

ENHANCED OIL  
RECOVERY

# UFAFLOW

## ANIONIC SURFACTANTS



RECOVER MORE OIL FROM EXISTING FIELDS

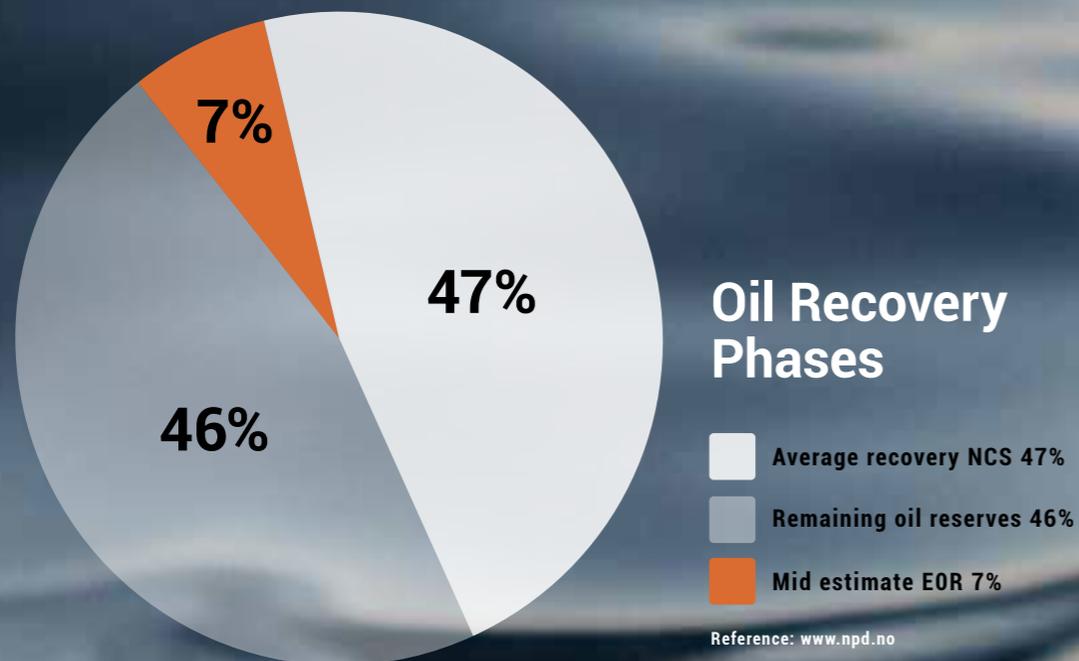
47%

**Unger**

PURE NORDIC QUALITY

# THE NORWEGIAN OIL ADVENTURE

The Norwegian oil adventure began with Philips Petroleum's discovery of Ekofisk in 1969, and the first oil was produced from this field two years later. In the following years, a number of major discoveries were made.



Today the Norwegian Continental Shelf (NCS) hosts more than 85 oil fields which are operated by more than 40 exploration and production companies.

New fields are continuously being discovered and many fields are reaching their end of planned production life.

The petroleum activities have, since the startup in 1971, contributed significantly to the economic growth of the Norwegian welfare with a contribution of more than 14 000 billion NOK to Norway's GDP. The first plans for recovering oil from the reservoir were estimated to be as little as 17% of original oil in place. Today almost 50 years later, the oil recovery from the same field is almost 50%, due to new technologies and innovations.

The average oil recovery basis at the NCS is around 47%, which is 7 % higher than the average worldwide oil recovery basis. These numbers present a huge potential for new technologies and innovations for recovering more oil, as almost half of the natural resources are being left in the reservoirs.

