DEFENSE LOGISTICS AGENCY
ENERGY
8725 JOHN J. KINGMAN ROAD
FORT BELVOIR, VIRGINIA 22060-6222

September 15, 2015

Dr. Wen Yang
Land Disposal Unit
Los Angeles Regional Water Quality Control Board
320 West 4th Street, Suite 200
Los Angeles, California 90013

Dear Dr. Yang:

This letter has been prepared in response to the Regional Water Quality Control Board - LA Region (RWQCB) request for information sent on September 01, 2015. The Defense Logistics Agency – Energy (DLA) would like to clarify the bacteria and surfactant currently in use at the DFSP Norwalk site (Site) for the bioremediation of petroleum contaminated soil. On February 6, 2015, the bioremediation methodology was approved by the Regional Water Quality Control Board - LA Region (RWQCB) in accordance with the referenced General Waste Discharge Requirements [WDR]).

At the time of your approval, F4 Remediation, Inc. (F4) was subcontracted by our contractor, The Source Group, Inc. (SGI) to conduct the soil bioremediation. On August 13, 2015, Bulldog Green Remediation, Inc. (BGR) was awarded a subcontract by SGI to replace F4 and continue soil remediation at the Site using the same technology and processes previously used. Upon issuance of the new subcontract to BGR, new suppliers (distributors) were secured for both the microbes and surfactant. The new distributors were selected to eliminate the need to import the US-made materials through Canada and to provide more flexibility in schedule and faster product delivery.

We hereby notify the RWQCB of the change in subcontractor and suppliers for bacteria and surfactants used at the site. Furthermore, we are requesting the RWQCB's concurrence that the change of suppliers does not constitute a material change as specified in in Provision C.4 of the WDR wherein it is stated that "*…in accordance with Section 13260 of the California Water Code, the discharger shall file a report with this Regional Board of any material change or proposed change in the character, location or volume of the discharge*."

As previously described and approved by the RWQCB, the ex-situ bioremediation technology being applied at the Site combines a proprietary blend of non-pathogenic microbes and surfactant to degrade petroleum hydrocarbons and other organic compounds into carbon dioxide and water. This technology was documented in the December 10, 2014, *Addendum To Soil Remedial Action Plan* (December 10, 2014, Addendum), prepared by SGI using documentation provided by F4.

The December 10, 2014, Addendum described the use of F4's Bioreclaim™ bacterial solution. The F4 solution was used until August 12, 2015, to treat approximately 20,338 cubic yards of soil at the Site. Subsequently, BGR has been subcontracted to continue the treatment of soil at the Site. A requirement of BGR's subcontract is that they continue to utilize the same bacteria and surfactant contained within the Bioreclaim™ and Bio-Surf solutions.

While the names of the treatment solution have changed, the active ingredients have not. Specifically, the microbes in the F4's Bioreclaim™ and BGR's Tomadol®/microbe solution consist of the same naturally occurring *Pseudomonas* bacteria. In fact, the bacteria used in the Tomadol ® solution is formulated by the same Southeast U.S. manufacturer that is used in Bioreclaim™. Similarly, the surfactant Bio-Surf described in the December 10, 2014, Addendum comprises a non-ionic ethoxylated alcohol solution. Similar to Bio-Surf, the surfactant used by BGR (specifically, Tomadol 91-6) is a non-ionic ethoxylated alcohol solution, manufactured by Air Products, Inc. and distributed by Brenntag Pacific, Inc. As with Bio-Surf, the Tomadol 91-6 surfactant is a mixture of C-9, C-10, and C-11 linear alcohols. Note that Tomadol 91-6 meets the criteria of the U.S. EPA Design for the Environment (DfE) as a safer choice surfactant.

Because the change in suppliers for the bacteria and the surfactant does not result in a change in the character, location, or volume of the discharge, it is our belief no material change has occurred. We respectfully request to your concurrence.

If you have any questions or need additional information concerning this report please contact Nicholas Carros at (703) 767-6624 or e-mail: nicholas.carros@dla.mil.

Sincerely,

Laura A. Fleming
Chief, Environmental Division
DLA Installation Support for Energy

Attachments: Safety Data Sheet for Tomadol 91-6
Tomadol Ethoxylated Alcohols Product Guide

Cc: Mr. Paul Cho, RWQCB
Ms. Adrianna Figueroa, City of Norwalk
Mr. Neil F. Irish, SGI

Safety Data Sheet

Version 2.1 SDS Number 300000021244
Revision Date 01/26/2015 Print Date 08/05/2015

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	TOMADOL ® 91-6 SURFACTANT
Product Use Description	:	Detergent
Manufacturer/Importer/Distributor	:	Air Products and Chemicals, Inc 7201 Hamilton Blvd. Allentown, PA 18195-1501 GST No. 123600835 RT0001 QST No. 102753981 TQ0001
Telephone	:	1-610-481-4911 Corporate 1-800-345-3148 Chemicals Cust Serv 1-800-752-1597 Gases/Electronics Cust Serv
Emergency telephone number (24h)	:	800-523-9374 USA +1 610 481 7711 International

2. HAZARDS IDENTIFICATION

GHS classification

Acute toxicity - Oral Category 4
Serious Eye Damage - Category 1

GHS label elements

Hazard pictograms/symbols

Signal Word: Danger

Hazard Statements:

H302:Harmful if swallowed.
H318:Causes serious eye damage.

Precautionary Statements:

Prevention	:	P264:Wash hands thoroughly after handling. P270:Do not eat, drink or smoke when using this product. P280:Wear eye protection/face protection.
Response	:	P301+P312 :IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. P305+P351+P338 :IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P310 :Immediately call a POISON CENTRE or doctor/physician. P330 :Rinse mouth.
Disposal	:	P501:Disposal of contents/container to be specified in accordance with regulations.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS Number	Concentration (Weight)
Alcohols, C9-11, ethoxylated	68439-46-3	100 %

4. FIRST AID MEASURES

General advice	:	Seek medical advice. If breathing has stopped or is labored, give assisted respirations. Supplemental oxygen may be indicated. If the heart has stopped, trained personnel should begin cardiopulmonary resuscitation immediately.
Eye contact	:	Rinse immediately with plenty of water for at least 15 minutes.
Skin contact	:	Wash with water and soap as a precaution.
Ingestion	:	Prevent aspiration of vomit. Turn victim's head to the side.
Inhalation	:	Move to fresh air.
Inhalation	:	No data available.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	:	Carbon dioxide (CO2). Dry chemical. Dry sand. Limestone powder.
Specific hazards	:	Incomplete combustion may form carbon monoxide.
Special protective equipment	:	Use personal protective equipment. Wear self contained breathing apparatus

for fire-fighters	for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions, Protective Equipment, and Emergency Procedures	:	Evacuate personnel to safe areas.
Environmental precautions	:	Construct a dike to prevent spreading.
Methods for cleaning up	:	Place in appropriate chemical waste container.
Additional advice	:	If possible, stop flow of product.

7. HANDLING AND STORAGE

Handling

Use personal protective equipment. When using, do not eat, drink or smoke.

Storage

Keep away from direct sunlight. Overheating of an ethoxylate stored under air should be avoided. When an ethoxylate is vigorously mixed in the presence of air or oxygen at temperatures >125 F (50 C), it can degrade product quality. Storage under an inert atmosphere is recommended.

Storage Temperature	:	55 - 100 °F (12.77 - 37.77 °C)

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures

Provide readily accessible eye wash stations and safety showers.
Provide natural or explosion-proof ventilation adequate to ensure concentrations are kept below exposure limits.

Personal protective equipment

Respiratory protection	:	Not required for properly ventilated areas.
Hand protection	:	Neoprene gloves. Nitrile rubber. Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Eye protection	:	Chemical safety glasses.
Skin and body protection	:	No specific recommendation.

Special instructions for protection and hygiene	:	Provide readily accessible eye wash stations and safety showers.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Liquid. Colorless.
Odor	:	Mild.
Odor threshold	:	No data available.
pH	:	No data available.
Melting point/range	:	23 °F (-5 °C)
Boiling point/range	:	> 4,212 °F (> 232,2 °C)
Flash point	:	289 °F (142.7 °C)
Evaporation rate	:	No data available.
Flammability (solid, gas)	:	Not applicable.
Upper/lower explosion/flammability limit	:	Not applicable.
Vapor pressure	:	0.10 mmHg at 100 °F (37.78 °C)
Water solubility	:	Completely soluble.
Relative vapor density	:	Not applicable.
Relative density	:	0.984
Partition coefficient (n-octanol/water)	:	No data available.
Auto-ignition temperature	:	No data available.
Decomposition temperature	:	No data available.
Viscosity	:	No data available.
Molecular Weight	:	No data available.

10. STABILITY AND REACTIVITY

Chemical Stability	:	Stable under normal conditions.
Conditions to avoid	:	No data available.
Materials to avoid	:	Reactive metals (e.g. sodium, calcium, zinc etc.). Materials reactive with hydroxyl compounds. Copper alloys Strong acids.
Hazardous decomposition products	:	Carbon monoxide. Carbon dioxide (CO2). Aldehydes Flammable hydrocarbon fragments.
Possibility of hazardous Reactions/Reactivity	:	No data available.

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Likely routes of exposure

Acute toxicity

Acute Oral Toxicity	:	LD50 : 1,400 mg/kg Species : Rat.
Inhalation	:	No data is available on the product itself.
Acute Dermal Toxicity	:	LD50 : > 5,000 mg/kg Species : Rat.
Skin corrosion/irritation	:	Mild skin irritation.
Serious eye damage/eye irritation	:	Moderate eye irritation.
Sensitization.	:	No data available.

Chronic toxicity or effects from long term exposures

Carcinogenicity	:	No data available.
Reproductive toxicity	:	No data is available on the product itself.
Germ cell mutagenicity	:	No data is available on the product itself.
Specific target organ systemic	:	No data available.

toxicity (single exposure)

Specific target organ systemic toxicity (repeated exposure) : No data available.

Aspiration hazard : No data available.

Delayed and Immediate Effects and Chronic Effects from Short and Long Term Exposure

This product contains no listed carcinogens according to IARC, ACGIH, NTP and/or OSHA in concentrations of 0.1 percent or greater.

12. ECOLOGICAL INFORMATION

Ecotoxicity effects

Aquatic toxicity : LC50 (96 h) : 8.5 mg/l Species : Fathead minnow (Pimephales promelas).
EC50 (48 h) : 5.3 mg/l Species : Daphnia magna.

Toxicity to algae - Components

Alcohols, C9-11, ethoxylated	ErC50 (96 h) : 1 - 10 mg/l	Species : Algae.

Toxicity to other organisms : No data available.

Persistence and degradability

Biodegradability : Readily biodegradable, as defined by OECD, substance that degrades > 60-70% within a 10 day window over 28 days.

Mobility : No data available.

Bioaccumulation : No data is available on the product itself.

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products : Contact supplier if guidance is required.

Contaminated packaging : Dispose of container and unused contents in accordance with federal, state, and local requirements.

14. TRANSPORT INFORMATION

DOT

Not dangerous goods

IATA

Not dangerous goods

IMDG

Not dangerous goods

TDG

Not dangerous goods

Further Information

Not classified as dangerous in the meaning of transport regulations. The transportation information is not intended to convey all specific regulatory data relating to this material. For complete transportation information, contact an Air Products customer service representative.

15. REGULATORY INFORMATION

Toxic Substance Control Act (TSCA) 12(b) Component(s):

None.

Country	Regulatory list	Notification
USA	TSCA	Included on Inventory.
EU	EINECS	Included on EINECS inventory or polymer substance, monomers included on EINECS inventory or no longer polymer.
Canada	DSL	Included on Inventory.
Australia	AICS	Included on Inventory.
Japan	ENCS	Included on Inventory.
South Korea	ECL	Included on Inventory.
China	SEPA	Included on Inventory.
Philippines	PICCS	Included on Inventory.

EPA SARA Title III Section 312 (40 CFR 370) Hazard Classification

Acute Health Hazard

EPA SARA Title III Section 313 (40 CFR 372) Component(s) above 'de minimus' level
None.

US. California Safe Drinking Water & Toxic Enforcement Act (Proposition 65)
This product does not contain any chemicals known to State of California to cause cancer, birth defects or any other harm.

This product meets the criteria of the US EPA Design for Environment (DfE) Surfactant screen and is listed on CleanGredients.

16. OTHER INFORMATION

HMIS Rating

Health	:	2
Flammability	:	1
Physical hazard	:	0

Prepared by	:	Air Products and Chemicals, Inc. Global EH&S Product Safety Department
Telephone	:	1-610-481-4911 Corporate 1-800-345-3148 Chemicals Cust Serv 1-800-752-1597 Gases/Electronics Cust Serv
Preparation Date	:	08/05/2015

For additional information, please visit our Product Stewardship web site at http://www.airproducts.com/productstewardship/

AIR PRODUCTS

Tomadol® Ethoxylated Alcohols

Product Guide

"Optimizing performance… while helping to meet environmental regulations."

Air Products produces one of the industry's most complete lines of ethoxylated alcohols and alkoxylated nonionic surfactants. The Tomadol® ethoxylates include both synthetic and naturally-derived linear primary alcohols. These products are suitable for a wide variety of applications, provide high performance in most detergent formulations, are physiologically mild to the skin, and are easy to color and perfume. The Nonidet™ surfactants are nonionic surfactants that incorporate both ethylene oxide and propylene oxide to provide a balance of low foam and good detergency.

In addition to our full product offering, our experienced technical team has a deep understanding of our customers' needs and works closely with them to develop effective solutions. Whether it's an environmental benefit, improving the performance of an existing product, or making a production process more cost effective, customers are always looking for assistance and ways to do things better than others in their market. We have been providing that edge for over 40 years.

Select product applications:

- Hard surface cleaning
- I & I laundry
- Emulsifiers
- Warewashing
- Foaming agents
- Solubilizers
- Personal Care
- Agricultural additives

Formulating can be a complex process. This product guide offers a good starting point providing an overview of our ethoxylated alcohols and alkoxylated nonionic surfactants. For free samples or technical assistance please call us at **800-345-3148**. You can also visit our web site at **www.airproducts.com/nimble**.

Contents

Nomenclature

Tomadol Ethoxylated Alcohols include products based on synthetic and naturally-derived alcohols, and cover three categories of surfactants.

Our complete range of **Tomadol Ethoxylated Alcohol surfactants** are made from linear synthetic alcohols, and are named to indicate the structure of the surfactant. These well-known surfactants are represented by the structure in Table 1 and include names of the general format Tomadol CC-n surfactant, where CC represents the number of carbon atoms present in the alkyl group (R) of the linear alcohol, and n indicates the average moles of ethylene oxide. As an example, the product Tomadol 91-6 surfactant is made from a distribution of C_9, C_{10}, and C_{11} linear alcohols with an average of 6 moles of ethylene oxide.

