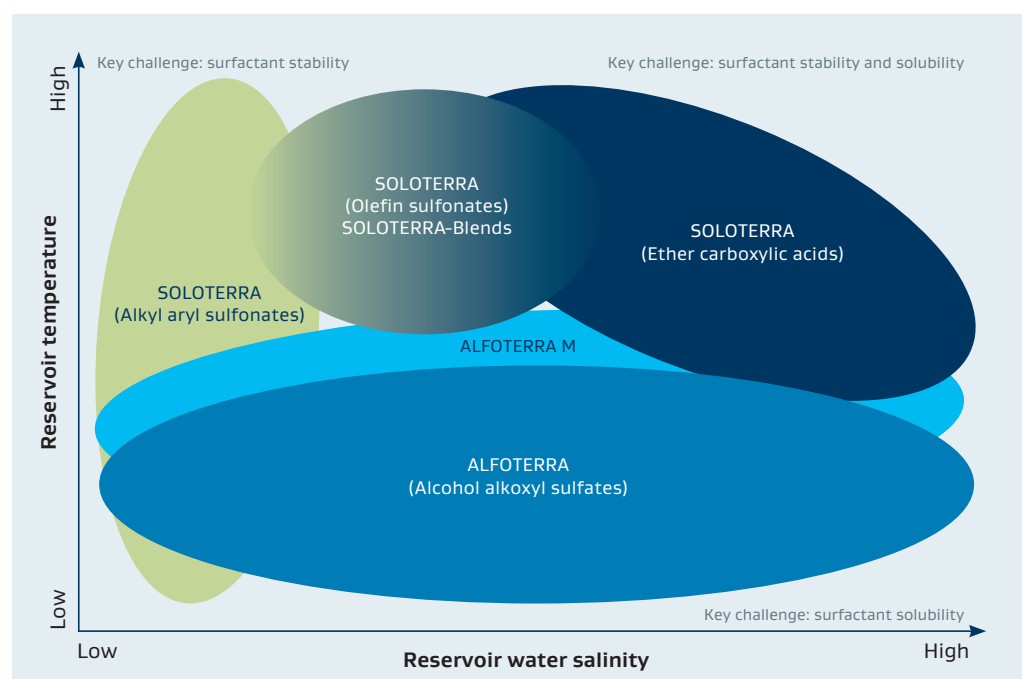
ALFOTERRA alcohol alkoxy sulfates are the best choice for lower temperatures, while our modified ALFOTERRA M series is suitable for intermediate temperatures in ASP floods. A broad range of hydrophobes and varying degrees of alkoxylation yield suitable materials for low as well as high salinities.

SOLOTERRA alkyl aryl sulfonates exhibit excellent temperature stability but only limited solubility in saline or hard water. Therefore, they are the best choice as workhorse surfactants for reservoirs with high temperatures and low salinities.

SOLOTERRA internal olefin sulfonates are temperature stable and available in different grades for a range of salinities.

SOLOTERRA ether carboxylates combine good temperature stability with the flexibility of alkoxylation chemistry, which similar to the ALFOTERRA surfactants allows materials to be tailored for a broad range of intermediate and high salinities.

Depending on reservoir conditions, our surfactants can be employed in single surfactant systems or blended into custom-made formulations. Sasol also offers a range of co-surfactants or co-solvents to further enhance your formulations.



ALFOTERRA

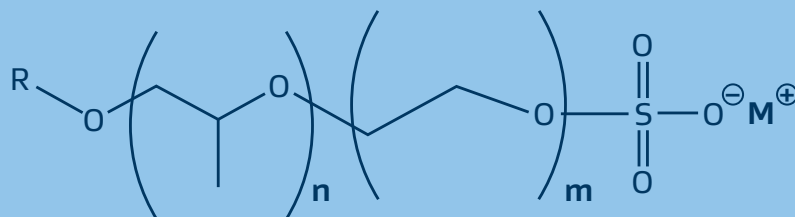
Alcohol alkoxy sulfates

ALFOTERRA alcohol alkoxy sulfates are available based on different feed alcohols and in different alkoxylation (PO/EO) grades. Like all other sulfates ALFOTERRA surfactants are suitable for low to moderate (up to ~ 60 °C) reservoir temperatures, while our patented and improved ALFOTERRA M series is also stable at intermediate temperatures (up to ~ 80 °C) in ASP floods.