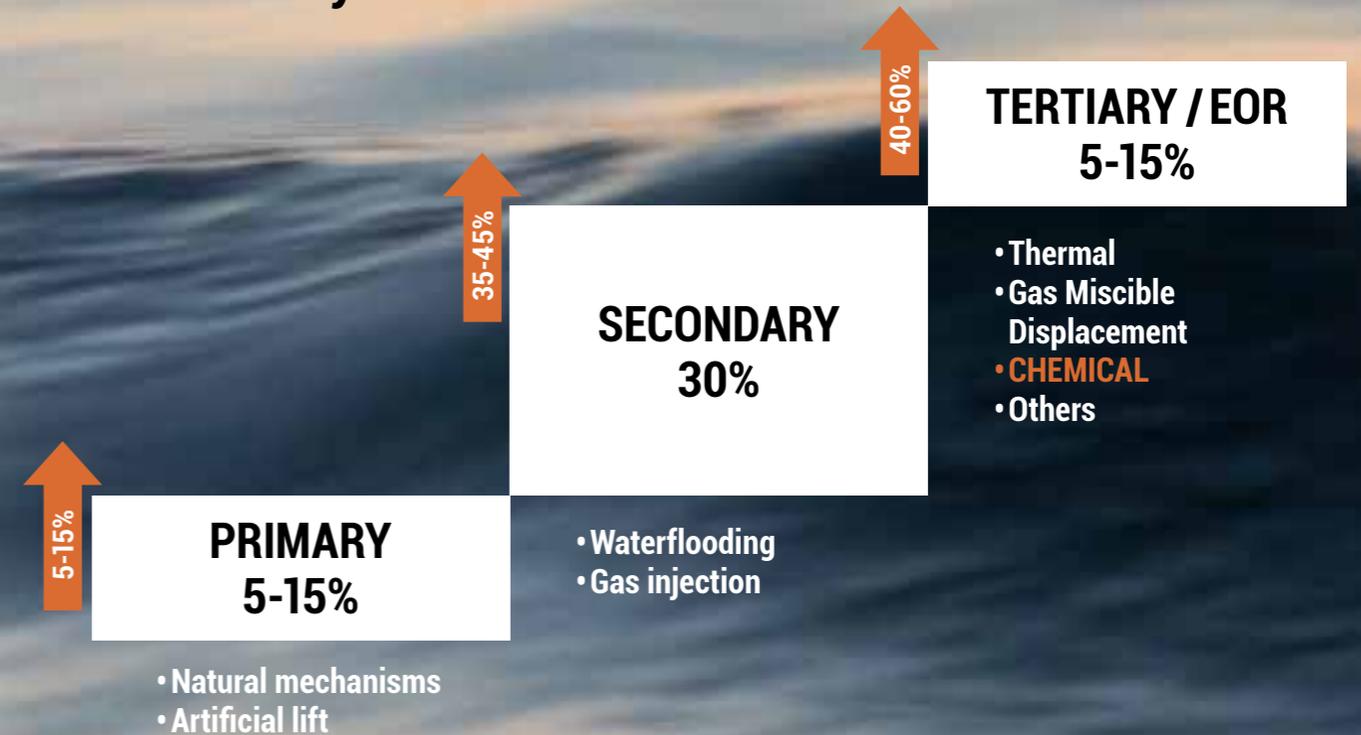
**Enhanced oil recovery (EOR) by using chemicals is one of several possible technologies which can play an important role in improving oil production in the future.**

# ENHANCED OIL RECOVERY (EOR)

EOR is the implementation of various advanced techniques for increasing the amount of crude oil that can be extracted from an oil field. Chemical EOR is one of the EOR techniques, and it is traditionally a third stage hydrocarbon production. The primary and secondary oil recovery techniques, using natural mechanisms and water and gas injections respectively, leave around 65 % of original oil in place. In addition to being beneficial of recovering more oil from reservoirs, EOR has also the benefits of continued use of existing infrastructure and minimizing the impact on the environment.

Unger Fabrikker AS has a long tradition of manufacturing designed anionic surfactants for the global market. Being a Norwegian company located nearby the oil fields, Unger wanted to contribute and take an active role in our common responsibility for an efficient and responsible resource management. The Ufaflow product line of new anionic surfactants are especially developed for EOR.

## Oil Recovery Phases



# Chemical EOR

While the mobile oil can be recovered by optimizing the production using more advanced well management, surfactants are one of several possible technologies that can be used to recover the remaining immobile oil in the reservoir.

Surfactants for EOR operations are normally used to lower the interfacial tension (IFT) between the oil and water or change the wettability of the rock. Surfactants can also have other functional roles, like generating foam or emulsions.

Combinations of surfactants and polymers (Surfactant Polymer flooding) can be used to improve sweep efficiency and accelerate the recovery of oil. Polymers are able to increase the viscosity of the water and they can be used as gels for blocking or diverting flow. Combinations of surfactants and polymers have shown to be very efficient to improve recovery by synergisms between the two components.



# Anionic Surfactants

Anionic surfactants are preferred surfactants for EOR in sandstone reservoirs, due to their low adsorption at neutral and high pH. They can be tailored and optimized to a wide range of conditions like different types of oil and high temperature reservoirs. Furthermore, the anionic surfactants are widely available in the market at a cost efficient level, and their chemical stability is very good, regarding handling, logistical solutions and performance properties under harsh conditions.