Table 1 — Nomenclature of Tomadol Ethoxylated Alcohol Surfactants

Tomadol CC-n Surfactant	Carbon chain present	$RO(CH_2CH_2O)_nH$ R – hydrophobic portion of molecule obtained from a linear alcohol of carbon length CC n – average moles of ethylene oxide per mole of alcohol
Tomadol 91-n Surfactant	$C_9/C_{10}/C_{11}$	
Tomadol 1-n Surfactant	C_{11}	
Tomadol 23-n Surfactant	C_{12}/C_{13}	
Tomadol 25-n Surfactant	$C_{12}/C_{13}/C_{14}/C_{15}$	
Tomadol 45-n Surfactant	C_{14}/C_{15}	

Tomadol L Series surfactants are based on naturally-derived alcohols. In order to optimize the performance of these products, they may include a range of natural-derived alcohols and ethoxylate distributions. They are named with the general format Tomadol L# surfactant, where the number (#) is the HLB number (hydrophile/lipophile balance) of the surfactant multiplied by 10. For example, Tomadol L124 surfactant has an HLB of 12.4.

Tomadol 400, 600, 900, 1200 surfactants are high-performance, environmentally-friendly nonionic surfactants designed specifically for ease of reformulation when replacing alkyl phenol ethoxylates. The first number within the product name, or two numbers in the case of Tomadol 1200 surfactant, corresponds to the number of moles of ethylene oxide within the alkyl phenol ethoxylate to be replaced. For example, use Tomadol 900 surfactant to replace NP-9EO.

Tomadol 400, 600, 900, 1200 Surfactants

Description

High-performance, environmentally-friendly nonionic surfactants designed specifically for ease of re-formulation when replacing alkyl phenol ethoxylates (APE). Within Industrial and Institutional cleaning, these products can provide equal or better performance than APE in a wide variety of formulations and are often used at a lower amount than the level of APE in the original cleaning formulation.

Advantages

- Ease of re-formulation
- Excellent cleaning and degreasing
- Lower formulation costs through reduced use levels
- Environmentally friendly
- Improved handling characteristics

Applications

Tomadol 400: Emulsification, boost degreasing when added to higher HLB surfactants

Tomadol 600: Wetting, emulsification, increase performance of higher HLB surfactants

Tomadol 900: General purpose replacement for NP-9EO and NP-10EO, hard surface cleaning, wetting, emulsification

Tomadol 901: Degreasing, nonionic surfactant for replacement of higher-cost optimized surfactants

Tomadol 910: Industrial and institutional laundry, hard surface cleaning, emulsification

Tomadol 1200: Stabilization of iodine based sanitizers, emulsification, laundry

Performance Advantages

FIGURE 1 — Tomadol 900 surfactant cleans more effectively and faster at lower concentrations

Immersion Degreasing on tenacious Li Grease/Motor Oil soil, 23 °C, 1000RPM

Formulation: 0.5% Na metasilicate, 0.5% glycol ether, 0.45% KOH

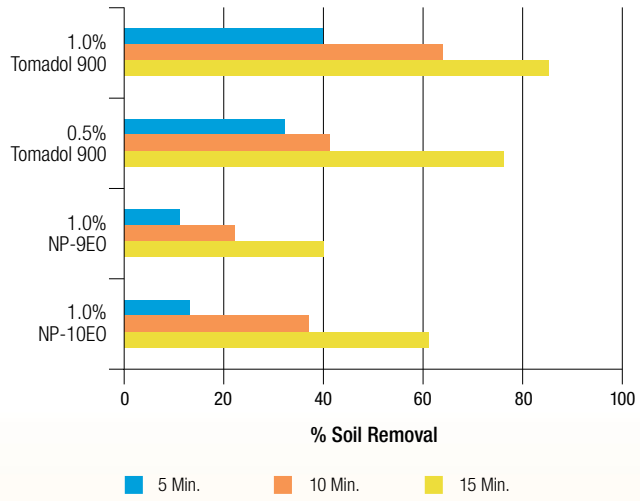


FIGURE 2 — Tomadol 901 surfactant is a high-performance nonionic surfactant that outperforms many competitive quaternary/nonionic products

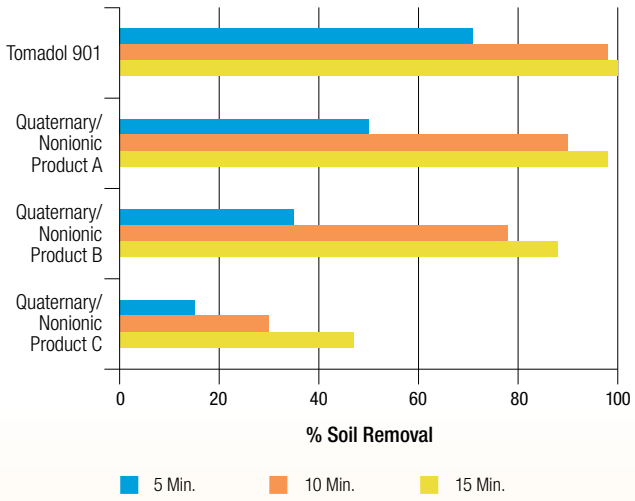
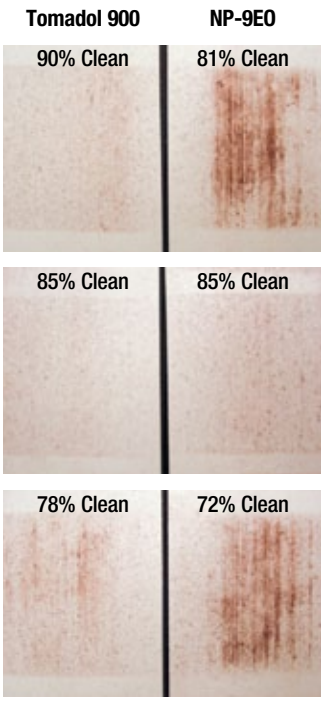


FIGURE 3 — Tomadol 900 surfactant can provide equal or better cleaning performance in a wide variety of I&I cleaning formulations

Conditions: Gardner Scrub results ASTM 4488-95 A5 method modified, 2 wt% active surfactant



Formula A:
1% Na metasilicate
2% Dowanol™ TPM*
2% Dowanol DPnB
2% Baypure® CX 100**, 34%

Formula B:
2.25% Na citrate
3.25% Butyl carbitol

Formula C:
2% Na metasilicate
3.5% Propylene glycol
1% Baypure CX 100, 34%

*Dowanol is a trademark of The Dow Chemical Company
**Baypure is a trademark of Lanxess Corporation

FIGURE 4 — Tomadol 600 surfactant provides fast wetting, Draves Test

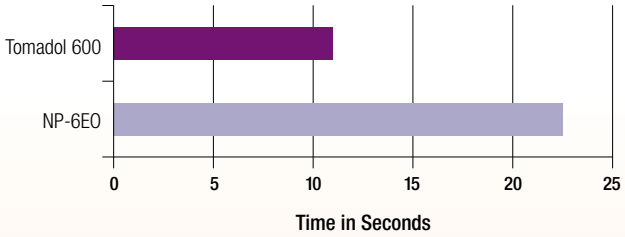


FIGURE 5 — Tomadol 1200 surfactant can yield higher emulsification capacity of a variety of oils

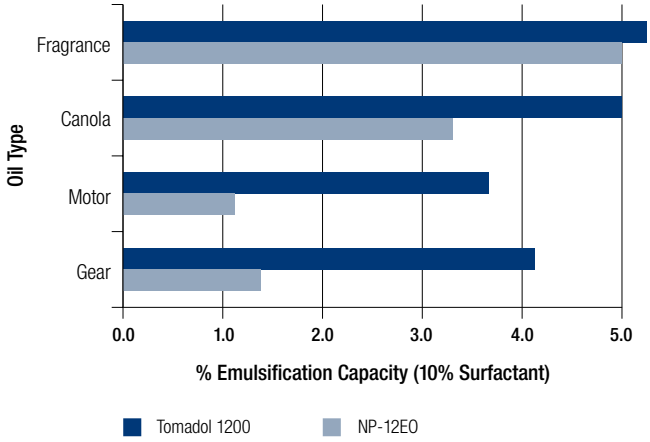
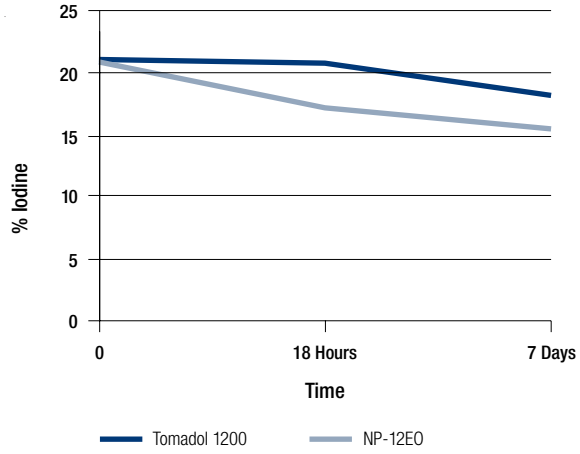


FIGURE 6 — Tomadol 1200 surfactant can improve iodine stability in sanitizer formulations



Nonidet Low-Foam Surfactants

Description

The Nonidet alkoxylated surfactants are low-foam nonionic surfactants that provide multi-functional benefits in applications where foam control is a concern. The Nonidet surfactants are based on linear alcohols, and are supplied as 100% active products. These products are designed for applications requiring minimum foam levels, fast wetting, free rinsing characteristics, and high emulsification.

Applications

Mechanical dishwash detergents

Spray or recirculation cleaners

Warewashing and CIP

Dairy and food

Rinse aids

Floor cleaners

Industrial laundry

Ag chem (emulsifiable and suspension concentrates)

Pulp and paper (defoamers and deinking agents)

Paints (dispersants and foam control)

Textiles (dyeing and printing aids)

Advantages

- Low to moderate foam
- Good detergency
- Compatibility with most surfactants, builders and sequestrants
- Emulsification and degreasing
- Fast wetting
- Lower pour and cloud point temperatures
- Reduced tendency for gel formation

Performance Advantages

FIGURE 7 — Ross-Miles Foam Height

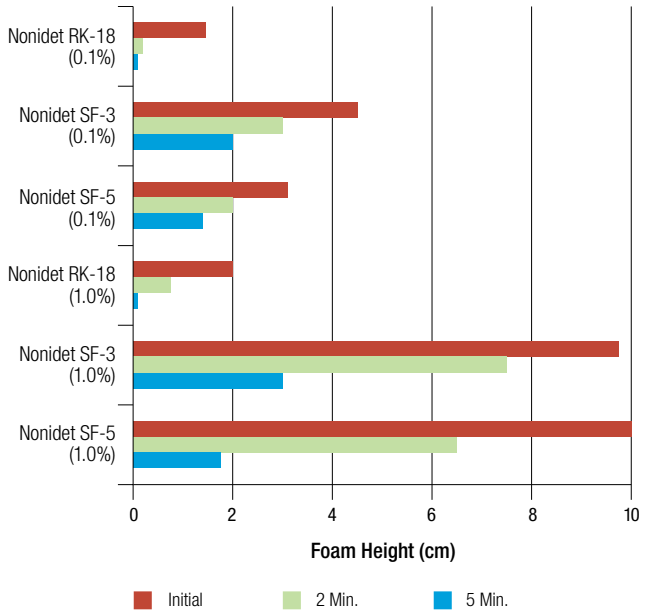


FIGURE 8 — Dynamic Spray Cleaning Performance

Conditions: 0.1 wt% TKPP, 0.25 wt% nonionic, 20 psi @ 50 °C, 90 sec

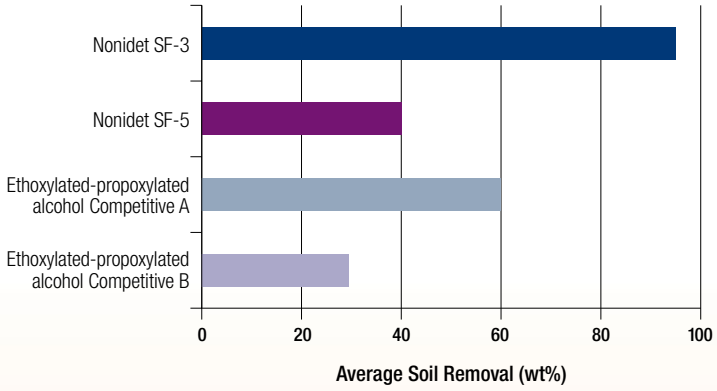


FIGURE 9 — Dynamic Spray Foam Heights

Conditions: 40 °C, 0.1 wt%, distilled water

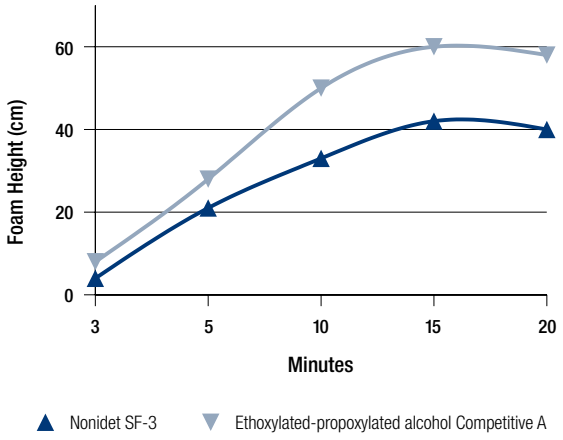
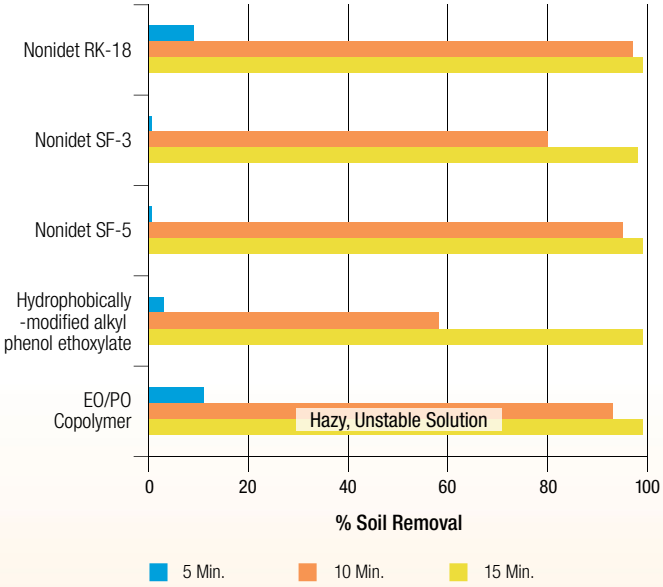


FIGURE 10 — Immersion Degreasing Test Results in Low-Foam Floor Cleaners

Nonidet Alkoxylated surfactants provide good balance of cleaning and compatibility



Formulation	
Component	**Weight %**
Sodium Metasilicate	5.0
Baypure® CX 100, 34%	7.0
Tomamine® Alkali Surfactant	1.0
Nonidet or competitive surfactant	1.0
Water	86.0

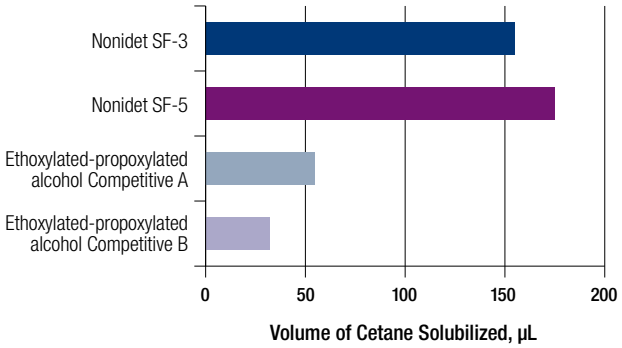
Table 2 — Draves Wetting Times of Nonidet Surfactants

Conditions: 5g cotton skein, 3g hook, 0.1 wt% surfactant @ 24 °C

Component	Wetting time, seconds
Nonidet SF-3	6
Nonidet SF-5	9
Ethoxylated-propoxylated alcohol Competitive C	20

FIGURE 11 — Oil Solubilization Capacity

Conditions: Test measured by turbidity, 1% by weight @ 24 °C



Tomadol L-Series Ethoxylated Alcohols – *Natural-derived Surfactants*

Description

The Tomadol L-Series ethoxylated alcohols are based on natural-derived hydrophobes and are suitable for a wide range of surfactant applications including household cleaners, industrial and institutional cleaners as well as industrial process and formulation aids. The Tomadol L Series are 90 to 100% active and range from liquids to low melting point solids. They are excellent wetting agents, emulsifiers, and detergents. The Tomadol L Series are moderate foamers.

