AIR PRODUCTS

Surfynol® 104 Surfactant

Introduction

Surfynol 104 surfactant is one in a series of Air Products' surfactants that provide a unique combination of performance benefits including wetting, defoaming and improving pigment dispersions. Surfynol 104 surfactant is a nonionic molecule containing a hydrophilic portion in the middle of two symmetrical hydrophobic groups. Its unique chemical structure allows this product to provide multifunctional properties such as surface tension reduction, foam control and viscosity stabilization. The hydrophobic nature of Surfynol 104 surfactant results in reduced water sensitivity compared to either conventional ethoxylated or anionic surfactants. Due to its multifunctional properties, Surfynol 104 surfactant provides performance benefits in many waterborne applications such as coatings, paints, adhesives, inks, pigment manufacture and dispersion, cements, metalworking lubricants, agricultural chemicals and dye processing.

Performance Benefits

Surface Tension

Surface tension reduction is an important property of any surfactant because it allows the wetting of substrates whose surface energy is less than the surface tension of water. Table 1 demonstrates the ability of Surfynol 104 surfactant to effectively lower the surface tension of water under static conditions using a duNouy tensiometer.

While steady state reduction in surface tension can give the formulator a quick gauge of a surfactant's effectiveness, many industrial applications never reach equilibrium. Therefore, it is important in processes where surfaces are generated at a rapid rate (printing, spray and roll coating, metalworking, etc.) that the surfactant migrate rapidly to the interface to prevent film retraction and other surface defects. As shown in Table 2, the ability of Surfynol 104 surfactant to

Table 1

Surfynol 104 Surfactant—Equilibrium Surface Tension

Concentration (%)	Surface Tension (dynes/cm)
.01	51.1
.05	37.7
.1	33.1

Table 2

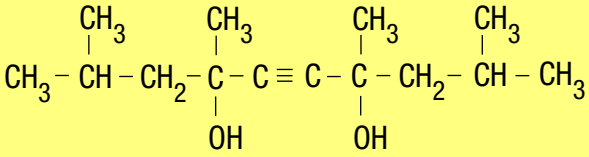
Dynamic Surface Tension Profile[1]

Relative Rate of Surface Formation (bubbles/sec)	Surface Tension (dynes/cm)	
	Surfynol 104 (0.1%)	Triton X-100[2] (0.1%)
1 (equilibrium)	33.1	33.4
3	34.1	35.4
6 (dynamic)	36.4	42.2

[1]Testing performed on a Sensadyne 5000 tensiometer (Chemdyne).
[2]Union Carbide

lower surface tension under conditions of rapid surface formation (represented by increasing the bubble rate) is due to its unique ability to migrate quickly to newly formed interfaces. As a result, Surfynol 104 surfactant's performance under dynamic conditions significantly surpasses that of conventional surfactants such as octyl phenol ethoxylate.

Surfynol 104 Surfactant (2,4,7,9-tetramethyl-5-decyne-4,7-diol)



Wetting

Water-based systems such as coatings, adhesives, inks, etc., have a higher surface tension than those which are solvent based. Consequently, surfactants are required to achieve good wetting. However, the addition of most wetting agents causes foam, and the subsequent addition of a defoamer can lead to the recurrence of the original wetting problems. Surfynol 104 surfactant prevents this problem by providing the necessary wetting under dynamic conditions, while controlling or eliminating foam.

The minimum surface tension that can be achieved using Surfynol 104 surfactant is limited by its solubility. If lower surface tensions are required, Surfynol surfactants with greater water solubility—such as Surfynol SE, TG and the 400 series—should be utilized.

Defoaming

Surfynol 104 surfactant is best described as a defoaming, nonionic surfactant. The defoaming nature of this surfactant is not closely related to temperature. Typical low-foaming nonionics foam less at temperatures above their cloud points because they become insoluble. Surfynol

