Wetting Agents for water-miscible Lubricants

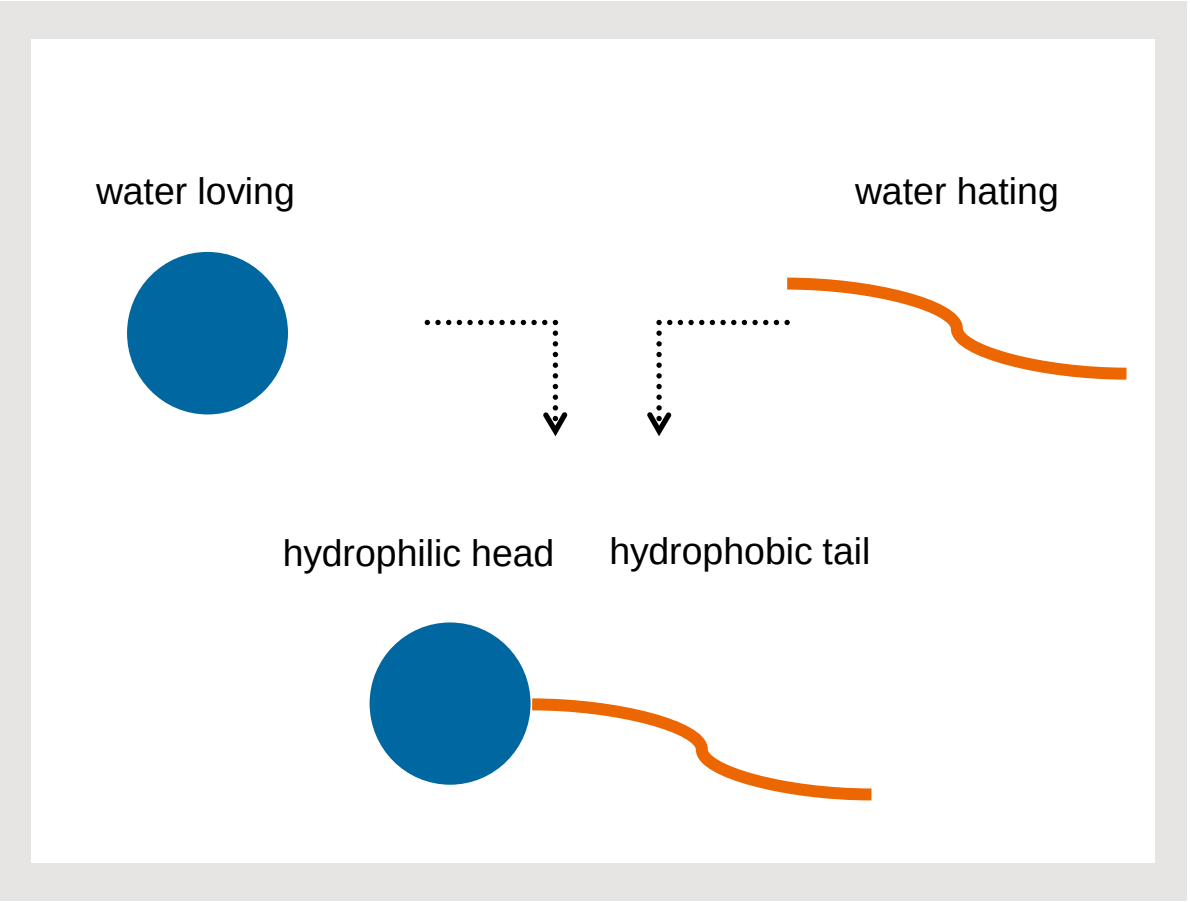
Product Overview

Evonik Operations GmbH – Specialty Additives
Interface & Performance | August 2023

EVONIK
Leading Beyond Chemistry

Surfactants
Definition

- Surface acting agents
- Amphiphilic as they contain two or more groups
- The structure has a hydrophobic tail and a hydrophilic head
- Lower the surface tension and migrate to different surfaces (interfaces)
- Affect wetting, foam, dispersion, and emulsion stability
- Wetting agents are surfactants optimized for substrate wetting
- Used in many applications ranging from detergents and cleaners to paints and inks