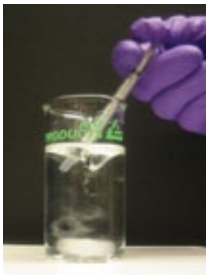
Table 3 — Tomadol L-Series Surfactant Properties and Applications

	HLB	Renewable Carbon	Volatile Organic Compound (VOC)	Some Suggested Uses
Tomadol L80	8.0	68%	9.2%	Useful as a low HLB component in cleaning formulations and as an intermediate to make ethoxysulfates
Tomadol L124	12.4	47%	1.4%	Useful as a high performance surfactant base for degreasers, hard surface cleaners and laundry applications
Tomadol L124F	12.4	47%	1.2%	Useful as a high performance surfactant base for degreasers, hard surface cleaners, and laundry applications
Tomadol L130	13.0	41%	1.4%	Useful in cleaning formulations where a high cloud point is needed
Tomadol L144	14.4	35%	< 1%	Useful in emulsification and laundry applications

Solution Properties

Table 4 — Typical Foam Behavior

	L80	L124	L130	L144
Ross-Miles Foam @ 25 °C, 0.1 wt%, Initial, mm	14	124	117	134
Ross-Miles Foam @ 25 °C, 0.1 wt%, 5 min, mm	14	119	110	113



The dissolution time of Tomadol L124 was measured by adding surfactant to water and measuring the time to completely dissolve the surfactant (2:55min)

FIGURE 12 — Effect of Electrolyte on Cloud Point
1 wt% surfactant; 5 wt% electrolyte

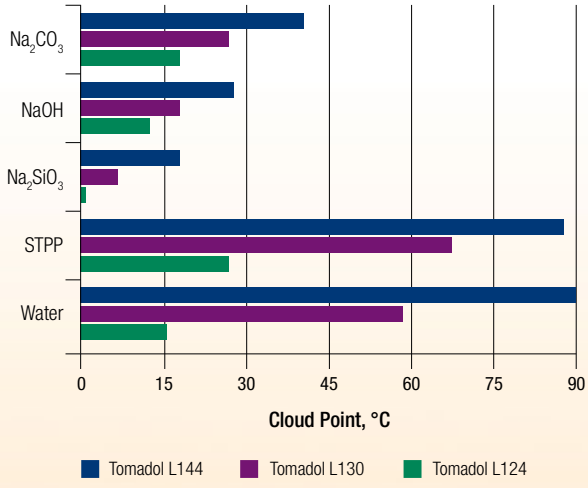
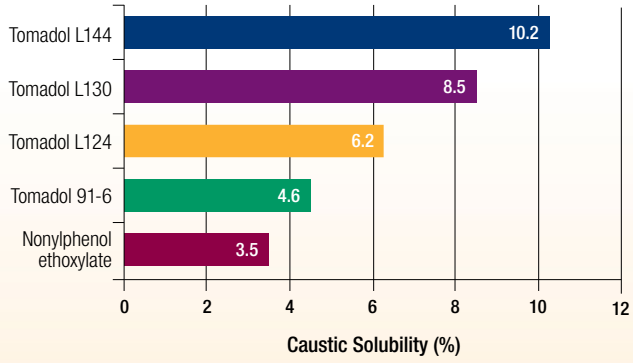


FIGURE 13 — Caustic Solubility
1 wt% surfactant



* The cloud point of Tomadol L144 in water is > 90 °C.

Cleaning Performance

FIGURE 14 — Hard Surface Cleaning Performance

1 wt% actives in built solution • Modified ASTM method D4488 A5

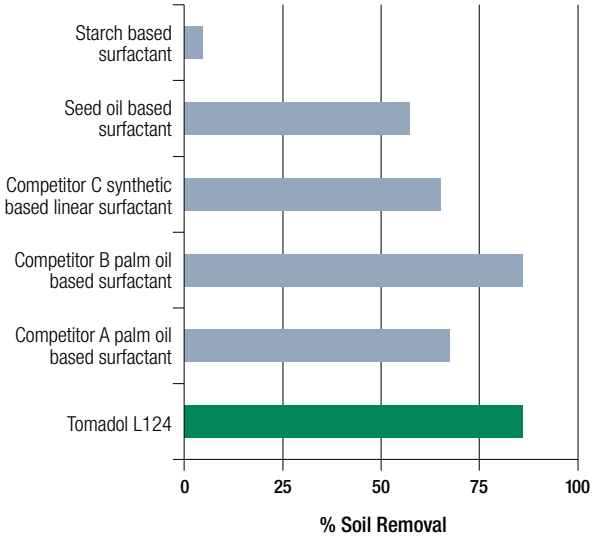
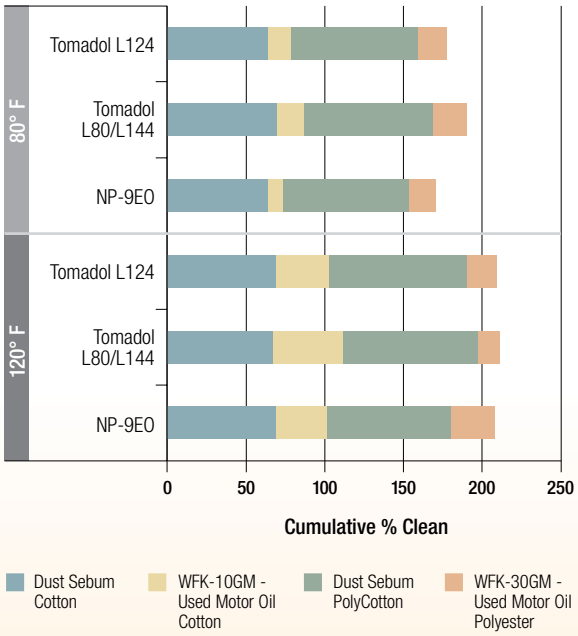


FIGURE 15 — Laundry Cleaning Performance



The Tomadol L-Series perform well in laundry applications. In this graph for a simple surfactant and light builder formula, each color represents a swatch of fabric/soil as listed in the key. A synergistic blend of 65% Tomadol L144 with 35% Tomadol L80 performs well in cold water.

The % clean for each formula is stacked as a summary of the swatches and separated into 2 wash temperatures, 80° F and 120° F.

Table 5 — Suggested Formulations

Concentrate Cleaner Formulation (Dilute 1/16)

Component	Wt %
Water	75.0
Propylene glycol	10.3
Sodium metasilicate pentahydrate	6.0
Baypure® CX 100, 34%[a]	3.0
Tomadol L-Series surfactant*	5.7

Hard Surface Cleaner Formulation

Component	Wt %
Water	92.5
Propylene glycol	3.5
Sodium citrate	2.0
Baypure® CX 100, 34%[a]	1.0
Tomadol L-Series surfactant**	1.0

Premium Laundry Formulation

Component	Wt %
Water	76.9
Optical Brightener	0.1
Polyacrylate	1.0
EDTA[b]	2.0
Tomadol L-Series surfactant***	20.0

Quality I&I Laundry Formulation

Component	Wt %
Water	77.9
Optical Brightener	0.1
EDTA[b]	2.0
Tomadol L-Series surfactant***	20.0

* Blend of 21% Tomadol L80 with 79% Tomadol L124

** Tomadol L124 or Tomadol L130

*** Tomadol L124 or blend of 35% Tomadol L80 with 65% Tomadol L144

(a) Baypure is a trademark of Lanxess Corporation

(b) Ethylenediamine tetraacetic acid, tetrasodium salt (100% basis)

Physical and Chemical Properties

Synthetic Linear Alcohols Used to Produce Tomadol Ethoxylated Alcohol Surfactants

The linear alcohols used to make ethoxylated alcohols with the designation **Tomadol CC-n surfactant** are high purity primary alcohols which typically contain 75-85% by weight normal (linear) alcohols. The remaining 15–25% of the alcohol content is 2-n-alkyl isomers, principally 2-methyl. These synthetic alcohols include one alcohol with a single carbon cut, and four that are a distribution of carbon chain lengths. Typical properties for the alcohols are provided in Table 6. With the exception of the $C_{14\text{-}15}$ linear alcohol, all of the synthetic linear alcohols used to produce the Tomadol Ethoxylated Alcohol surfactants are pourable at room temperature.

Tomadol Ethoxylated Alcohols

Tomadol ethoxylates are colorless and range from liquids to low melting point solids of pasty consistency. They are excellent wetting agents, emulsifiers, and detergents, and are moderate foamers. Typical physical and chemical properties of Tomadol Ethoxylated Alcohols are provided in Table 8.

Pour point is one indication of the ease of handling of a nonionic surfactant and indicates if heated storage is required. If clarity of a formulation at use is desirable, the cloud point may indicate the approximate maximum temperature range for the application of the surfactant. Figures 16 and 17 describe the Tomadol Ethoxylated Alcohol surfactants in terms of HLB number and pour point. Surfactant systems with intermediate HLB number, pour point, and cloud point can be obtained by blending appropriate amounts of higher and lower EO-containing Tomadol Ethoxylated Alcohols.

The base-catalyzed condensation reaction of ethylene oxide (EO) with an alcohol gives a mixture of ethylene oxide adducts of varying chain length. The composition of the mixture follows a standard distribution curve, peaked at the average EO content. Table 7 provides additional detail on this distribution and should help the formulator in selecting the appropriate Tomadol Ethoxylated Alchol surfactant for their application.

The Tomadol 25 alcohol ethoxylates are recommended for general purpose high-performance applications. Tomadol 91 and Tomadol 1 alcohol ethoxylate series, with shorter hydrophobic chains, are faster wetting agents and have improved handling properties, such as lower pour points, easier dilution properties, and good compatibility in liquid concentrates.

Table 6 — Typical Physical and Chemical Properties of the Linear Alcohols Used to Make Tomadol Ethoxylated Alcohol Surfactants

	LINEAR PRIMARY ALCOHOLS				
PROPERTY	**91**	**1**	**23**	**25**	**45**
Carbon chain present	C_9/C_{10} C_{11}	C_{11}	C_{12}/C_{13}	C_{12}/C_{13} C_{14}/C_{15}	C_{14}/C_{15}
Molecular weight	160	172	194	203	221
Active content, %w	100	100	100	100	100
Melting range, °F	3-25	42-57	45-72	54-77	59-97
°C	-16 to -4	6-14	7-22	12-25	15-36
Pour point, °F	10	52	63	66	84
°C	-12	11	17	19	29
Color, Pt-Co (APHA)	0-5	0-5	0-5	0-5	0-5
Sp. Gravity, 77 °F	0.829	0.831	0.833	0.834	0.820[(a)]
Viscosity, cSt @ 100 °F	9	11	14	15	18
Acid value, eq/100g	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Carbonyl value, ppm as C = O	35	35	40	40	50
Hydroxyl value, eq/100g	0.624	0.579	0.515	0.492	0.453
Hydroxyl No., mg KOH/g	350	325	289	276	254
Flash point, PMCC °F	228	250	279	286	315
(ASTM D-93) °C	109	121	137	141	157
Water, %w	0.02	0.02	0.02	0.02	0.02
Normality, %w	82	82	80	79	78

(a) Measured at 122 °F

FIGURE 16 — Pour Point and HLB Number for Tomadol 91 and Tomadol 1 Ethoxylated Alcohol Series

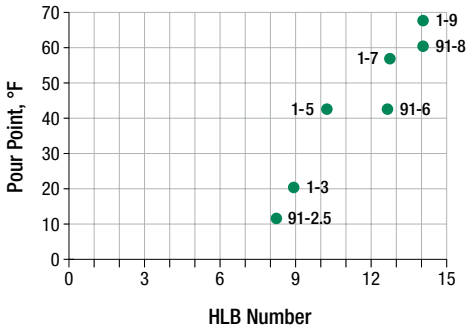


FIGURE 17 — Pour Point and HLB Number for Tomadol 23, 25, and 45 Ethoxylated Alcohol Series

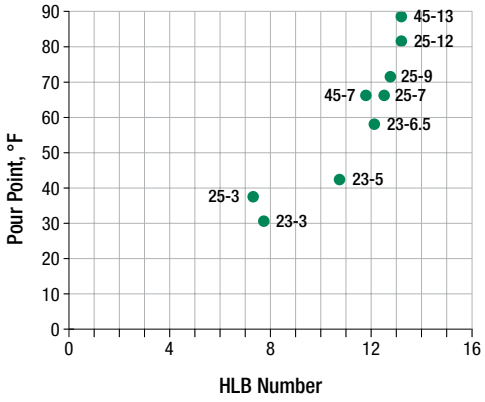
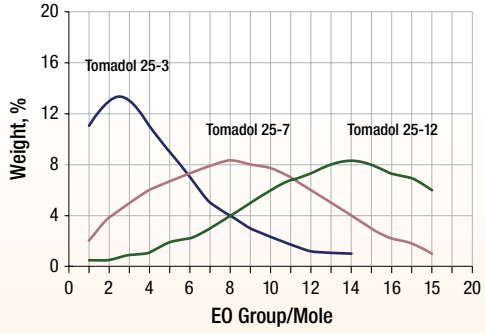


FIGURE 18 — Typical EO Distribution in Tomadol 25 Ethoxylated Alcohol Series



The Tomadol 1, 23 and 45 series have narrower carbon distributions than the Tomadol 25 and Tomadol 91 series and may be preferred for particular applications.