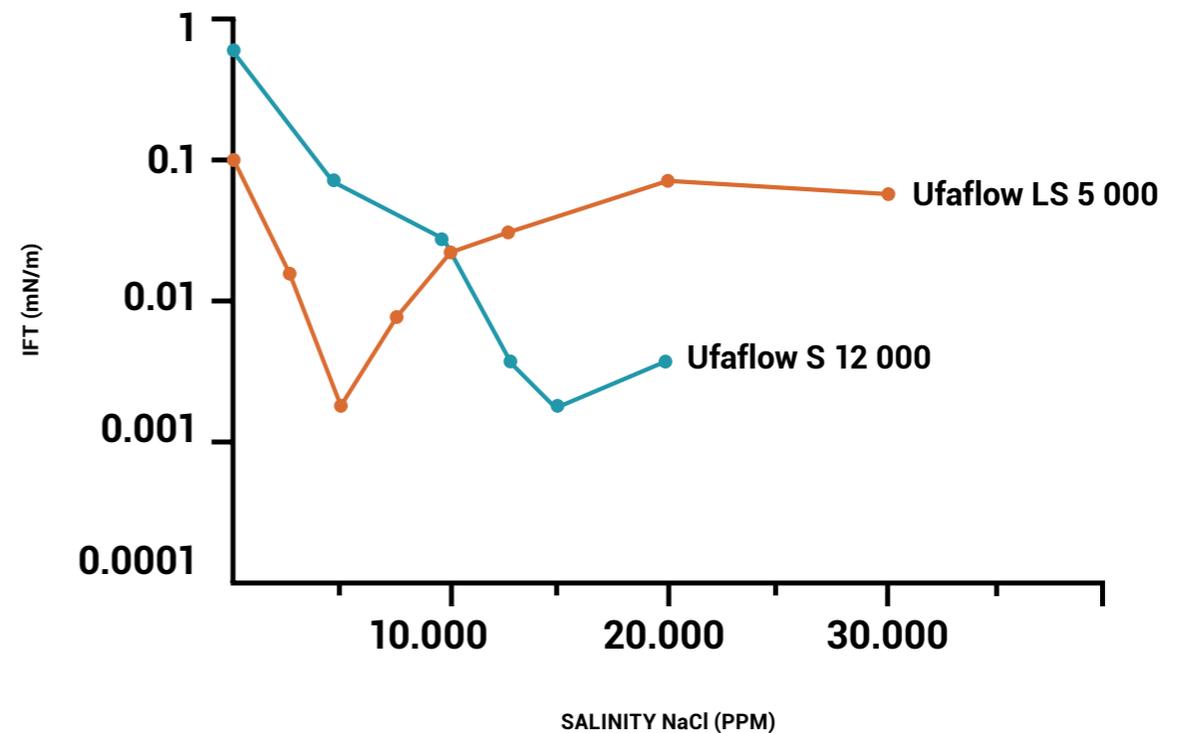
Schematic illustration of Mono Alkylbenzene Sodium Sulfonate.