Table 3

Typical Properties

Surfynol Surfactant	Physical Form	Liquid Composition	Specific Gravity[1] (@ 25°C)	Lb/Gal (Approx)	Melt Point	Viscosity[2] (cps)
Surfynol 104A	Light Yellow Liquid 2-ethylhexanol	50% wt 104 in	0.865	7.2 (32°F)	<0°C	100 @ 20oC
Surfynol 104BC	Light Yellow Liquid 2-butoxy ethanol	50% wt 104 in	0.898	7.6 (–40°F)	<–40°C	100 @ 20oC
Surfynol 104DPM	Light Yellow Liquid dipropylene glycol monomethyl ether	50% wt 104 in	0.928	7.8 (23°F)	–5°C	100 @ 20oC
Surfynol 104E	Light Yellow Liquid ethylene glycol	50% wt 104 in	0.999	8.3 (32°F)	<0°C	100 @ 20oC
Surfynol 104H	Light Yellow Liquid ethylene glycol	75% wt 104 in	0.946	7.9 (50°F)	10°C	150 @ 35oC
Surfynol 104NP	Light Yellow Liquid n-propyl alcohol	50% wt 104 in	0.856	7.1 (–4°F)	–20°C	100 @ 20oC
Surfynol 104PA	Light Yellow Liquid isopropyl alcohol	50% wt 104 in	0.839	7.0 (–40°F)	<–40°C	100 @ 20oC
Surfynol 104PG-50	Light Yellow Liquid propylene glycol	50% wt 104 in	0.971	8.1 (4°F)	–16°C	200 @ 20oC
Surfynol 104S	Free-Flowing Powder amorphous silica	46% wt 104 on	0.457	3.9	—	—

[1]Specific Gravity of Surfynol 104 surfactant measured with a pycnometer.
[2]Viscosity measured with Brookfield viscometer, #1 spindle at 30 rpm's.

104 surfactant does not have a cloud point; therefore, it defoams over a very broad temperature range.

Surfynol 104 surfactant can be used in combination with conventional defoamers. If used in this manner, the conventional defoamer concentration can often be reduced to a level where it causes fewer side effects such as fisheyes and pinholes. In addition, Surfynol 104 is very effective against microfoam.

Water Sensitivity

Many surfactants that effectively reduce surface tension cause water sensitivity problems in dried coatings, inks, adhesives, etc. Highly hydrophilic surfactants such as anionic (sodium dioctyl sulfosuccinate) or heavily ethoxylated (alkyl phenol ethoxylates) surfactants readily resolubilize in water, causing surface defects in the dried product. This resolubilization can promote loss of adhesion, hazing, spotting and other problems. Due to its more hydrophobic nature, Surfynol 104 surfactant does not adversely affect the water sensitivity of formulations.

Physical Properties

As shown in Table 3, Surfynol 104 surfactant is available in liquid forms for ease of handling, or as a free-flowing powder on a solid support.

Freezing Point

Liquid versions of Surfynol 104 surfactant may tend to crystallize at low temperatures. Surfynol 104H surfactant is particularly prone to crystallization in cold weather. If the product has crystallized in the solvent, recovery to the clear solution form is a function of time and temperature.

See "How to Formulate with Surfynol 104 Surfactant" (120-9829) for further information

Cloud Point

Surfynol 104 surfactant does not have a cloud point. Also, although it is a diol, its water solubility is not increased appreciably by higher temperatures.

Stability

Surfynol 104 surfactant alone and in most applications has high thermal stability. It should not be compounded with strong oxidizing or reducing agents or with high levels of caustic (pH>12) such as sodium hydroxide or potassium hydroxide.

Solubility

Surfynol 104 surfactant is soluble in all common solvents except highly aliphatic products like kerosenes or oils.

Applications and Benefits

Coatings

Surfynol 104 surfactant is employed in coatings to solve a variety of formulating problems including foam and coverage over difficult-to-wet surfaces. Due to its ability to reduce surface tension under dynamic conditions, Surfynol 104 surfactant is incorporated into spray, dip and coil coatings to enhance wetting of oily or improperly cleaned substrates. Surfynol 104 surfactant is also used to aid in the proper coverage of water-based coatings over low surface tension substrates like plastics. And, as a result of its unique structure, Surfynol 104 surfactant will reduce water sensitivity problems associated with most surfactants.

Unlike conventional surfactants that typically cause foam in waterborne coatings, Surfynol 104 surfactant has foam control capabilities. Consequently, traditional defoamers can sometimes be removed or reduced when Surfynol 104 surfactant is employed in the coating formulation. The chemical nature of Surfynol 104 surfactant ensures coating formulators that this surfactant will not lead to the many problems associated with foam. However, if additional foam control agents are necessary, Surfynol 104 surfactant can be used with a wide variety of conventional defoamers.

In coatings, Surfynol 104 surfactant can be included in the grind or letdown, depending on the function required of the surfactant.