Our large portfolio of alcohols with different carbon chain lengths and branching patterns allow for the surfactant hydrophobe to be matched to the crude oil for optimum interaction. Variation in the alkoxylation type and grade results in a range of materials with optimum salinities from almost fresh water to very high values.

ALFOTERRA surfactants are high active materials (> 85 % a.m.) with low viscosities and moderate pour points for easy logistics and handling. Depending on the formulation concept, ALFOTERRA surfactants can successfully be applied as single surfactant systems but are also suitable for combination packages.

C6–32 = R
0–20+ = n
0–20+ = m
cation = M
(alkali or
alkanol amine)



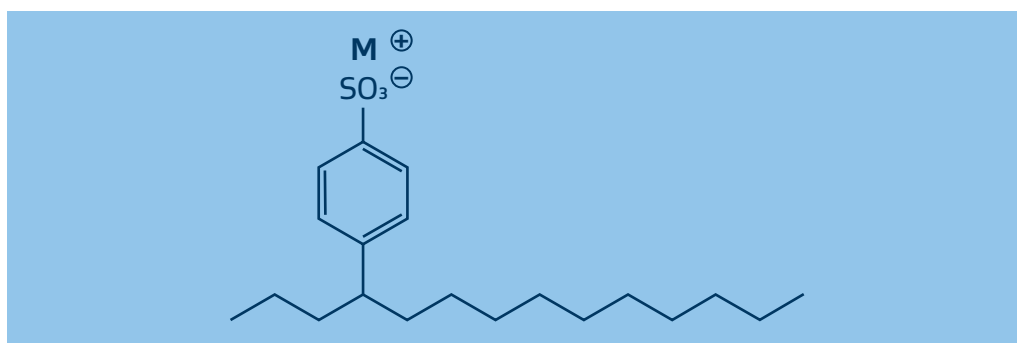
SOLOTERRA

Alkyl aryl sulfonates

SOLOTERRA alkyl aryl sulfonates are based on linear alkyl benzenes with an alkyl chain length of either 10 – 13 or 15 – 16 carbons. Alkyl benzene sulfonates are stable up to very high temperatures (> 250 °C) but they have a low tolerance to divalent ions (water hardness) and solubility in brine is limited. Therefore, a co-surfactant/co-solvent is usually required to achieve optimum performance.

SOLOTERRA alkyl aryl sulfonates are supplied in their acidic form with active matter of > 90 % and require neutralisation before use – this can be done in line with an ASP set-up, for example. Neutralised versions are available as well.

Alkyl chains:
C10 – 13
C15 – 16
cation = M
(hydrogen, alkali
or alkanol amine)

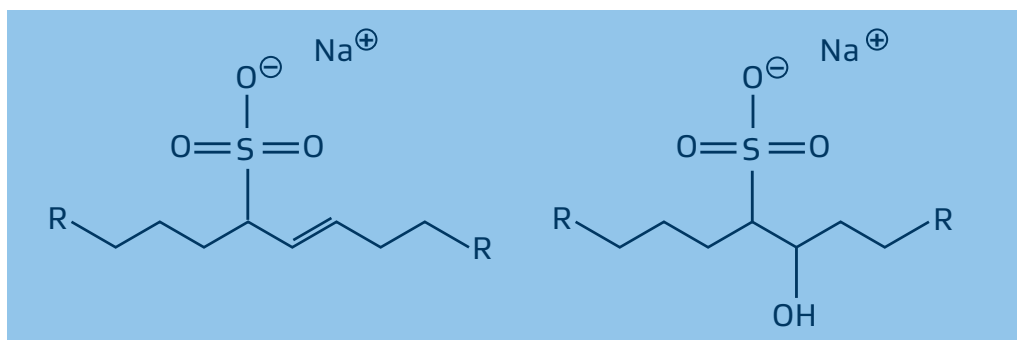


Internal olefin sulfonates

SOLOTERRA internal olefin sulfonates are a mixture of alkene sulfonates and hydroxy alkane sulfonates that are stable at high temperatures. Available in different carbon chain lengths SOLOTERRA internal olefin sulfonates are suitable for a range of salinities, as the optimum salinity decreases with increasing carbon chain length. A co-surfactant/co-solvent is usually required to achieve optimum performance.

SOLOTERRA internal olefin sulfonates are supplied as sodium salts as low to medium active products to ensure good storage and handling properties.