# UFAFLOW product line

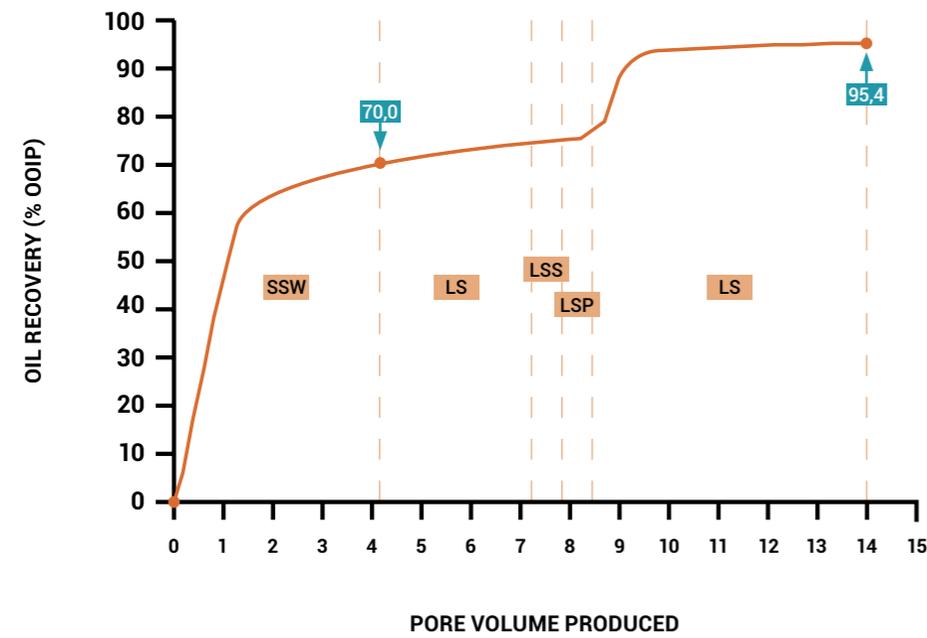
Our newly developed mono alkyl benzene sulfonates are different from traditionally available sulfonates used in home and personal care and Industrial & Institutional applications. Their higher molecular weight, hydrophobic character and their unique molecular structures and specifications are able to obtain ultralow interfacial tension (IFT) at optimal salinity and a low IFT value at Winsor II- phase. Combining low or optimal salinity with the UFAFLOW products have proven high oil recovery in core flooding experiments in the laboratory at realistic and typical conditions found at NCS. The system design has included high temperature, typically 70-80 °C with reservoir cores and crude oil from NCS fields. Unger is able to further customize and develop new EOR surfactants to meet the specific field and reservoir conditions when needed.

To meet the practical challenge of performing a real EOR operation, injection design has devoted much attention to optimize time and volume of injection water containing chemicals. By having screened and tested our surfactants for different conditions, we are able to meet new specific fields much faster, cheaper, more efficient and with a reduced risk. Typical usage of Ufaflow surfactant in injection water is 0,5 % but can vary from 0,3 till 1,0 %.

Interfacial tension between crude oil and Ufaflow products at different salinities



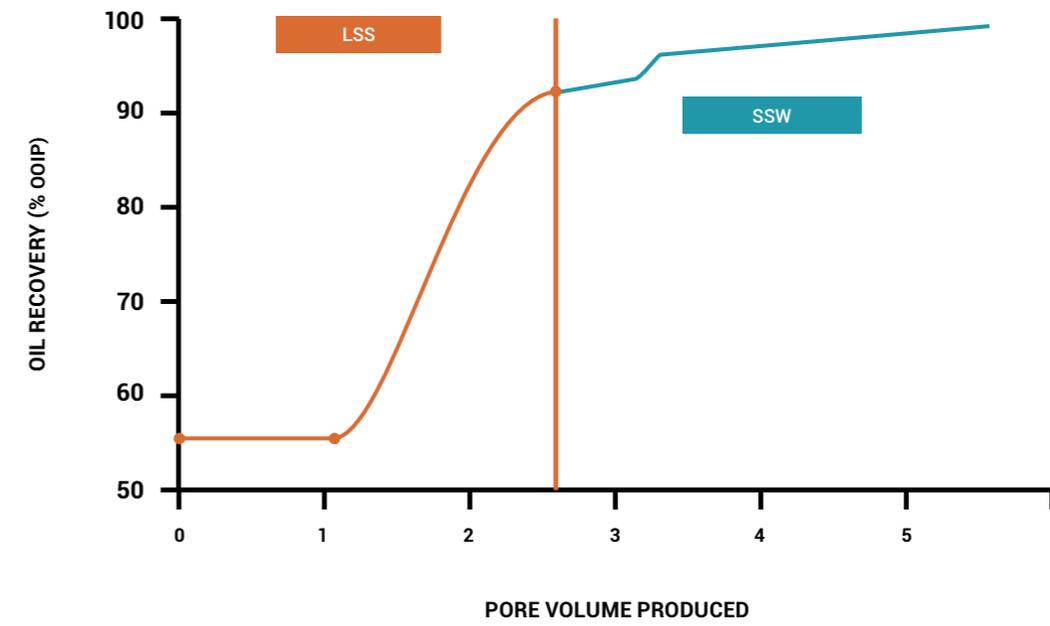
### Total oil recovery from one of the core flood experiments performed with Ufaflow LS 5 000