The Tomadol 1 series ethoxylates are intermediate to the Tomadol 25 series and the Tomadol 91 series. Tomadol 1 ethoxylates offer exceptional cleaning capability, particularly with oily soils in both household and industrial applications

Table 7 — Tomadol Ethoxylated Alcohols — Typical Distribution of Ethoxylate Adducts

	WEIGHT PERCENT OF $RO(CH_2CH_2O)_nH$								
	23-1	**91-2.5**	**23-3 25-3 1-3**	**1-5 23-5**	**91-6**	**23-6.5 25-7 45-7 1-7**	**91-8**	**25-9 1-9**	**25-12 45-13**
n*									
0	42	17	16	5	3	3	2	2	1
1	22	14	11	4	3	2	1	1	0.5
2	15	14	13	6	5	4	2	2	0.5
3	8	13	13	8	7	5	3	3	1
4	5	11	11	10	8	6	4	4	1
5	3	8	9	10	9	7	5	5	2
6	2	6	7	10	9	7	6	5	2
7	1	4	5	9	9	8	7	6	3
8	1	3	4	8	9	8	7	7	4
9	1	3	3	7	8	8	9	8	5
10	—	2	2	6	7	8	9	8	6
11	—	2	2	5	6	7	8	8	7
12	—	1	1	3	5	6	8	8	7
13	—	1	1	3	4	5	7	7	8
14	—	—	1	2	3	4	6	6	8
15	—	—	—	1	2	3	4	5	8
16	—	—	—	1	1	2	3	4	7
17	—	—	—	1	1	2	3	3	7
18	—	—	—	—	—	1	2	3	6
Higher	—	1	1	1	1	4	4	5	16

*n = Number of moles of ethylene oxide.

Table 8 — Typical Physical and Chemical Properties of Tomadol Ethoxylated Alcohols and Nonidet Alkoxylated Surfactants

	EO groups/alcohol mole/mole, Avg.	Molecular weight	Active content, %w	EO Content, %w	Melting range[f], °F / °C	Color, Pt-Co (APHA)	Sp. Gravity @ 77 °F	Viscosity, cSt @ 100 °F	Acid value, Eq/100g	Hydroxyl value, Eq/100g	Hydroxyl No., mg KOH/g	Surface tension, dynes/cm @ 0.1 wt%	Flash pt., PMCC (ASTM D-93) °F / °C	Cloud pt. °F / °C	Pour pt. °F / °C	HLB No.	pH, 1% Aq. sol'n	Water, %w
Tomadol Ethoxylated Alcohol Surfactants																		
Tomadol 91-2.5	2.7	281	100	42.3	-13 to 1 -25 to -17	5-10	0.925	12	<0.001	0.356	200	24	255 124	35.8[a] 2.1	9 -13	8.5	6.5	0.02
Tomadol 91-6	6.0	425	100	62.1	23-59 -5 to 15	5-10	0.984	23	<0.001	0.235	132	29	289 143	126 52	43 6	12.4	6.5	0.02
Tomadol 91-8	8.3	524	100	69.7	45-75 7-24	5-10	1.008	39	<0.001	0.191	107	30	318 159	176 80	59 15	13.9	6.5	0.02
Tomadol 1-3	3.0	305	100	43.3	5-40 -15 to 4	5-10	0.936	10	<0.001	0.328	184	25	287 142	47.6[a] 8.6	20 -7	8.7	6.5[d]	0.03
Tomadol 1-5	5.0	392	100	56.1	25-63 -4 to 17	5-10	0.966	21	<0.001	0.255	143	25	298 148	___[e] ___	43 6	11.2	6.5[d]	0.03
Tomadol 1-7	7.0	479	100	64.3	39-68 4-20	5-10	0.996	28	<0.001	0.209	117	28	329 165	136 58	55 13	12.9	6.5	0.03
Tomadol 1-73B	5.6	418	100	59.0	39-68 4-20	5-10	0.987	48	<0.001	0.239	134	26	297 147	97 36	55 13	11.8	6.5	0.03
Tomadol 1-9	9.0	569	100	69.6	59-82 15-28	5-10	1.011	31	<0.001	0.176	99	31	349 176	165 74	65 18	13.9	6.5	0.03
Tomadol 23-1	1.0	238	100	18.5	36-52 2-11	5-10	0.873	13	<0.001	0.421	236	[g]	289 143	13.6[a] -10.2	41 5	3.7	6.5[d]	0.02
Tomadol 23-3	2.9	322	100	39.6	25-43 -4 to 6	5-10	0.922	14	<0.001	0.310	174	25	306 152	33.1[a] 0.61	34 1	7.9	6.5	0.02
Tomadol 23-5	5.0	413	100	53.3	27-73 -3 to 23	5-10	0.965	23	<0.001	0.242	136	26	315 157	___[e] ___	45 7	10.7	6.5	0.02
Tomadol 23-6.5	6.6	484	100	60.0	52-77 11-25	5-10	0.984	29	<0.001	0.207	116	28	334 168	111 43	59 15	12.0	6.5	0.02
Tomadol 25-3	2.8	330	100	37.3	36-52 2-11	5-10	0.921	19	<0.001	0.303	170	26	315 157	32[a] 0	37 3	7.5	6.8[d]	0.02
Tomadol 25-7	7.3	524	100	61.3	36-79 2-26	5-10	0.965[b]	34	<0.001	0.191	107	30	367 186	122 50	66 19	12.3	6.5	0.02
Tomadol 25-9	8.9	597	100	65.6	57-86 14-30	5-10	0.982[b]	41	<0.001	0.168	94	30	370 188	165 74	70 21	13.1	6.5	0.02
Tomadol 25-12	11.9	729	100	71.8	68-93 20-34	5-10	0.999[b]	53	<0.001	0.137	77	34	433 223	172[c] 78	81 27	14.4	6.5	0.02
Tomadol 45-7	7.0	529	100	58.2	48-88 9-31	5-10	0.959[b]	35	<0.001	0.189	106	29	365 185	113 45	66 19	11.6	6.5	0.02
Tomadol 45-13	12.9	790	100	71.8	77-99 25-37	5-10	1.003[b]	59	<0.001	0.126	71	34	480 249	176[c] 80	86 30	14.4	6.7	0.02

	Hydrophilic moiety	Molecular weight	Active content, %w	EO Content, %w	Melting range[f], °F / °C	Color, Pt-Co (APHA)	Sp. Gravity @ 77 °F	Viscosity, cSt @ 100 °F	Acid value, Eq/100g	Hydroxyl value, Eq/100g	Hydroxyl No., mg KOH/g	Surface tension, dynes/cm @ 0.1 wt%	Flash pt., PMCC (ASTM D-93) °F / °C	Cloud pt. °F / °C	Pour pt. °F / °C	HLB No.	pH, 1% Aq. sol'n	Water, %w
Tomadol L Series Surfactants																		
Tomadol L80	EO	330	100	40	19-50 -7 to10	5-10	0.911	45	<0.001	0.305	171	26	>250 >120	___[e] ___	52 11	8.0	6.5[d]	0.03
Tomadol L124	EO	520	100	62	23-68 -5 to 20	5-10	0.974	44	<0.001	0.194	109	29	>250 >120	140 60	66 19	12.4	6.5	0.03
Tomadol L124F	EO	520	90	62	14-59 -10 to 15	5-10	0.990	43	<0.001	0.194	109	29	>250 >120	144 62	57 14	12.4	6.5	10
Tomadol L130	EO	595	100	66	54-95 12-35	5-10	0.993[b]	50	<0.001	0.169	95	32	>250 >120	172 78	73 23	13.0	6.5	0.03
Tomadol L144	EO	725	100	72	75-104 24-40	5-10	1.014[b]	65	<0.001	0.139	78	36	>250 >120	178[c] 81	88 31	14.4	6.5	0.03
Tomadol 400, 600, 900, 1200 Surfactants – NPE Alternatives																		
Tomadol 400	EO	300	100	44.5	-13 to 19 -25 to -7	5-10	0.93	15	<0.001	0.337	189	24	255 124	___[e] ___	-14 10	8.9	6.5[d]	0.02
Tomadol 600	EO	400	100	53	23-75 -5 to 24	5-10	0.97	21	<0.001	0.239	134	26	315 157	___[e] ___	45 7	10.6	6.5	0.02
Tomadol 900	EO	460	95	65	36-59 2-15	5-10	0.98	15	<0.001	0.217	122	27	318 159	147 64	47 8	13.1	6.5	5
Tomadol 901	EO	445	96.2	60	36-52 2-11	5-10	0.97	15	<0.001	0.225	126	26	255 124	102 39	37 3	12.1	6.5	3.8
Tomadol 910	EO	495	95	59	36-59 2-15	5-10	0.99	30	<0.001	0.201	113	27	360 182	109 43	47 8	11.8	6.5	5
Tomadol 1200	EO	590	95	68	58-82 15-28	5-10	1.00	35	<0.001	0.169	95	30	293 145	176 80	66 19	13.6	6.5	5
Nonidet Alkoxylated Surfactants																		
Nonidet RK-18	EO PO	--	100	- -	-24 to 39 -31 to 4	100	1.02	83	- -	- -	- -	34	450 232	63 17	18 -8	6	6.5	0.5
Nonidet SF-3	EO PO	--	100	- -	-13 to 54 -25 to 12	100	0.99	53	- -	- -	- -	33	310 154	102-118 39-48	40 4	9	7.0	0.5
Nonidet SF-5	EO PO	--	100	- -	-13 to 45 - 25 to 7	100	0.99	54	- -	- -	- -	34	350 177	95-104 35-40	30 -1	8	6.5	0.5

(a) Partially insoluble-ml H_2O titrated.

(b) Measured at 122/77 °F.

(c) In 5% aqueous NaCl.

(d) Measured in 1% aq. sol'n. in 10:6 isopropanol: water.

(e) Aqueous solubility < 1%.

(f) Determined by differential scanning calorimeter.

(g) Aqueous solubility < 0.1%

Handling Characteristics

Viscosities of Tomadol Ethoxylated Alcohols as a Function of Temperature

The viscosity of a neat nonionic surfactant is an indication of its ease of pumping. In general, the lower the viscosity at a given temperature, the easier the material is to pump. This, however, depends on the individual user's equipment. Many nonionic surfactants require heating to lower the viscosity to a level that is readily pumpable under practical conditions.

Figures 19-23 show the decrease in viscosity with increasing temperature for the five series of Tomadol CC-n Ethoxylated Alcohol surfactants. As illustrated in Figure 19, the Tomadol 91 series surfactants have relatively low viscosities near room temperature and consequently are easy to pump and handle. Viscosities of the Tomadol 1 series surfactants exhibit very similar low viscosities and also offer excellent handling characteristics.

FIGURE 19 — Viscosity of Tomadol 91 Ethoxylated Alcohol Series as a Function of Temperature

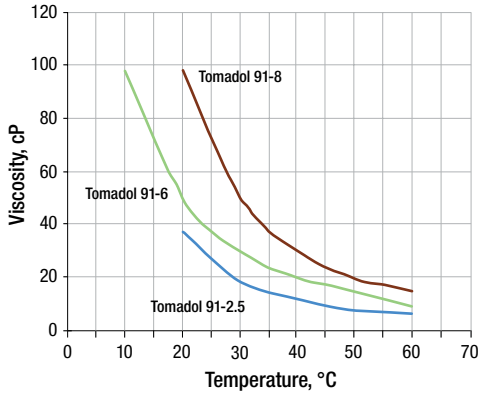


FIGURE 20 — Viscosity of Tomadol 1 Ethoxylated Alcohol Series as a Function of Temperature

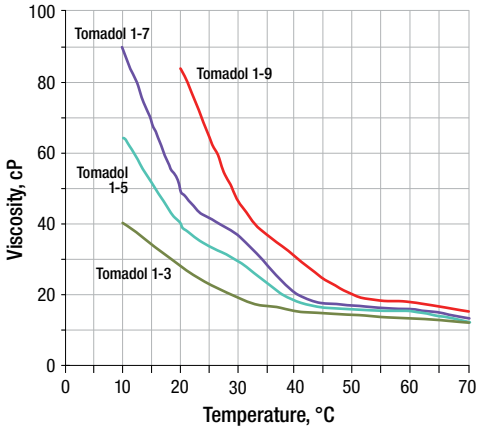


FIGURE 21 — Viscosity of Tomadol 23 Ethoxylated Alcohol Series as a Function of Temperature

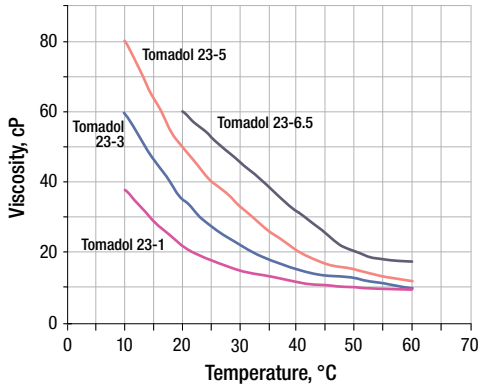


FIGURE 22 — Viscosity of Tomadol 25 Ethoxylated Alcohol Series as a Function of Temperature

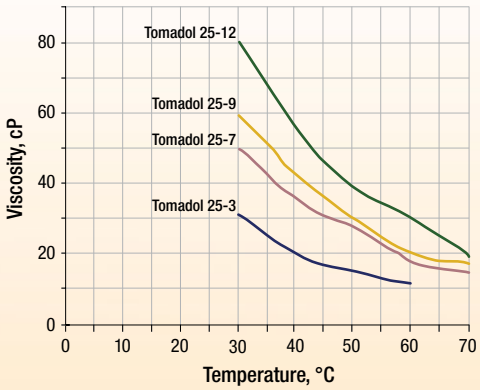
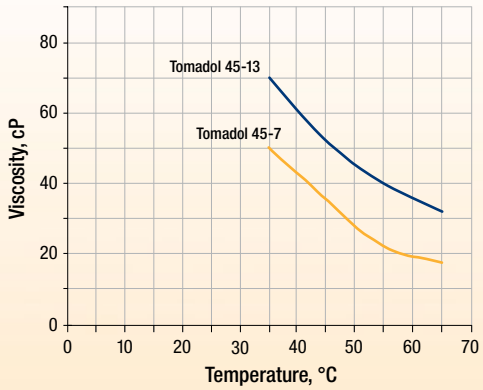


FIGURE 23 — Viscosity of Tomadol 45 Ethoxylated Alcohol Series as a Function of Temperature



Aqueous Solutions at Room Temperature

At room temperature, most nonionic surfactants form a gel with the addition of water.

Table 9 illustrates the viscosity of some of the Tomadol Ethoxylated Alcohol surfactants at varying concentration in water. This information provides an indication of the ease of formulating with, and handling of, the respective nonionic surfactant solutions. Since Tomadol 91-6 does not form a gel in water at room temperature, its aqueous solutions are pumpable fluids at all concentrations.