Alkyl chains:
C15 – 18
C20 – 24



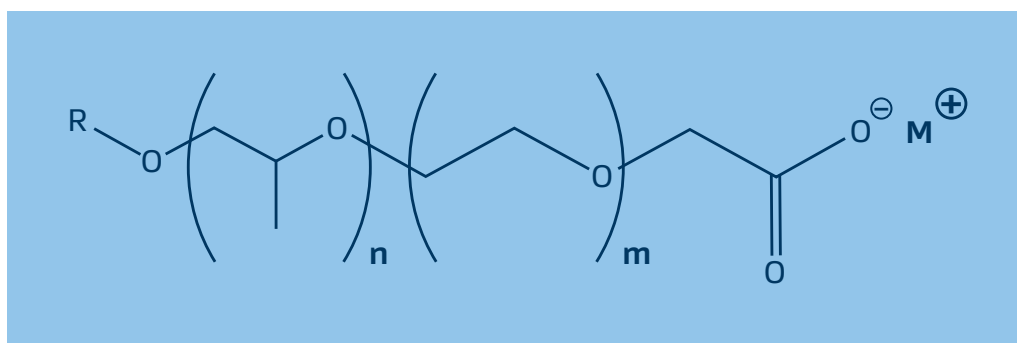
Ether carboxylic acids

SOLOTERRA ether carboxylic acids – or rather alcohol ether carboxylates in their neutralised active form – are available based on different feed alcohols and in different alkoxylation (PO/EO) grades. Ether carboxylates show good temperature stability over extended periods of time at up to 120 °C. Ether carboxylates are well known for their excellent salinity tolerance, including divalent ions.

Similar to our ALFOTERRA alcohol alkoxy sulfate portfolio, our SOLOTERRA alcohol ether carboxylates can be adjusted to specific optimum temperatures and salinity conditions by selecting the hydrophobe chain length, branching pattern and alkoxylation degree. They can be applied as a primary surfactant or as a co-surfactant, for example in a blend with a sulfonate main surfactant.

SOLOTERRA ether carboxylates are usually supplied in their acidic form (ether carboxylic acids) as high active, low viscosity liquids that require neutralisation prior to use. However, neutralised materials can also be made available.

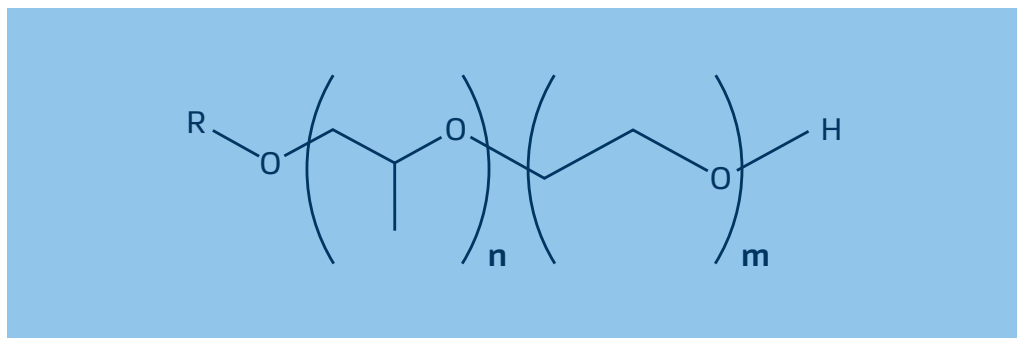
C6 – 32 = R
0 – 40+ = n
0 – 20+ = m
cation = M
(hydrogen, alkali
or alkanol amine)



Co-surfactants/co-solvents

Sasol offers a wide range of nonionic co-surfactants and co-solvents to enhance surfactant formulations for chemical flooding. Alcohol ethoxylates are available based on linear and branched C4 up to C32 alcohol feedstocks in EO grades ranging from low mole (3 EO) to very high mole (50+ EOa); Alcohol propoxylates and mixed alkoxyates are available as well. Alcohol ethoxylate co-surfactants enhance the solubility of sulfate or sulfonate surfactants in high saline. Standard co-solvents like butyl glycol ethers and phenyl glycol ethers are also available.

R = C4 – 32
n = 0 – 20+
m = 0 – 20+





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Technical Formulations

For further information on these or other Sasol products
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EOR@sasol.com

www.sasol.com

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