EVONIK
Leading Beyond Chemistry

Wetting Mechanism of Surfactants
As a Function of Contact Angle

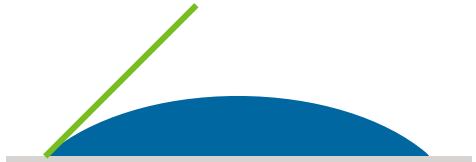
The contact angle θ is a measure to characterize the behavior of a liquid on a solid substrate

In case that θ is >90° the solid is not wettable

Θ >90°
poor wetting

Pure water
No surface activity
No wetting
θ > 90°

If θ is between 0 – 90°, the solid is wettable

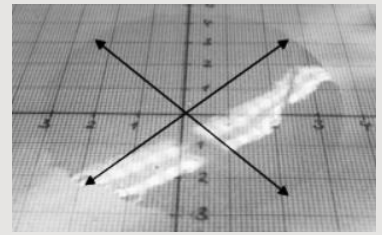


Θ 45°
good wetting

Water + surfactant
Good wetting
Contact angle 45°

In case of complete wetting (spreading) the contact angle is 0°

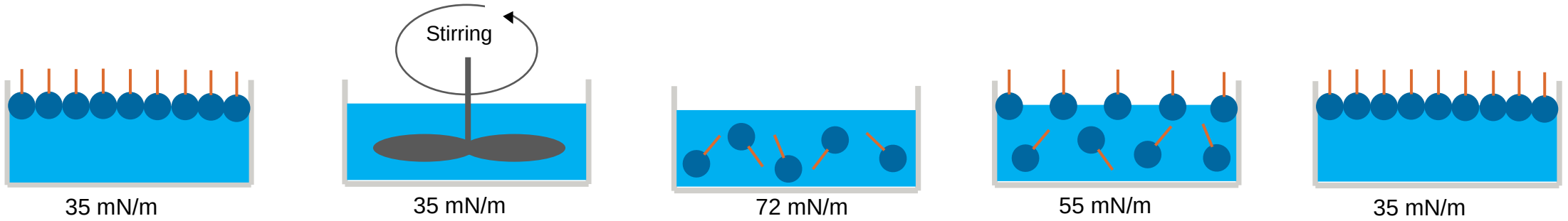
Θ 0°
complete wetting



Water + trisiloxane
Superspreading
Contact angle < 1°

EVONIK
Leading Beyond Chemistry

Dynamic Processes require low Dynamic Surface Tension



Surface tension is lowered when surfactant molecules assemble at the air/liquid interface

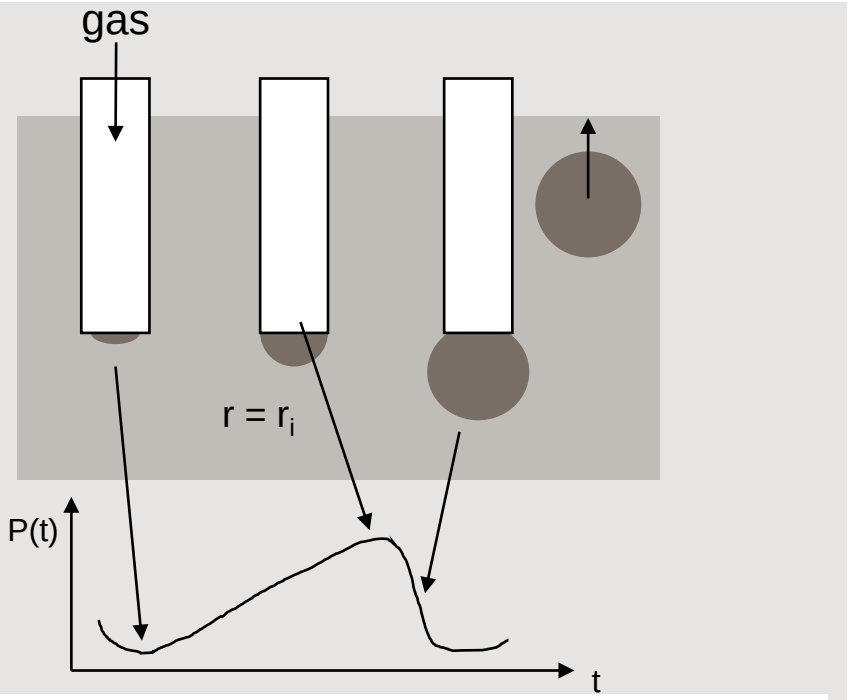
When the surface changes, surfactants are moved from the surface and must move back to new surface. This takes time. Different surfactants move at different speeds.