Table 9 — Viscosity of Aqueous Ethoxylated Alcohol Solutions (Centipoise at 22 °C)

	Concentration, %w						
PRODUCT	**10**	**20**	**30**	**40**	**50**	**60**	**80**
Tomadol 91-6	3	13	63	173	187	144	80
Tomadol 91-8	2	6	29	138	Gel	Gel	120
Tomadol 1-5	30	48	58	71	1,649	30,350	54,400
Tomadol 1-7	3	14	109	Gel	Gel	235	87
Tomadol 1-9	2	6	26	245	Gel	Gel	104
Tomadol 23-5	282	4,895	Gel	Gel	Gel	Gel	56,500
Tomadol 23-6.5	27	431	1,620	Gel	Gel	37,000[a]	Gel
Tomadol 25-7[b]	—	—	960[c]	Gel	Gel	Gel	Gel
Tomadol 25-9[b]	—	—	70[c]	Gel	Gel	Gel	Gel
Tomadol 25-12[b]	—	—	71[c]	Gel	Gel	Gel	Gel
Tomadol 45-7[b]	—	—	2,530	Gel	Gel	Gel	Gel
Tomadol 45-13[b]	—	—	80	Gel	Gel	Gel	Gel
Linear C_{10-12} primary alcohol (5.2 EO)	—	—	160	208	176[a]	37,750[a]	201[a]
Random secondary alcohol (7 EO)	—	—	88	179	205[d]	1,940[a]	116
Nonylphenol (9 EO)	—	—	290	Gel	Gel	3,020	1,080[a]
Octylphenol (9.5 EO)	—	—	100	Gel	Gel	1,640	456
Linear C_{8-12} primary alcohol EO/PO nonionic (HLB 13.0)	—	—	36	120	170	125	90
Tridecyl alcohol ethoxylate, 85%[b] (HLB 13.1)	—	—	110	300	360	380	Gel

(a) Fluid gel, by examination with polarized light.

(b) Measured at 25 °C.

(c) Centistokes

(d) Clear solution—another sample showed as a gel up to 80 °C, then separated into two layers.

Gel Characteristics of Tomadol Ethoxylated Alcohol Surfactants

Concentrated solutions of ethoxylated alcohols and water can often form gels. The gelling characteristics are depicted in temperature vs. surfactant concentration plots called gel curves. To avoid gel formation, the formulator must add the surfactant to, or dilute neat surfactant with, water that has been heated sufficiently to keep the temperature of the mixture above the peak temperature displayed on the gel curve. The gel curves for some of the Tomadol Ethoxylated Alcohols are shown in Figures 24-37.

As an example, mixing of Tomadol 91-6 surfactant with water at about room temperature does not require the addition of heat since the gel curve of Tomadol 91-6 is below room temperature for all surfactant concentrations. This is an attractive advantage to the formulator when comparison is made to the 9-mole nonyl- and octylphenol ethoxylates. These can form gels at room temperature in the concentration range of approximately 40-80 %w (Figure 37). In order to formulate with nonylphenol ethoxylate solutions at these concentrations, water must be heated above 35 °C or 40 °C, depending upon the desired concentration sought (40-60 %w or 60-80 %w, respectively).

FIGURE 24 — Gel Curve for Tomadol 91-6 Surfactant

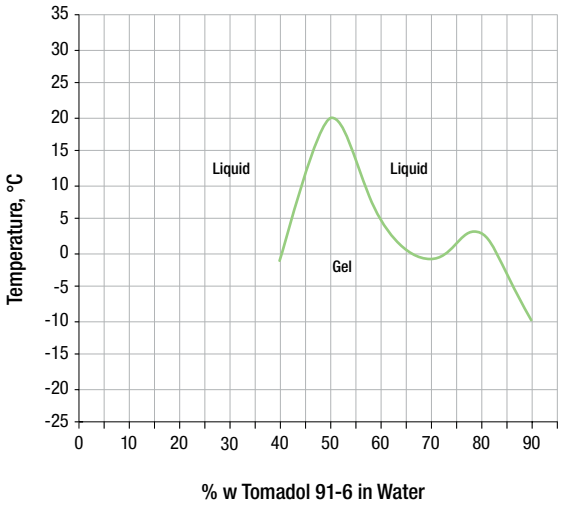


FIGURE 25 — Gel Curve for Tomadol 91-8 Surfactant

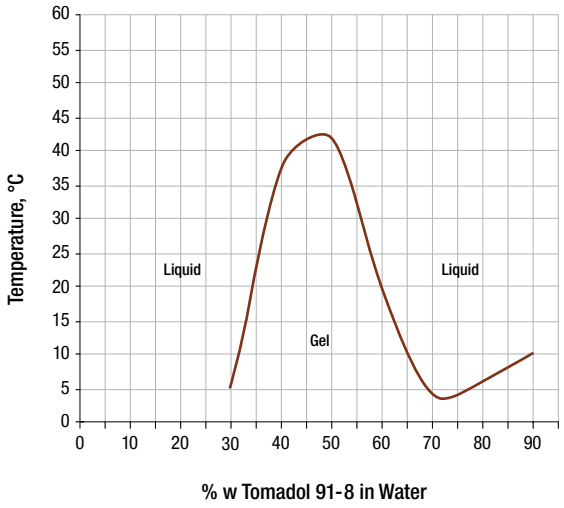


FIGURE 26 — Gel Curve for Tomadol 1-5 Surfactant

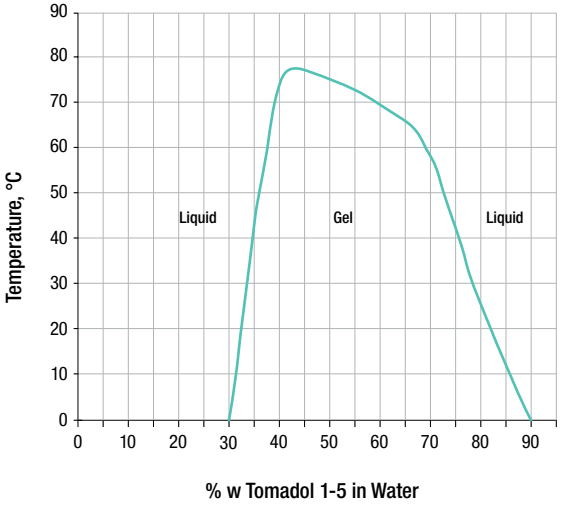


FIGURE 27 — Gel Curve for Tomadol 1-7 Surfactant

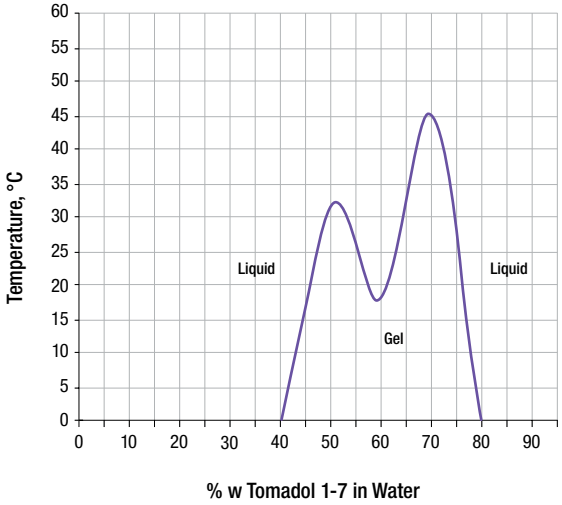


FIGURE 28 — Gel Curve for Tomadol 1-73B Surfactant

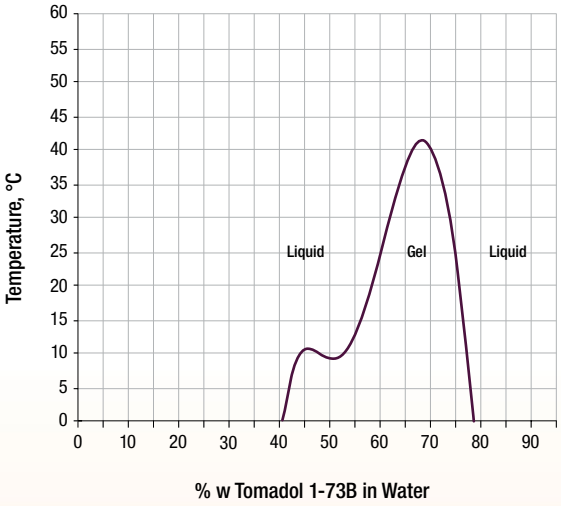


FIGURE 29 — Gel Curve for Tomadol 1-9 Surfactant

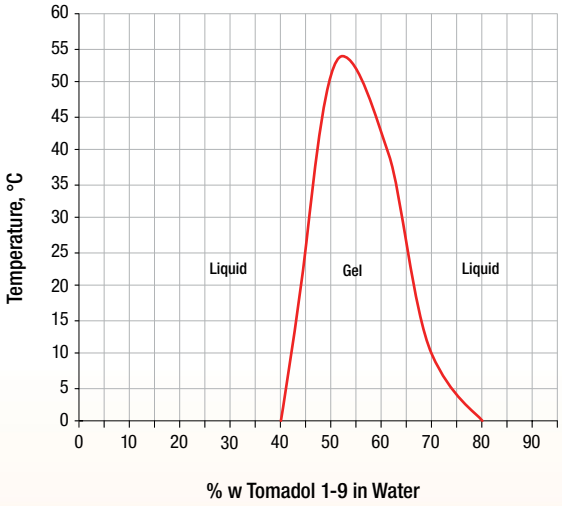


FIGURE 30 — Gel Curve for Tomadol 23-5 Surfactant

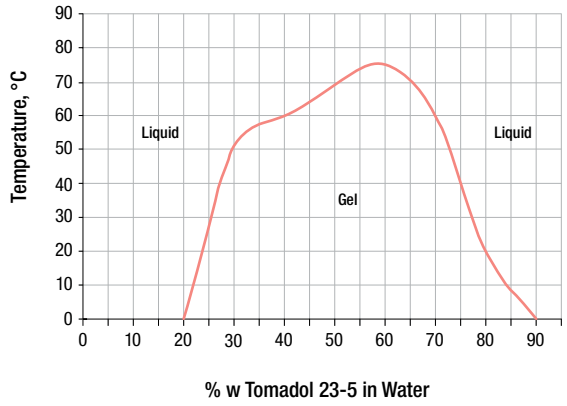


FIGURE 31 — Gel Curve for Tomadol 23-6.5 Surfactant

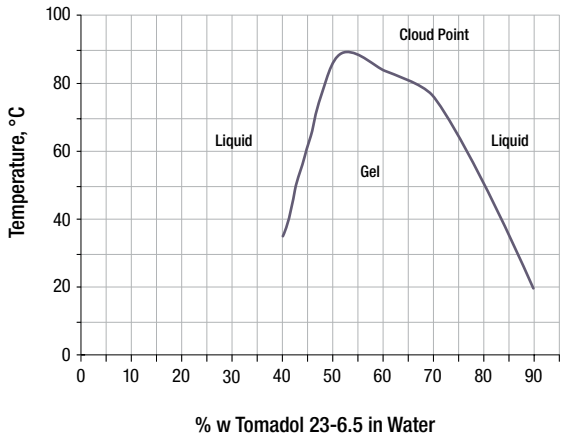


FIGURE 32 — Gel Curve for Tomadol 25-7 Surfactant

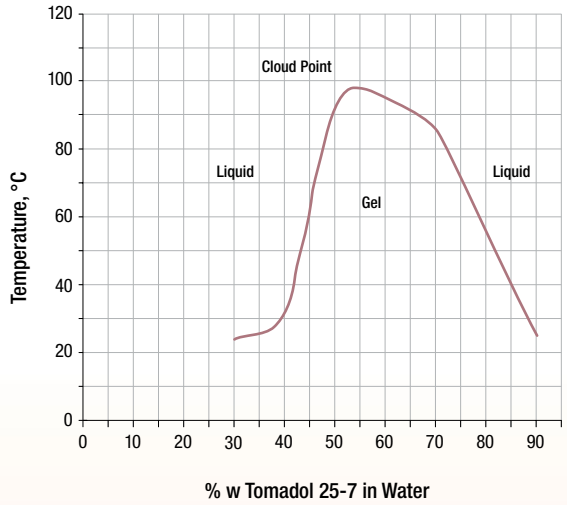


FIGURE 33 — Gel Curve for Tomadol 25-9 Surfactant

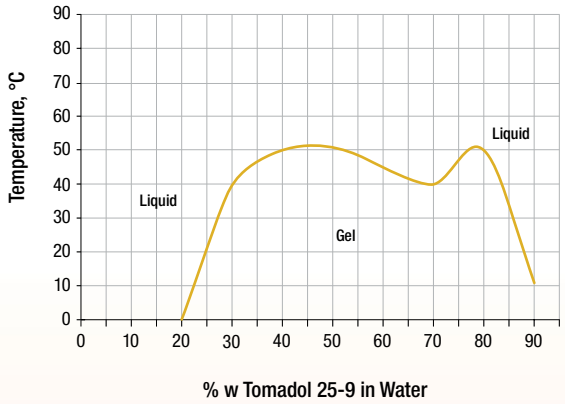


FIGURE 34 — Gel Curve for Tomadol 25-12 Surfactant

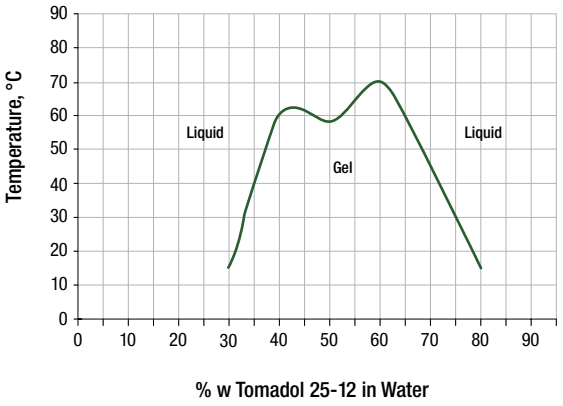


FIGURE 35 — Gel Curve for Tomadol 45-7 Surfactant

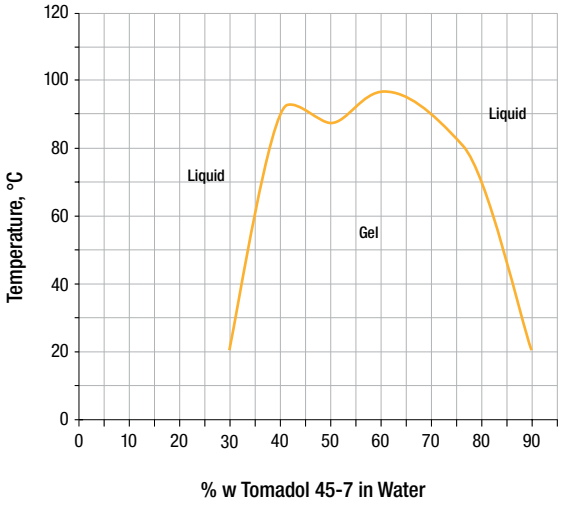


FIGURE 36 — Gel Curve for Tomadol 45-13 Surfactant

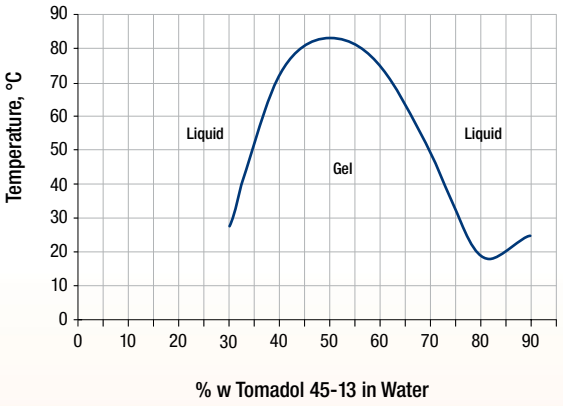
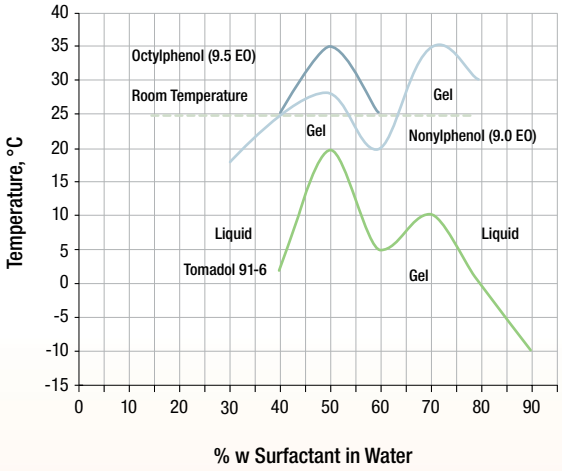