SSW - Synthetic Seawater  
LS - Low Salinity water

LSS - Low Salinity water with Surfactant  
LSP - Low Salinity water with Polymer

### Total oil recovery in core flood experiment performed with Ufaflow S 12 000



SSW - Synthetic Seawater  
LSS - Low Salinity water with Surfactant

## Table Proof of concept

Product	IFT Reduction		Solubilization	Oil types			Dynamic Adsorption	Storage Temperature	Core flooding results		Surfactant polymer flooding	Stability	Active Matter	Molecular Weight	pH	Offshore Classification
	Optimal Salinity	IFT value		Octane model oil	Crude A NCS	Crude B NCS			Berea	Reservoir cores						
Ufaflow LS 5 000	5 000-8000 ppm	0,027 (mN/m) <sup>1</sup> 0,008 (mN/m) <sup>2</sup> 0,002 (mN/m) <sup>3</sup>	70°C	*	*	*	0.30 mg/g	>5°C	75-95% oil recovery <sup>5</sup>	75-95% oil recovery <sup>5</sup>	HPAM	* <sup>4</sup>	0.3-1.0 %	431 (g/mol)	>10	Yellow <sup>6</sup>
Ufacid LS								>40°C					>95%	388 (g/mol)	<2	* <sup>6</sup>
Ufaflow S 12 000	12 000-15 000 ppm	0,002 (mN/m) <sup>2</sup>	70°C	*	*	NA	0.06-0.38mg/g	>5°C	75-95% oil recovery <sup>5</sup>	75-95% oil recovery <sup>5</sup>	HPAM	* <sup>4</sup>	0.3-1.0 %	410 (g/mol)	>10	Yellow <sup>6</sup>
Ufacid S								>40°C					>95%	409 (g/mol)	<2	* <sup>6</sup>

- 1) IFT measurements at 80 °C , with 0,5 % Ufaflow surfactant at optimal salinity and crude A
- 2) IFT measurements at 70 °C , with 1,0 % Ufaflow surfactant at 5000 ppm and crude B
- 3) IFT measurements at 70 °C , with 0,5 % Ufaflow surfactant at 5000 ppm and crude A
- 4) Stability test at 2200 PSI at 100°C for 63 days
- 5) Typical total oil recovery after different sequences of flooding through Berea or reservoir cores.
- 6) Ongoing

Crude A = EACN 6,8 Saturate 58,8 Aromatics 27,6, Resins 12,2 Asphaltens 1,4  
 Crude B= Oil from a field at Norwegian continental Shelf (NCS)  
 Reservoir core= Highly permeable sandstone reservoir core from a field at NCS  
 HPAM= Hydrolyzed polyacrylamide  
 NA= Not Analyzed

# Chemical EOR concept

Unger's approach has been to prove the concept of robust EOR using low salinity water (LSW) with surfactant and polymer. Several experiments, tests and analysis have been performed together with our partners, external research institutes and oil companies, to ensure realistic and accurate test conditions. The surfactants do not only have to perform well regarding ability to mobilize oil, they do also need to be efficiently implemented into the injection water at the desired localization.

The logistical solutions and economical aspects of performing an EOR operation especially offshore are key parameters to overcome. We have therefore worked to simplify surfactant flooding processes and to maximize oil recovery per unit surfactant by finding synergism between LSW, surfactant and polymer. The Strategic location of our production plant by the North Sea delivers a cost efficient production process. It makes it possible to achieve a coverage of solutions through local deliveries of high active surfactants.



## LOGISTICS

Our Supply Chain is global in terms of sourcing material and meeting customer demands all over the world. We handle all modes of transport and Unger is dedicated to deliver customer value across the value chain.

## HEALTH, SAFETY AND THE ENVIRONMENT

Ufaflow Surfactants for the oil and gas industry is specifically characterized and regulated under the Harmonized Offshore Chemical Notification Format (HOCNOF) and are ready to be used at NCS.

## QUALITY ASSURANCE AND QUALITY CONTROL

Unger is certified to ISO 9001:15. All substances produced are registered in REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) or are planned to be registered in REACH after a new product development period.



# Unger

PURE NORDIC QUALITY

## **Unger Fabrikker AS**

P.O.Box 254, N-1601 Fredrikstad Tel. +47 69708200 Fax. +47 69323775  
sales@unger.no www.unger.no

*This information is based upon Unger Surfactant experience and knowledge in this field. The information is only a guide for application of the products and Unger Surfactant gives no guarantee for the results from the application of the product, which lies outside Unger Surfactant control. Unger Surfactant responsibility and guarantee in selling this product is covered at all times by the relevant general sales conditions.*