The surface tension during this time is called dynamic surface tension. This changes at different rates of surface creation.

- During machining, new surfaces are constantly being created
- Increasing process speeds and high pressures in the coolant supply place particularly high demands on the suitability of a wetting agent
- For uniform substrate wetting, surfactants have to migrate rapidly to those new interfaces
- **Low surface tension is a basic precondition for good wetting properties**

Source:www.kruss.de

Bubble Pressure Tensiometer determines the Dynamic Surface Tension that is important for fast Processes



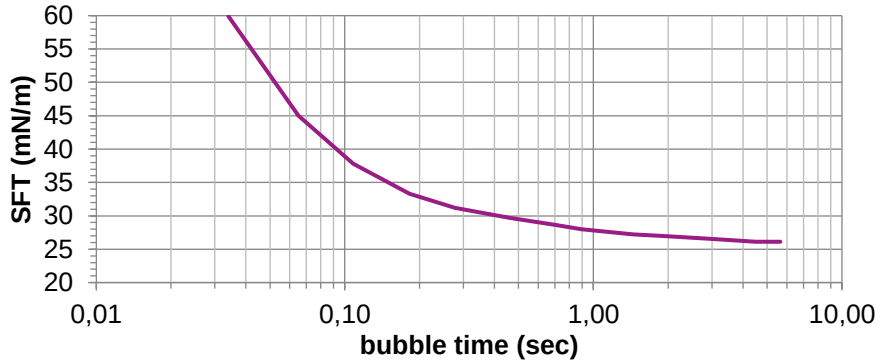
$$\sigma = \frac{\Delta P r}{2}$$

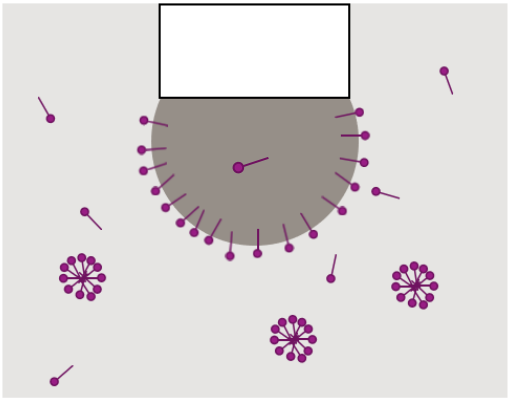
ΔP = Pressure difference between maximum and minimum value