FIGURE 37 — Gel Curve for Tomadol 91-6 Surfactant versus Competitive Ethoxylates



Solution Properties and Stabilities

Surface Tension

Surface tension is an important physical property to consider when selecting a surfactant. Aqueous solutions of nonionic surfactants exhibit significantly lower surface tensions and consequently better wetting characteristics than water alone. As the surfactant concentration is increased in very dilute solutions, surface tension decreases. This effect continues until a particular concentration is reached above which the surface tension remains nearly constant. This particular concentration is termed the "critical micelle concentration" (CMC) of the surfactant. In emulsification and cleaning applications, ethoxylated alcohol surfactants generally are much less effective at concentrations below the CMC value.

Table 10 lists the surface tension of several Tomadol Ethoxylated Alcohols ethoxylates over a range of dilute concentrations. The CMC value for each surfactant is also tabulated. Both the Tomadol 25 and Tomadol 45 series of ethoxylated alcohols exhibit particularly low CMC values.

Table 10 — Surface Tension (Dynes/cm at 24 °C in Distilled Water)

	Surfactant Concentration, %w				
	0.0001	**0.001**	**0.01**	**0.1**	**CMC, %w**
Tomadol 91-6	62	53	33	29	0.025
Tomadol 91-8	63	54	37	30	0.027
Tomadol 1-5	57	43	26	25	0.012
Tomadol 1-7	60	50	30	28	0.010
Tomadol 1-73B	62	48	28	27	0.013
Tomadol 1-9	60	50	34	31	0.015
Tomadol 23-5	49	28	27	26	0.0007
Tomadol 23-6.5	53	33	28	28	0.0017
Tomadol 25-7	51	32	30	30	0.0009
Tomadol 25-9	54	35	31	30	0.0018
Tomadol 25-12	59	39	34	34	0.0018
Tomadol 45-7	46	31	29	29	0.0004
Tomadol 45-13	50	41	36	34	0.0007
Tomadol L124	56	36	31	30	0.002
Tomadol L130	60	40	32	32	0.002
Tomadol 400	61	44	27	26	0.012
Tomadol 900	61	50	31	28	0.025
Tomadol 901	61	49	29	27	0.018

Solution Times—Ease of Dissolution

The period of time required for a surfactant to dissolve in water is an indication of the ease of mixing and formulating with that surfactant. A surfactant with a short solution time increases the production efficiency of formulations.

Table 11 lists solution times of water-soluble Tomadol Ethoxylated Alcohols. Figure 38 illustrates that Tomadol 91-6 surfactant dissolves very rapidly at room temperature; consequently, it is easier and saves formulating time versus the familiar 9-mole nonyl- and octylphenol ethoxylates.

Table 11 — Solution Times of Tomadol Ethoxylated Alcohols at 25 °C

PRODUCT	Solution Time[a] @ 25 °C, Minutes
Tomadol 91-6	0.1
Tomadol 91-8	1.5
Tomadol 1-5	2.3
Tomadol 1-7	5.5
Tomadol 1-9	9.0
Tomadol 23-6.5	2.6
Tomadol 25-7	4.9
Tomadol 25-9	4.9
Tomadol 25-12	4.9
Tomadol 45-7	8.5
Tomadol 45-13	5.9
Tomadol L124	2.9
Tomadol L130	3.5
Tomadol 400	0.5
Tomadol 600	2.2
Tomadol 900	2.1

(a) Method: To 50 ml of deionized water at 25 °C in a flat bottom pour point tube (Corning No. 6900) stirred at 500 rpm with a 1.5 x 0.5 cm magnetic stirring bar is added 0.20 ml of ethoxylate below the water level. The time required to dissolve the ethoxylate completely is the solution time.

FIGURE 38 — Solution Times of Competitive Liquid Ethoxylates at 25 °C

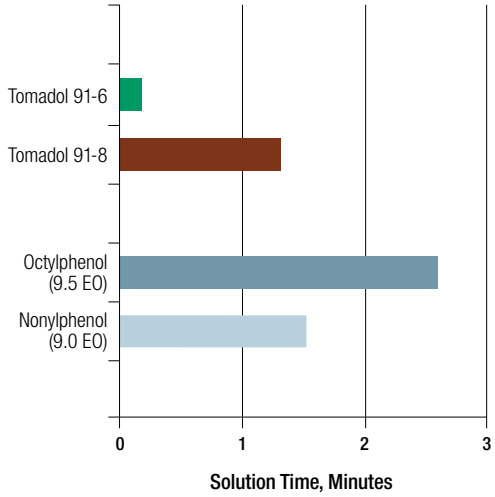
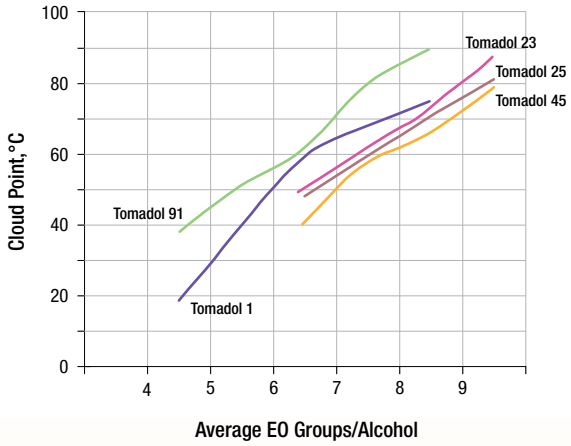


FIGURE 39 — Relationship Between Cloud Point [b] and Ethylene Oxide Content



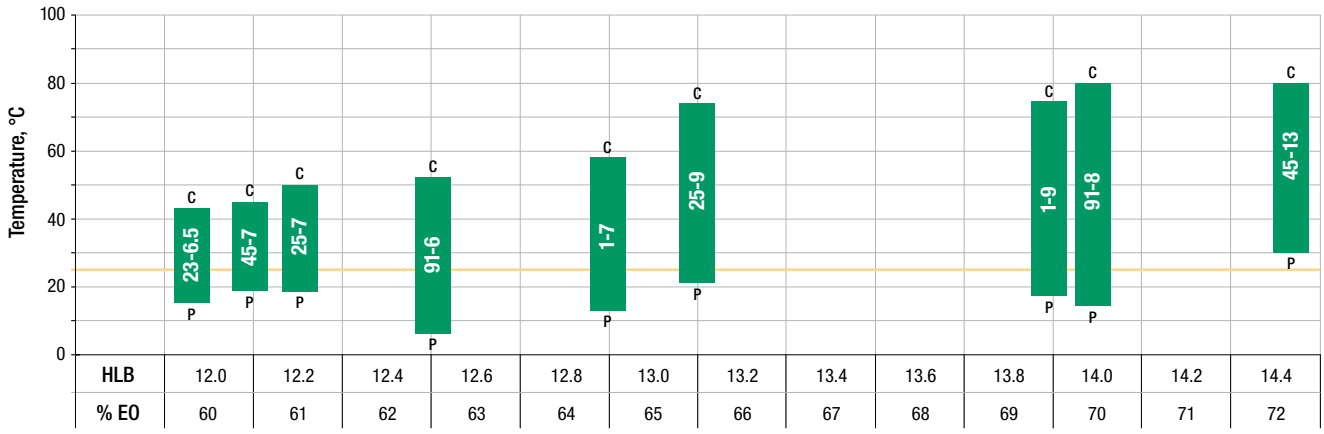
(b) measured at 1 wt% surfactant

Relationship between Cloud Point and Ethylene Oxide Content

The cloud point temperature is the temperature above which a surfactant-rich phase separates from an aqueous solution.

Figure 39 shows the relationship between cloud point and average EO content of Tomadol Ethoxylated Alcohol surfactants for the five linear synthetic alcohol series. As the ethylene oxide content of the surfactant increases, the cloud point and water solubility increase accordingly. As the carbon number of the alcohol increases, a greater number of moles of ethylene oxide must be added to the molecule to retain the same cloud point. Figure 39 is useful in comparing the relative cloud points of the Tomadol Ethoxylated Alcohol surfactants.

FIGURE 40 — HLB, Cloud Point and Pour Point of Water-Soluble Tomadol Ethoxylated Alcohols



C = Cloud point °C from Table 8 (pgs.14-15); P = Pour point °C from Table 8 (pgs.14-15)

Effect of Electrolytes on Cloud Point

Many salts will depress the cloud points of nonionic surfactants. The extent of the depression depends more on the nature of the electrolyte than on the particular surfactant. Formulators, therefore, must be aware of this depression factor when incorporating electrolytes into surfactant formulas and choose the surfactant and salt appropriately in order to achieve the desired properties for the finished formulation.

The cloud point of Tomadol Ethoxylated Alcohols and selected competitive ethoxylates in distilled water containing five percent concentrations of various electrolytes are given in Table 12. For most of the surfactants evaluated, the extent of cloud point depression by salts increased in the following order:

Tetrapotassium pyrophosphate (TKPP) < Sodium tripolyphosphate (STPP) < Sodium sulfate (Na_2SO_4) < Sodium metasilicate (Na_2SiO_3) < Caustic soda (NaOH) < Sodium carbonate (Na_2CO_3)

Table 12 — Effect of Electrolyte on Cloud Point

	Cloud Point[(a)], °C								
PRODUCT	**Water**	**TKPP**	**STPP**	**Na_2SO_4**	**Na_2SiO_3**	**NaOH**	**Na_2CO_3**	**H_2SO_4**	**HCl**
Tomadol 91-6	52	36	34	31	26	19	14	51	71
Tomadol 91-8	80	58	58	52	47	41	31	81	89
Tomadol 1-5	15-22	10	15	—	1	17	13	—	30
Tomadol 1-7	55	41	—	—	29	24	—	—	68
Tomadol 1-9	81	62	—	—	50	40	—	—	92
Tomadol 23-6.5	45	29	29	29	24	17	9	41	50
Tomadol 25-7	50	37	35	30	29	22	15	49	58
Tomadol 25-9	74	56	55	49	47	38	26	71	79
Tomadol 25-12	97	73	71	64	60	51	54	99	>100
Tomadol 45-7	46	<25	<25	<25	<0	<0	<0	45	52
Tomadol 45-13	>100	71	70	62	54	37	32	94	~100
Nonylphenol 9 EO	54	38	37	30	29	19	8	54	64
Octylphenol 9.5 EO	65	49	48	41	39	30	19	67	76
Random Secondary Alcohol (9 EO)	60	49	48	42	40	31	23	59	68

(a) 1%w surfactant, 5%w electrolyte, distilled water.

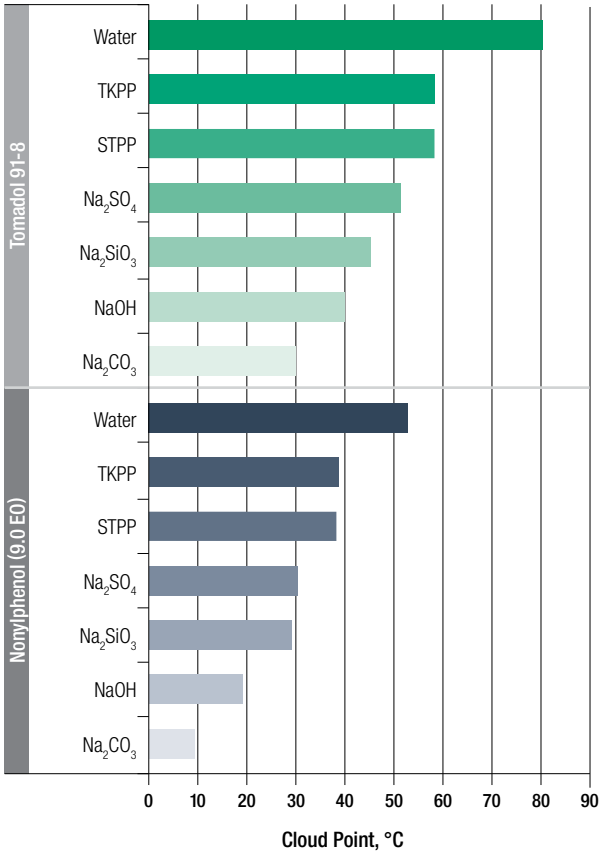
Sulfuric acid had only a minor effect on cloud point, while hydrochloric acid actually increased cloud point. Tomadol surfactants 91-8, 1-9, 25-12, and 45-13 exhibit high cloud points in water and moderately high cloud points in the presence of electrolytes. Tomadol 25-12 surfactant had the highest cloud point in caustic soda solutions among all the nonionic ethoxylates evaluated.

In Figure 41, Tomadol 91-8 surfactant is compared to nonylphenol 9 EO in terms of the effects of various electrolytes on cloud point reduction. In this example, Tomadol 91-8 surfactant maintains a higher cloud point than the competitive ethoxylate for every electrolyte tested. A higher cloud point in the presence of salts could translate to enhanced solution stability.

Acid and Caustic Stability

Tomadol alcohol ethoxylates are chemically stable in both alkaline and acidic media, allowing for their application in a wide range of liquid and powder cleaning products.

FIGURE 41 — Effect of Electrolyte on Cloud Point[a] of Aqueous Surfactant Solutions



(a) 1% surfactant, 5% electrolyte.

Dynamic Spray Foam Performance

Most Tomadol Ethoxylated Alcohols are moderately foaming surfactants. Figures 42-44 show the dynamic foam heights for select Tomadol surfactants using a Dynamic Spray Foam Test apparatus. The equipment and test method was designed to generate foam data under realistic dynamic conditions.