For more information see Air Products' technical article entitled "The Importance of Low Dynamic Surface Tension in Waterborne Coatings" (120-9303)

Industrial Maintenance Coatings

The incorporation of Surfynol 104 surfactant into the letdown or grind stage of spray-applied waterborne industrial maintenance coatings aids in the reduction of external and internal microfoam, resulting in improved gloss. Flow and leveling properties are also improved, without additional generation of foam.

For more information see Air Products' brochures entitled "The Benefits of Surfynol® Surfactants in Waterborne Industrial Maintenance Coatings" (120-9755) and "The Benefits of Surfynol Surfactants in Waterborne Thermoplastic Industrial Maintenance Primers" (120-9532)

Printing Inks

Surfynol 104 surfactant is employed for its multifunctional benefits in water-based flexographic and gravure printing inks. The product aids in penetration of the ink into absorbent stocks, such as paper, and also improves coverage over polymeric films, such as polyethylene. In addition, Surfynol 104 surfactant's defoaming capabilities eliminate troublesome foam which causes many problems in printing inks. Surfynol 104 surfactant can be incorporated into the grind or letdown, depending on the surfactant function desired.

For more information see Air Products' brochure entitled "Surfynol Surfactants: Applications in Water-Based Printing Inks" (120-9319)

Factory Applied Wood Coatings

The use of Surfynol 104 surfactant in waterborne wood coatings gives formulators a solution to typical problems encountered when spraying coatings. Problems such as loss of gloss due to microfoam, poor flow and leveling, adhesion and water sensitivity can be reduced or eliminated with incorporation of Surfynol 104 surfactant.

For more information see Air Products' brochures entitled "Surfynol® Surfactants: Multifunctional Problem Solvers in Waterborne Wood Coatings" (120-9756)

DIY Wood Finishes

The performance of waterborne Do-It-Yourself (DIY) wood finishes is enhanced when Surfynol 104 surfactant is used in stain, sealer or topcoat formulations. Primary benefits obtained include color uniformity in stains, early stain lapping resistance and consistent wetting, flow and leveling on various types of wood.

For more information see Air Products' brochures entitled "Surfynol® Surfactants:

Multifunctional Problem Solvers in Waterborne Do-It-Yourself Wood Finishes" (120-9831)

Overprint Varnishes

In overprint varnish systems, Surfynol 104 surfactant provides wetting so that proper coverage of an aqueous overprint varnish can be achieved over wet, solvent-based lithographic ink. In addition, troublesome foam can be reduced when Surfynol 104 is used as the wetting agent. And, because this product's unique structure is hydrophobic in nature, water sensitivity problems are reduced when compared to conventional anionic or ethoxylated nonionic surfactants.

Fountain Solutions

Surfynol 104 surfactant is used in lithographic fountain solutions for the dynamic wetting of aluminum printing plates without causing excess emulsification of the ink. At the same time, Surfynol 104 surfactant controls foam caused by formula components and high shear conditions.

Pressure Sensitive Adhesives

The low surface tensions presented by silicone and plastic film release liners require strong wetting agents in order to achieve proper coverage by the adhesive. Surfynol 104 surfactant's ability to provide good wetting under dynamic conditions ensures consistent substrate coverage while reducing foam problems.

Many commonly used wetting agents provide the required coverage, but also produce foam. In addition, these same wetting agents remain water sensitive in the dried adhesive, causing a loss of bond strength. Surfynol 104 surfactant does not adversely affect the water sensitivity of the adhesive.

For more information see Air Products' brochure entitled "Surfynol® Surfactants for Pressure Sensitive and Laminating Adhesives" (120-9846)

Paper Coatings

When used in paper coating and sizing applications, Surfynol 104 surfactant effectively defoams while improving flow characteristics, thus eliminating pinholes, fisheyes and other surface defects. Water sensitivity of the finished product is also minimized by a reduced rate of water absorption into the coating.

Agricultural Chemicals

As an additive in both wettable powder and flowable pesticide systems, Surfynol 104 surfactant improves wetting, controls foam and enhances leaf and soil penetration. In flowable systems, the wetting benefits of Surfynol 104 surfactant are evident not only in formulating, but also upon dilution, where bloom and dispersion stability are enhanced.