r_i = Radius of bubble

r = Radius of capillary

Bubble lifetime can be varied



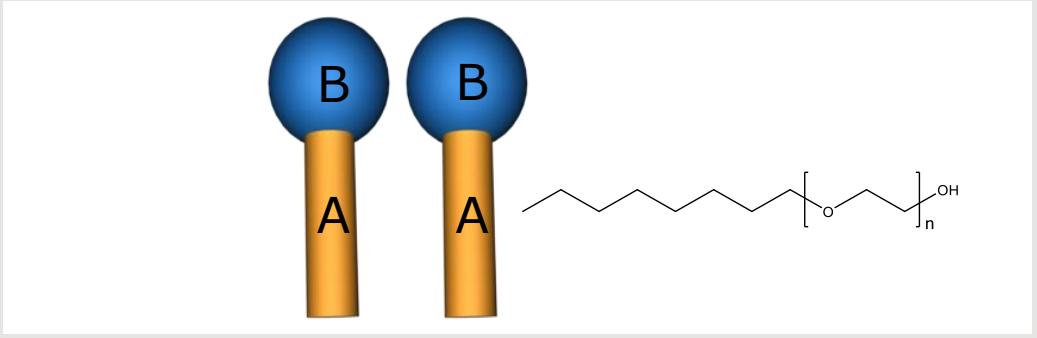


EVONIK Leading Beyond Chemistry

SURFYNOL® Surfactants
Traditional Surfactons vs. Gemini Wetting Agent Technology

Traditional Surfactants

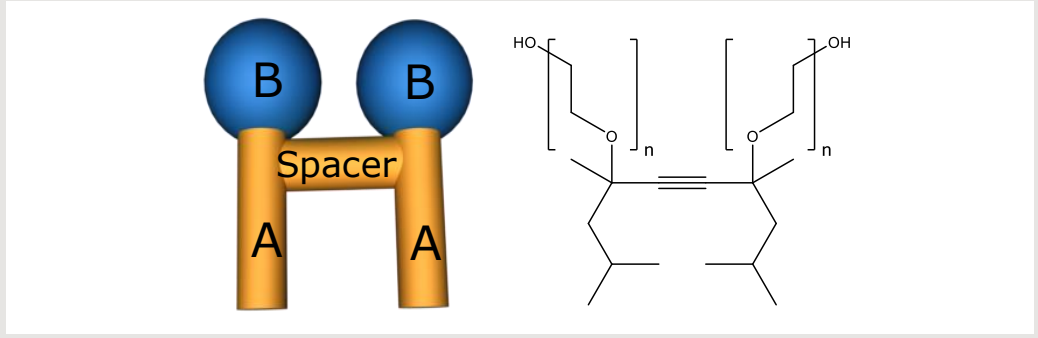
- E.g. alcohol ethoxylates, alkyphenol ethoxylates
- Contain two groups - a hydrophobic tail and a hydrophilic head
- Lower the surface tension and provide wetting, emulsification, detergency, foam.
- Typically form micelles and surfactant layers



VS.

Evonik´s Gemini Wetting Agents

- E.g. acetylenic diols, specialty chemistries
- Contain two hydrophiles and (at least) two hydrophobes within a single molecule
- Are more surface active than their single hydrophile – single hydrophobe analogs
- Best for substrate wetting, dynamic surface tension reduction
- Most have been designed to not form micelles



EVONIK
Leading Beyond Chemistry

SURFYNOL® Surfactants
Our nonionic Gemini Wetting Agents

Efficient Dynamic Wetting
Zero Foam / Defoaming
Lower Water Solubility
Does Not Readily Emulsify

Optimal balance between solubility, wetting and low/no foam

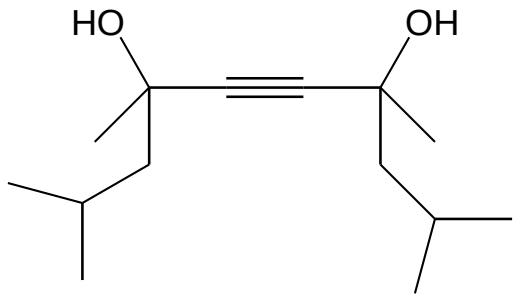
Moderate Dynamic Wetting
Minimal Foam
Higher Water Solubility
Increased Emulsification

Hydrophobic ⟵ ⟶ **Hydrophilic**

- Surfynol® 104
- Surfynol® 420
- Surfynol® 440
- Surfynol® 2502
- Surfynol® 465
- Surfynol® 485

SURFYNOL® 104 surfactant

- Well known Gemini wetting agent and antifoam
- Lowers dynamic surface tension very well
- Solid at room temperature - available in a wide variety of solvent cuts