In the test, foam is generated by injection of the surfactant solution through a spray nozzle onto a glass column under controlled conditions. Impingement of the sprayed solution onto the glass column wall generates foam continuously; the solution is recirculated, and the foam height is measured as a function of time. Trends observed in this test will generally be consistent with those obtained from the Ross Miles Foam Test. For the Dynamic Spray Foam Test results presented in Figures 42-45, tests were performed at 10 psig, 24°C, and a surfactant concentration of 0.1%w in distilled water.

Comparative data are shown in Figure 45 for the competitive surfactants octylphenol 9.5 EO, nonlyphenol 9E0, and C11-C15 secondary alcohol 5 EO.

FIGURE 42 — Dynamic Spray Foam Height for Tomadol 91 Ethoxylated Alcohol Series

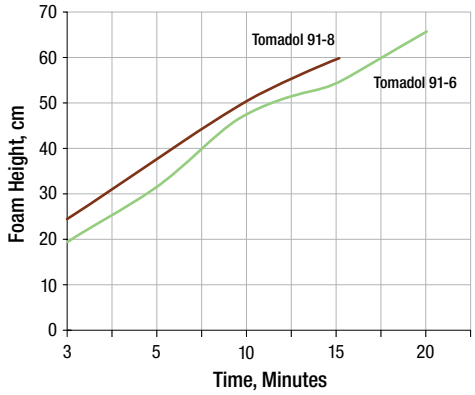


FIGURE 43 — Dynamic Spray Foam Height for Tomadol 1 Ethoxylated Alcohol Series

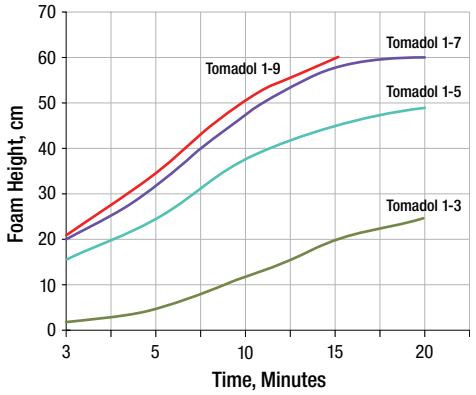


FIGURE 44 — Dynamic Spray Foam Height for Tomadol 25 Ethoxylated Alcohol Series

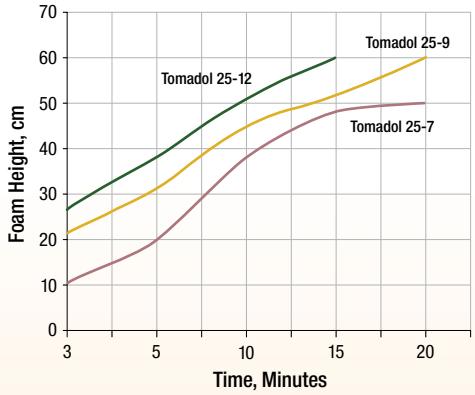
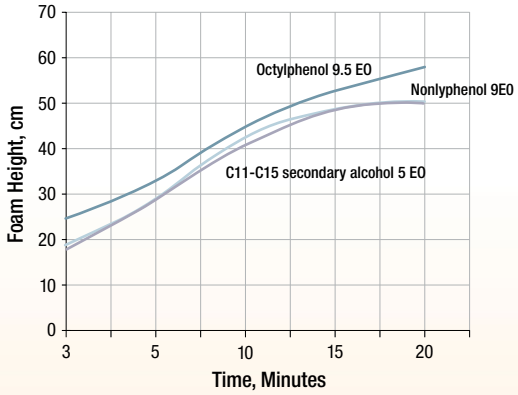


FIGURE 45 — Dynamic Spray Foam Height for Competitive Ethoxylates

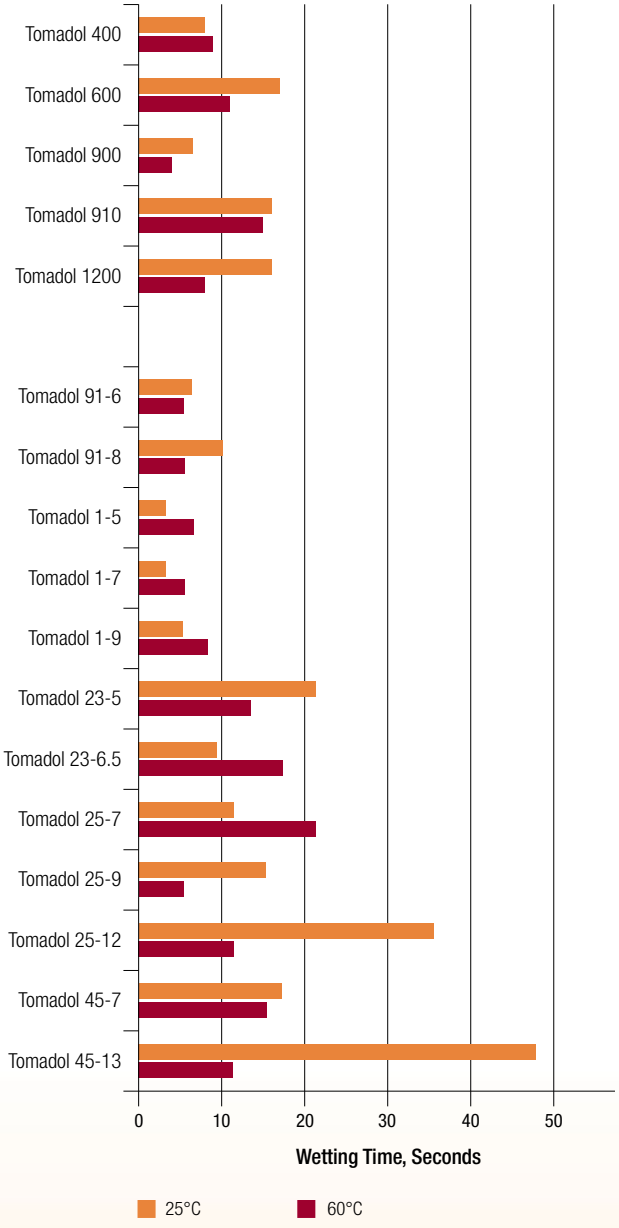


Draves Wetting Times

The Draves Wetting Test, ASTM D 2281, measures the rate at which a surfactant solution "wets" or spreads evenly onto a cotton surface. Surfactants that exhibit the shortest wetting time often perform better in other applications where rapid wetting is important.

Figure 46 displays the wetting times of selected Tomadol Ethoxylated Alcohols at room (25 °C) and elevated (60 °C) temperatures. Both the Tomadol 91 and Tomadol 1 Ethoxylated Alcohol Series have short wetting times at room and elevated temperatures, and all of these surfactants are also pourable at room temperature. Tomadol 1-5 surfactant and Tomadol 1-7 surfactant are notably outstanding wetting agents, with wetting times at room temperature about one-fifth that of competitive 9-mole octyl- and nonylphenol ethoxylates.

FIGURE 46 — Draves Wetting Times [(a)]



(a) ASTM D 2281 5g cotton skein, 3g-hook, 0.1%w surfactant, deionized water

Wetting Properties of Tomadol Ethoxylated Alcohols in Acidic and Basic Solutions

In many applications, Tomadol Ethoxylated Alcohols are utilized in acidic and basic solutions. Therefore, wetting properties in these environments are important. Table 13 displays wetting properties of select Tomadol surfactants in acidic and basic solutions. Results show that performance generally equals or exceeds that of the competitive surfactant octylphenol 9.5 EO. Consistent with results in distilled water, the Tomadol 91-6 surfactant and Tomadol 1-5 surfactant offer exceptional performance in both acidic and basic solutions at room temperature.

Table 13 — Wetting Properties of Tomadol Ethoxylated Alcohols in Acidic and Basic Solutions

	Draves Wetting Times, Seconds									
	Temperature		H_2SO_4, %w				NaOH, %w			
PRODUCT	°C	°F	0	2	5	10	0	1	2	3
Tomadol 91-6	25	77	5	6	7	6	5	4	4	5
	49	120	4	3	3	4	4	6	13	22
	66	150	5	22	21	29	5	21	40	62
Tomadol 91-8	25	77	10	12	11	17	12	11	11	11
	49	120	8	8	9	9	8	11	12	10
	66	150	5	10	14	17	5	13	12	24
Tomadol 1-5	25	77	5	7	9	12	5	6	12	21
	49	120	5	9	12	9	5	8	13	18
	66	150	5	25	17	28	5	9	29	39
Tomadol 23-6.5	25	77	11	13	13	15	11	12	13	17
	49	120	7	10	13	13	7	28	38	32
	66	150	14	23	24	24	14	21	40	69
Octylphenol (9.5 EO)	25	77	12	15	15	21	12	15	17	18
	49	120	8	11	13	17	8	14	19	82
	66	150	9	18	21	24	9	51	75	165

HLB Numbers

The applicability of a surfactant as an emulsifier, wetting agent, detergent or solubilizing agent can often be predicted by its hydrophile/lipophile balance (HLB). The HLB number expresses the basic principle that the emulsifying efficiency of a surfactant is associated with the relative molecular contribution of the polar hydrophilic head and the nonpolar lipophilic tail.

More oil-soluble surfactants have low HLB numbers. Surfactants with high HLB numbers tend to be more water soluble. The HLB number is particularly useful in predicting the behavior and performance of nonionic surfactants and is directly proportional to the ethylene oxide content of the molecule.

The HLB numbers of the Tomadol Ethoxylated Alcohols can be used as a rough guide for selection of a suitable surfactant for specific applications. HLB ranges, as shown in Table 14, indicate the water dispersibility of surfactants. Table 15 gives HLB ranges and applications for ethoxylated alcohols.

Solvent Miscibility of Tomadol Ethoxylated Alcohols

Tomadol Ethoxylated Alcohols are miscible with many organic solvents. The $C_{9\text{-}11}$ linear alcohol is the most soluble of the linear alcohols used to produce these products , and the Tomadol 91 Ethoxylated Alcohol series exhibits especially good compatibility with many solvents. The Tomadol 45 Ethoxylated Alcohol series exhibits miscibilities similar to the Tomadol 25 Ethoxylated Alcohol series when comparing surfactants with comparable ethylene oxide contents.

Air Products has developed miscibility data for many different solvents and would be pleased to work with customers to satisfy their specific needs.

Emulsification Characteristics

An important application of Tomadol Ethoxylated Alcohols is the emulsification of various solvents in water. Many emulsion systems can be complex and require combinations of various surfactants to achieve maximum efficiency and required emulsion stability. Air Products has developed extensive experience in the area of emulsification utilizing Tomadol Ethoxylated Alcohols and can provide technical assistance to customers in obtaining desired solutions.

Table 14 — HLB by Water Dispersibility

Type of Dispersion	HLB Range
No dispersion	1-4
Poor dispersion	3-6
Milky dispersion after vigorous agitation	6-8
Stable milky dispersion	8-10
Translucent to clear dispersion	10-12
Clear solution	13+

Table 15 — HLB Ranges and Applications for Tomadol Ethoxylated Alcohols

HLB Numbers	Ethylene Oxide Content Range, %w	Applications
4-6	20-30	W/O emulsifier
7-15	35-75	Wetting agent
8-18	40-90	O/W emulsifier
10-15	50-75	Detergent
10-18	50-90	Solubilizer

Health, Safety, and Environment

Human Safety of Tomadol Ethoxylated Alcohols

Tomadol Ethoxylated Alcohols have been used safely for many years in consumer products and other industrial applications. These materials have low to moderate acute oral and dermal toxicity. Their irritancy potential is similar to materials derived from coconut alcohols.

Like other nonionic surfactants, Tomadol Ethoxylated Alcohols are moderate to severe eye and skin irritants. Based on study results of dilutions of some of the Tomadol surfactants, it would be expected that 1% and 10% concentrations would only be mild to moderate skin irritants. The Tomadol Ethoxylated Alcohols have not been found to cause allergic skin reactions.

For additional information, refer to the current Material Safety Data Sheet of the product of interest.

Biodegradability

Many properties of surfactants that are useful in applications such as industrial cleaning can have undesirable effects on the environment. For example, surfactants frequently migrate to solid/liquid or liquid/air interfaces and exhibit foaming characteristics when they function as cleaning agents. These properties cause toxicity to aquatic life and unsightly foam, which also tends to minimize good oxygen transport from the air to lakes, streams, and other receiving waters.

The U.S. Clean Water Act regulates discharge of surfactants and other chemicals to receiving waters by requiring permits to dischargers. They must show that the contents of the discharge do not foam or cause harm to aquatic life. These discharges, whether they originate from household or industrial and institutional waste, must be treated prior to entry into public waters. The heart of waste treatment today is an aerobic microbial process which converts organic materials like surfactants to products which are not deleterious to the environment.

What separates environmentally acceptable surfactants from those that are environmentally unacceptable is the capability of that surfactant to biodegrade during its residence time in the waste treatment process. The United States Environmental Protection Agency (EPA), the European Union (EU), and the Organization for Economic Co-operation and Development (OECD) all have definitions of biodegradability. Tomadol Ethoxylated Alcohols have been shown to be biodegradable by these definitions, and are biodegradable according to the criteria set forth in the EU Regulation No 648/2004 on detergents. Most of the Tomadol Ethoxylated Alcohols have been shown to meet even the most stringent biodegradability criteria and are classified as readily biodegradable. Many of the Tomadol Ethoxylated Alcohols meet the criteria of the U.S. EPA Design for the Environment Surfactant Screen. For a current list of products that meet this criteria, refer to Publication No. 110-10-005-US.

FIGURE 47 — Biodegradation of Tomadol 91-6 and Two Highly Branched Nonionics in Closed Bottle BOD TEST

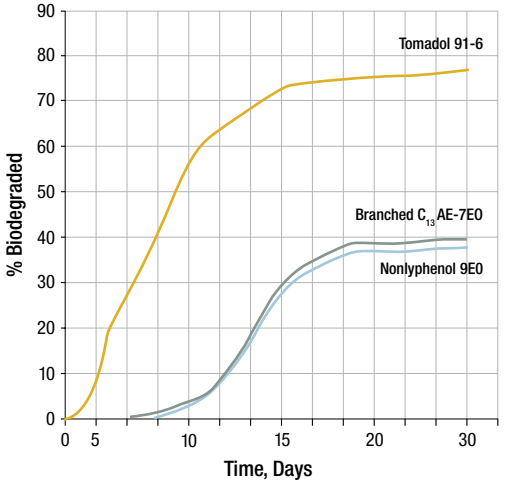


FIGURE 48 — Measurement of Intact Surfactant in Biotreater Effluents Under Industrial Use Conditions

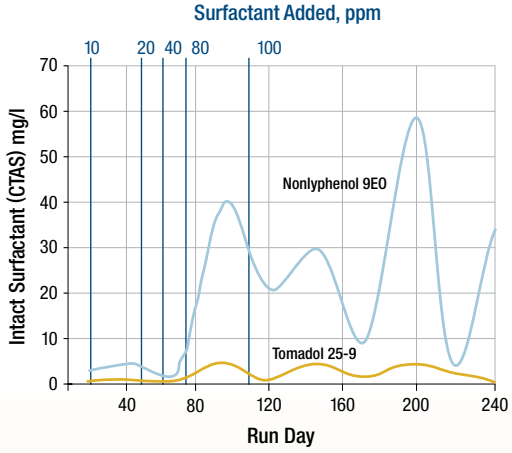


Figure 47 shows the results of the Closed Bottle BOD Test—one of the EPA guideline tests—on Tomadol 91-6 surfactant. For comparison, C13 AE-7EO, a highly branched alcohol ethoxylate, and NP-9EO, a highly branched alkylphenol ethoxylate, are also included. As shown, the highly branched nonionics biodegrade more slowly and less extensively than Tomadol 91-6 surfactant, which is an essentially linear ethoxylated alcohol.