Dye Processing

Surfynol 104E surfactant is widely used to control the foam caused by gas generated during the production of azo dyes. It also effectively defoams mechanically generated foam produced during the spray drying, mixing and filtering of any type of dye. An added benefit is the ability of this product to reduce static charge during spray drying.

When added during dispersion, especially in the presence of lignosulfonate dispersants, Surfynol 104 surfactant controls foam while imparting improved wetting properties leading to more stable dispersions at reduced viscosities. Additionally, higher solids are possible due to these reduced viscosities, promoting savings in the time and energy needed for filtering and spray drying.

For more information see Air Products' brochure entitled "Surfynol® Surfactant Applications in Dye Manufacture" (120-315)

Metalworking Fluids

Lubrication in metalworking is aided by Surfynol 104 surfactant's affinity for metal surfaces and its ability to rapidly migrate to newly formed surfaces. And, unlike many foam generating surfactants, it acts to displace air from the metal surface as well as the bulk lubricant, resulting in improved workpiece and metal part cooling.

Once the metalworking process is completed, it is important to remove residual surfactant from the part to prevent contamination in downstream processes such as painting or coating. While the majority of Surfynol 104 surfactant will be removed using traditional methods, the product's volatile nature assures that any residual surfactant will evaporate upon heating.

For more information see Air Products' brochure entitled "Surfynol® Surfactants and Ancor® Corrosion Inhibitors in Water-Based Metalworking Fluids" (120-641)

Cements, Mortars and Grouts

Surfynol 104 surfactant, as well as several other Surfynol surfactants, is used in water-based cement formulations for construction and oil well applications. These products are effective deairentraining agents for both ready-mix and precast construction cements where they control or eliminate entrained air and improve compression strength. In oil well cements, Surfynol surfactants effectively deairentrain without affecting fluid loss or rheological properties.

Additional Applications

The preceding applications are only a sample of the many different existing and potential end uses for Surfynol surfactants. Other end uses include industrial and household cleaners, carpet backing adhesives, foundry core coatings, textiles, emulsion polymerization and chemical processing, to name just a few. If you have questions about a specific end use, please call 1-800-345-3148 or 610-481-6799 to receive technical information and/or free samples of Surfynol surfactants.

How to Formulate with Surfynol 104 Surfactant

1 When blending, maintain adequate agitation and allow sufficient mix times of 15 to 30 minutes. If high viscosity is preventing adequate mixing, heating the mixture will reduce the viscosity.

2 Add Surfynol 104 surfactant after other surfactants and polymers have been added.* This will allow the maximum rate of dissolution or dispersibility of Surfynol 104 surfactant into the system.

3 If pigments, fillers or other solids are being incorporated, add them after the Surfynol 104 surfactant. This will allow the Surfynol 104 surfactant to wet the solids and control any foam produced during addition.

4 Surfynol 104 surfactant is a multifunctional product which may replace one or more formulation additives. Consequently, a ladder study should be conducted to determine optimum use levels.

5 When shipped or stored in extremely cold temperatures, several Surfynol 104 surfactant liquid blends can freeze or partially crystallize. Warming above the melt point using mild agitation will provide a liquid product.

*If the formulation viscosity increases, add Surfynol 104 surfactant earlier in the formulation.

Toxicity Data

Surfynol 104 surfactant has a low degree of toxicity and has several FDA and EPA clearances. For specific safety and handling information, please see the MSDS on Surfynol 104 surfactant.

Summary

When used in your formulations, Surfynol 104 surfactant offers the following features and application benefits.

Features
Quick migration, leading to low dynamic surface tension
Low static (equilibrium) surface tension
Defoaming/deairentraining/nonfoaming nature
Ability to wet contaminated substrates
Ability to reduce pigment particle size and prevent re-agglomeration
Non-micelle forming
Thermal stability over a broad temperature range
Chemical stability from pH ~ 3 to pH ~ 12

Application Benefits
Prevents surface defect problems such as fisheyes, crawling and cratering
on low-energy substrates
Prevents surface defect problems on contaminated or poorly prepared
substrates
Reduces microfoam in spray-applied systems
Improves pigment grind efficiency
Reduces water sensitivity
Defoams and deairentrains coatings, inks, cements, mortars, grouts and dyes
Defoams and improves flow of coatings, inks, adhesives, paper coatings and sizings
Enhances leaf and soil penetration while improving bloom and stability in agricultural chemical formulations
Lubricates, wets and prevents smut formation while eliminating hot spots in metalworking fluids

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