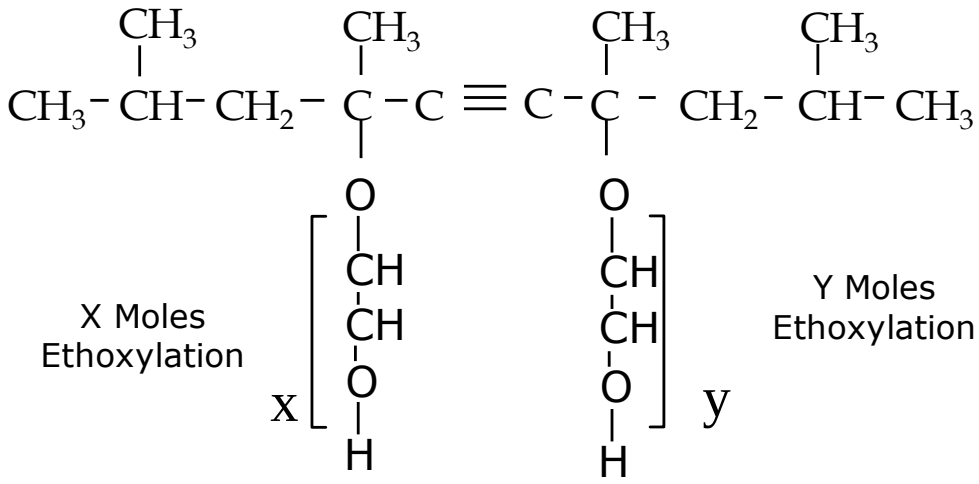
2,4,7,9-Tetramethyl-5-Decyne-4,7-Diol

Surfynol Product	Activity (%)	Carrier
S104 Solid	100	None; Wax melts at >54 °C
S104A	50	2-Ethylhexanol
S104BC	50	2-Butoxyethanol
S104DPM	50	Dipropylene glycol monomethylether
S104E	50	Ethylene glycol
S104H	75	Ethylene glycol
S104PA	50	2-Propanol
S104PG50	50	Propylene glycol
S104S	50	Amorphous silica

SURFYNOL® 400 series Surfactants
ethoxylated SURFYNOL® 104

	Average Moles EO (x+y)	
Surfynol 104	0	
Surfynol 420	1.3	Non-micellar
Surfynol 440	3.8	
Surfynol 465	10	
Surfynol 485	30	

with increasing EO proportion



As Degree of Ethoxylation Increases:

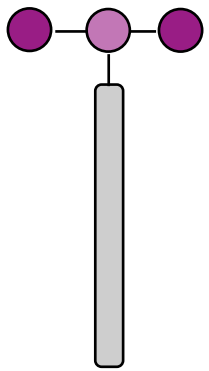
✓water solubility increases (HLB increases)

✓ability to control foam decreases

Surfynol® 440 Surfactant can achieve the lowest DST because it can be incorporated at up to 1.5 wt.% in many aqueous formulations

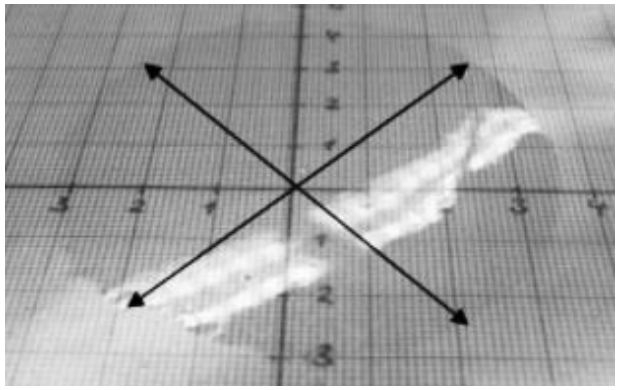
EVONIK Leading Beyond Chemistry

Polyether-modified Trisiloxanes
TEGOPREN® 5840 & TEGOPREN® 5847



= silicone backbone

= polyether



Water + trisiloxane
Superspreading
Contact angle < 1°

- Small amounts of our polyether-modified trisiloxanes reduces surface tension of water-borne systems
- Apart from the extraordinary reduction of surface tension in aqueous solutions, the main property of polyether-modified trisiloxanes is
  - spreading
  - fast coverage of large hydrophobic surfaces

Selected Wetting Agents for water-miscible Lubricants such as MWF
Product overview