Results of biodegradability tests based on closed bottle oxygen uptake data are listed in Table 16. These results show 62-96% biodegradation for Tomadol Ethoxylated Alcohols as measured by a 30-day BOD test. In contrast, a nonylphenol ethoxylate showed only 30% biodegradation by this test method.

In addition to the EPA guideline tests, Tomadol Ethoxylated Alcohols have been studied in radiolabeled biodegradation tests in laboratory tests simulating full scale sewage treatment in summer and winter conditions under industrial waste treatment plant conditions, and in full scale sewage treatment. The results show Tomadol surfactants biodegrade rapidly and extensively under a variety of normal and stressed conditions to non-foaming, non-toxic products which do not present a problem in obtaining discharge permits for waste treatment plant effluents.

Table 16 — Biochemical Oxygen Demand (BOD) of Tomadol Ethoxylated Alcohols[a]

Surfactant	BOD[b], g/g 5 Days	BOD[b], g/g 15 Days	BOD[b], g/g 30 Days	COD[c],g/g	% Biodegraded[d] 30 Days
Tomadol 91-2.5	0.88	2.0	2.0	2.4	83
Tomadol 91-6	0.36	1.6	2.0	2.2	91
Tomadol 91-8	0.20	0.85	1.6	2.1	76
Tomadol 1-5	—	—	2.1	2.3	91
Tomadol 23-3	1.1	1.9	2.0	2.4	83
Tomadol 23-6.5	0.33	1.8	2.2	2.3	96
Tomadol 25-3	1.3	1.9	2.6	2.8	93
Tomadol 25-7	0.45	1.5	1.9	2.2	86
Tomadol 25-9	0.26	1.6	1.8	2.2	82
Tomadol 25-12	0.12	0.84	1.3	2.1	62
Tomadol 45-7	0.65	1.4	2.0	2.3	87
Tomadol 45-13	0.29	1.3	1.5	2.1	71
Nonlyphenol (9 EO)	0.04	0.65	0.65	2.2	30

(a) Performed on unacclimated bacterial inocula, according to Standard Methods for the Examination of Water and Wastewater, 15th Edition, 1980.

(b) Biochemical oxygen demand (BOD) is a measure of oxygen consumed by microorganisms during conversion of the organic substrate to CO_2 and H_2O.

(c) Chemical oxygen demand (COD) is a measure of the theoretical amount of oxygen consumed assuming total conversion of the organic substrate to CO_2 and H_2O.

(d) % Biodegraded = $BOD_{30}/COD \times 100$.

Aquatic Safety and Industrial Effluents

Surfactants are used in processing by such industries as agriculture, textiles, pulp and paper, and institutional laundry. These industries use surfactants at much higher concentrations than are typically used in household applications. The spent process streams entering receiving waters from these industries are increasingly undergoing close scrutiny by regulatory agencies. Rules have been promulgated that require non-foaming effluents which are non-toxic to aquatic life. Surfactants that are not fully biodegraded exhibit appreciable foaming and aquatic toxicity behavior. In order to meet the requirements of state and federal environmental agencies, surfactants which biodegrade rapidly must be selected.

To address such concerns, biodegradation studies were conducted under industrial use conditions to compare Tomadol Ethoxylated Alcohols and nonylphenol ethoxylates. The results, shown in Figure 48, demonstrate that considerably higher levels of nonylphenol ethoxylate remained than Tomadol 25-9 surfactant after biotreatment. Since much of the nonylphenol ethoxylate remained intact after biotreatment, its effluent was highly foaming and toxic to two aquatic species tested, Daphnia pulex (waterbug) and Pimephales promelas (fathead minnow), as presented in Table 17. In contrast, Tomadol 25-9 surfactant biodegraded to non-foaming, non-toxic products even at the relatively high, but realistic, concentration levels tested.

Since surfactants are generally toxic to aquatic life, their capability to biodegrade to non-toxic products under realistic biotreatment conditions is an important part of the considerations of their environmental impact. Tomadol Ethoxylated Alcohols, as well as sulfate and ethoxysulfate derivatives of Tomadol Ethoxylated Alcohols biodegrade rapidly and extensively to non-toxic, non-foaming products even under such stress conditions as high loadings and low temperature.

Conformance with Federal Regulations

Tomadol Ethoxylated Alcohols are acceptable for use in compliance with FDA applications as indirect food additives under 21 CFR 176.170 and 176.180.

In some cases, these products are also approved for use as inert ingredients in pesticide formulations.

For additional information, contact our Product Information Center at 800-345-3148 or 610-481-6799.

Table 17 — Acute Aquatic Toxicities of Neat Surfactants and Their Biotreated Effluents Under Industrial Use Conditions[c]

Surfactant	Neat Surfactant, mg/l Daphnia Pulex[a]	Neat Surfactant, mg/l Pimephales Promelas[b]	Biotreated Effluent, % Daphnia Pulex[a]	Biotreated Effluent, % Pimephales Promelas[b]
Tomadol 25-7	0.76	0.50	>100.0	>100.0
Nonlyphenol ethoxylate (9 E0)	2.9	1.6	14.7	7.3
Control (No surfactant)	—	—	82.7	>100.0

(a) 48 hour EC50—the higher the value, the lower the toxicity.

(b) 96 hour LC50—the higher the value, the lower the toxicity.

(c) from feeding 100 ppm surfactant to the biotreater

Applications

Tomadol Ethoxylated Alcohols and Nonidet Alkoxylated surfactants can be used in a wide-variety of applications, including Industrial & Institutional Cleaning, Industrial Process Aids, Household Cleaners and Personal Care Products. For a given end-use product, more than one Tomadol or Nonidet surfactant is often suitable. In selecting the best surfactant (or combination of surfactants) for an application, the formulator commonly considers such physical properties as HLB (see Tables 8 and 15), cloud point or surface tension (see Table 8). Other surfactant characteristics such as the gel curve, environmental properties, or handling characteristics may also be important.

Table 18 provides common surfactant recommendations for a variety of end-use Industrial & Institutional applications. For further technical assistance in selecting the best Tomadol Ethoxylated Alcohol or Nonidet Alkoxylated surfactant for your formulation, please contact your account manager, call us at 800-345-3148, or visit our web site at www.airproducts.com/nimble.

Table 18 — Recommendations for Industrial & Institutional Formulations

HARD SURFACE CLEANERS

All-Purpose

— Concentrates
1. Tomadol 91-6 (optionally, use in combination with 91-2.5)
2. Tomadol 900
3. Tomadol 23-6.5
4. Tomadol 25-7 / 25-3 (start 75:25 wt:wt)
5. Tomadol 1-7
- Tomadol L124 / L80 (start 79:21 wt:wt)

— Degreasers
1. Tomadol 901
2. Tomadol 1-73B
3. Tomadol 25-7 / 25-3 (start 75:25 wt:wt)
4. Tomadol 1-5

— Solvent Cleaners
1. Tomadol 91-8 / 91-2.5 (start 50:50 wt:wt)
2. Tomadol 91-6
3. Tomadol 1-5

— Ready-to-Use and Spray-and-Wipe
1. Tomadol 900
2. Tomadol 91-6
3. Tomadol 23-6.5
4. Tomadol 1-73B
- Tomadol L124 / L80 (start 79:21 wt:wt)

Industrial

— Dairy Cleaners – CIP
1. Tomadol 901
2. Tomadol 25-7 / 25-3 (start 75:25 wt:wt)
3. Tomadol 1-5

— Dairy Cleaners – Iodophor formulations
1. Tomadol 1200
2. Tomadol 25-12

— Rust Removers
1. Tomadol 900
2. Tomadol 901

— Low Foam Cleaners
1. Tomadol 1-5 (check for solubility, formulate near cloud point)
2. Nonidet SF-5
3. Nonidet SF-3
4. Nonidet RK-18

— Steam Cleaners
1. Tomadol 900 (check foam performance)
2. Tomadol 901

— Metal Cleaners
1. Tomadol 901
2. Tomadol 91-6 / 91-2.5 (ladder study to optimize performance)
3. Tomadol 1-7 / 1-3 (ladder study to optimize performance)

— Tank Cleaners
1. Tomadol 900 / 400 (ladder study to optimize performance)

Institutional

— Acid Cleaners
1. Tomadol 900
2. Tomadol 91-6
3. Tomadol 25-12

— Bathroom Cleaners
1. Tomadol 900
2. Tomadol 25-12
3. Tomadol 23-6.5

— Floor Cleaners
1. Tomadol 900 (check foam performance)
2. Tomadol 91-6 (check foam performance)
3. Tomadol 901

— Disinfectant Cleaners
1. Tomadol 25-12
2. Tomadol 900

— Dishwash
1. Tomadol 25-12
2. Tomadol 91-8
3. Nonidet RK-18 (as rinse aid)
- Tomadol L130 / L80 (start 82:18 wt:wt)

— Glass Cleaners
1. Tomadol 901
2. Tomadol 25-12

— Rug and Upholstery Cleaners – Less Foaming
1. Tomadol 1-5 (formulate near CMC)
2. Tomadol 91-6 / 91-2.5 (start 75:25 wt:wt)

— Rug and Upholstery Cleaners – Higher Foaming
1. Tomadol 25-12
2. Tomadol 23-6.5

— Wall and Tile Cleaners
1. Tomadol 901
2. Tomadol 900
- Tomadol L124 / L80 (start 79:21 wt:wt)

This symbol shows our natural-derived product recommendation.

LAUNDRY

Industrial & Institutional

1. Tomadol 25-7 / 25-3 (start 70:30 wt:wt)
2. Tomadol 25-9
3. Tomadol 900 / 600 (start 67:33 wt:wt)
4. Tomadol 23-6.5
   (optionally, use in combination with 91-6)

- Tomadol L144 / L80 (start 60:40 wt:wt)

MISCELLANEOUS

Foam Markers

1. Tomadol 25-12
2. Tomadol 91-8

Hand Cleaners

1. Tomadol 25-9
2. Tomadol 25-7

- Tomadol L130

Fragrance Oil Solubilizers

1. Tomadol 900
2. Tomadol 901
3. Tomadol 1200

- Tomadol L130 / L80 (ladder study to optimize performance)

Table 19 — Cosmetic Ingredients Nomenclature for Tomadol Ethoxylated Alcohols & Linear Alcohol Precursors

Tomadol Ethoxylated Alcohols & Linear Alcohol Precursors	**Adopted Name**
91 Linear alcohol	$C_{9\text{-}11}$ Alcohols
1 Linear alcohol	Undecyl Alcohol
23 Linear alcohol	$C_{12\text{-}13}$ Alcohols
25 Linear alcohol	$C_{12\text{-}15}$ Alcohols
45 Linear alcohol	$C_{14\text{-}15}$ Alcohols
Tomadol 91-2.5	$C_{9\text{-}11}$ Pareth-3
Tomadol 91-6	$C_{9\text{-}11}$ Pareth-6
Tomadol 91-8	$C_{9\text{-}11}$ Pareth-8
Tomadol 1-5	Undeceth-5
Tomadol 23-3	$C_{12\text{-}13}$ Pareth-3
Tomadol 23-6.5	$C_{12\text{-}13}$ Pareth-7
Tomadol 25-3	$C_{12\text{-}15}$ Pareth-3
Tomadol 25-7	$C_{12\text{-}15}$ Pareth-7
Tomadol 25-9	$C_{12\text{-}15}$ Pareth-9
Tomadol 25-12	$C_{12\text{-}15}$ Pareth-12
Tomadol 45-7	$C_{14\text{-}15}$ Pareth-7
Tomadol 45-13	$C_{14\text{-}15}$ Pareth-13
25-3A[(a)]	Ammonium $C_{12\text{-}15}$ Pareth Sulfate
25-3S[(a)]	Sodium $C_{12\text{-}15}$ Pareth Sulfate

(a) Equivalent products available from sulfators utilizing Tomadol 25-3 surfactant for sulfation.

Shipping Data/Storage and Handling

Table 20 contains shipping data on the Tomadol Ethoxylated Alcohols.

For complete information on the safety and handling precautions for these products, refer to the current Material Safety Data Sheet on the product of interest.

Table 20 — Shipping Data for Tomadol Ethoxylated Alcohols

Product	Density Lb/Gal @ 60 °F[a]	Coefficient of Expansion Lb/Gal °F	Coefficient of Expansion Lb/Gal °C	Typical Net Weights (Lb) for Containers[b] 1-Gal[b] Container	5-Gal[b] Pail	55-Gal[b] Drum
Tomadol 91-2.5	7.74	0.0035	0.0063	7	35	420
Tomadol 91-6	8.28	0.0036	0.0065	8	40	450
Tomadol 91-8	8.46	0.0036	0.0065	8	40	455
Tomadol 1-3	7.85	0.0035	0.0063	8	40	425
Tomadol 1-5	8.12	0.0030	0.0054	8	40	440
Tomadol 1-7	8.34	0.0036	0.0065	8	40	450
Tomadol 1-9	8.36 @ 90 °F	0.0036	0.0065	8	40	460
Tomadol 23-1	7.32	0.0033	0.0059	7	35	395
Tomadol 23-3	7.75	0.0034	0.0061	7	35	420
Tomadol 23-5	8.08	0.0035	0.0063	7	35	435
Tomadol 23-6.5	8.22	0.0035	0.0063	8	40	445
Tomadol 25-3	7.75	0.0034	0.0061	7	35	420
Tomadol 25-7	8.25	0.0035	0.0063	8	40	445
Tomadol 25-9	8.39	0.0035	0.0063	8	40	455
Tomadol 25-12	8.56	0.0035	0.0063	8	40	465
Tomadol 45-7	8.16 @ 70 °F	0.0036	0.0065	8	40	445

(a) Exceptions to 60 °F are so noted.

(b) Air Products does not offer package quantities, except as samples. Drums and totes, as well as actual fill weights, are available through authorized distributors.

Index of Tables and Figures

For additional technical information, formulation guidance or pricing contact the nearest Air Products sales contact or our Product Information Center at 800-345-3148 or 610-481-6799.

For order placement, order status, or information on product availability, call 800-352-3528.

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