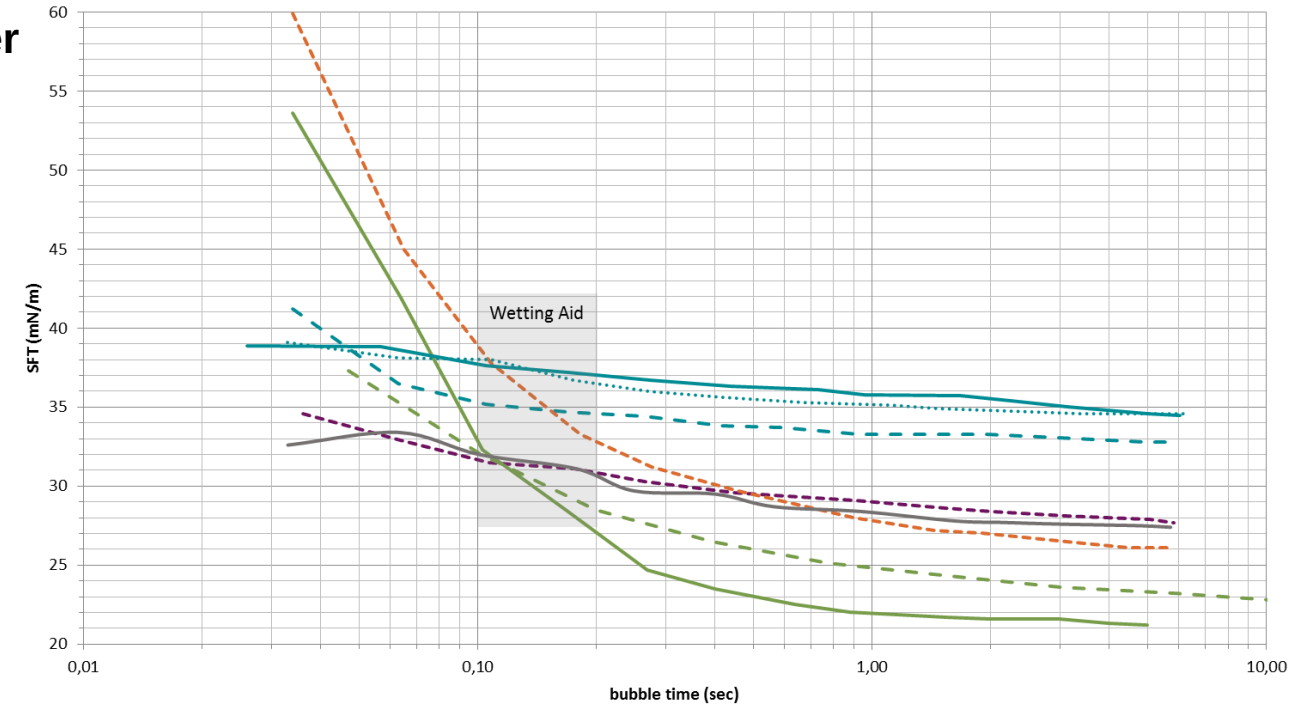
Product	Application		Chemical Base	Remarks
	emulsifiable fluids	water soluble fluids		
TEGO® SURTEN W 111	●	●	Alkoxylated alcohol	▪ Excellent balance between low foam and dynamic wetting ▪ Dispersing of finely ground metal fines, carbon black particles and fine iron/carbon black particles
TEGOPREN® 5840 **TEGOPREN® 5847**	●	●	Polyether-modified trisiloxanes	▪ Extraordinary dynamic reduction of surface tension ▪ Super-spreading properties (fast coverage of large hydrophobic surfaces)
SURFYNOL® 104 H 75 % active in ethylene glycol	●	○	Acetylenic-diol based gemini surfactant	▪ Excellent dynamic wetting ▪ Very low/no foaming tendency (destabilizing of foam) ▪ Non-micelle forming ▪ Faster Dropping of metal fines
SURFYNOL® 440	●	●	Acetylenic-diol based gemini surfactant, ethoxylated	▪ Excellent balance between low foam, dynamic wetting and increased water-solubility ▪ Non-micelle forming
SURFYNOL® 2502	●	●	Alkoxylated acetylenic-diol based gemini surfactant	▪ Optimal balance between low/no foam, dynamic wetting and high water-solubility
TOMADOL® 1 - 5	●	●	PEG-5 C_{11} alcohol	▪ Excellent reduction of surface tension ▪ Combines improved wetting properties with moderate foaming ▪ HLB 11.2
DYNOL® 360	●	●	Hydroxy thio-ether based surfactant	▪ Superior reduction of dynamic surface tension ▪ Provides fast wetting while very low/no foaming ▪ Excellent alternative to fluorocarbon surfactants ▪ Promotes rapid separation of metal fines without clumping

● recommended ○ depending on fluid composition

Dynamic Surface Tension of selected Wetting Agents for water-miscible Lubricants

Dynamic Surface Tension (DST) evaluated by bubble pressure method (sita science line t100)

1 g/l in DI-water



Alkoxylated alcohol

- TEGO® Surten W 111

Polyether-modified trisiloxanes

- TEGOPREN® 5840
- TEGOPREN® 5847

Alkoxylated alcohol

- TOMADOL® 1 - 5

Acetylenic diol based gemini surfactants

- SURFYNOL® 104 H
- SURFYNOL® 440
- SURFYNOL® 2502

Hydroxy thio-ether based surfactant

- DYNOL® 360

EVONIK Leading Beyond Chemistry


EVONIK
Leading Beyond Chemistry