Amphoteric surfactants for household and I&I: widely used in the personal care industry, these materials offer many benefits to household manufacturers too.

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AMPHOTERIC SURFACTANTS are widely used in personal care products because of their mildness, cleaning and viscosity modifying properties. Their use in household and industrial & institutional (I&I) cleaning products is increasing as well. That is because amphoteric surfactants provide a wide range of benefits in finished formulations due to their mildness, improved wetting properties, low foaming characteristics, stability in the presence of alkalis and acids and good hydrotroping and coupling ability.

In addition, amphoterics have a good biodegradability profile, are excellent viscosity modifiers and have good tolerance in hard water. Moreover, they have excellent emulsification properties, are compatible with quats and exhibit good dye transfer inhibition. They are ideal for low or nonstreak glass cleaning applications.

Physical Properties

Amphoterics possess excellent surface properties. They show good surface tension and critical micelle concentration properties. The CMC and surface tension data is listed in table 1.

Wetting and penetration is a requirement in the majority of cleaning products. Amphoterics are good wetting agents that can be used at practically the entire pH range. Table 2 lists the Drave's wetting times for various amphoteric surfactants.

Amphoterics can be high, moderate or low foaming surfactants. The foam height data for various amphoteric surfactants is listed in table 3.

Amphoterics can build viscosity of anionic systems. To evaluate this property, we made a simple anionic based formula that can be used for any light duty cleaning application. Various amphoteric surfactants were added to this formula and the viscosity was measured. Tallow dihydroxy ethyl betaine and sodium cocoamphoacetates have shown good viscosity building properties in our tests. The data is listed in table 4. Tests were run on commercial products as supplied.

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Base Formula

Ingredient % w/w

Sodium lauryl ether sulfate (solids) 4.00
TEA lauryl sulfate (solids) 6.00
Citric acid 0.30
Sodium chloride 2.00
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Amphoteric surfactant (solids) 2.00
Water q.s. to 100%
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The viscosity (Cps.) of formulas made with various amphoteric surfactants is listed in table 4.

Performance Tests and Results

Standard manual dishwash liquids can be formulated with linear alkyl benzene sulfonate and sodium lauryl ether sulfate. Alkanolamides such as cocamide DEA is used for viscosity building and foam stabilization. We compared the performance of cocamidopropyl betaine with that of the cocamide DEA in the following standard formula.

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Ingredient % w/w

Sodium linear alkylbenzene sulfonate 10.0
Sodium lauryl ether sulfate 10.0
Cocamide DEA/cocamidopropyl betaine 3.0
Water q.s. to 100%
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The above formula was subjected to the plate-washing test. The results are as follows.

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Product Used # of Plates washed

Formula with cocamide DEA 12
Formula with cocamidopropyl betaine 13
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Use of cocamidopropyl betaine has some other advantages such as mildness to skin and eyes. Another plate washing test was ran using AOS (sodium C14-16 alpha olefin sulfonate) alone, AOS and cocamide DEA in 8:1 ratio and AOS and sodium cocoamphopropionate in 8:1 ratio. The results are listed below.

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Product Used # of Plates washed

AOS only 12
AOS + cocamide DEA 1:8 13
AOS + sodium cocoamphopropionate 1:8 16
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In industrial cleaners and degreasers amphoteric surfactants can be used to provide wetting, penetration, emulsification and solubilization of the greasy, oily soil. In order to compare the performance of amphoterics with nonionic we developed the following base formula.

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Degreasing Base

Tetrapotassium pyrophosphate 12.5
Sodium metasilicate pentahydrate 3.5
Sodium hydroxide 4.0
Water 80.0
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Next, several formulas were made by adding various nonionic and amphoteric surfactants to the degreasing base. The formulas are listed below.

Degreasing Formulas				
	A	B	C	D
Degreasing base	74.0	74.0	74.0	74.0
Nonylphenol, 9 EO	8.0			
SXS	18.0			
Lauramidopropyl hydoxy sultaine		9.0		
Cocamidopropyl hydroxy sultaine			9.0	
Sodium cocoamphopropionate				9.0
Water	17.0	17.0	17.0	

The grease removal performance of the above formulas was evaluated by baking a greasy soil on a ceramic tile. A drop of the each cleaner was placed on the tile and rinsed after 60 seconds. The amount of soil removed by various formulas is listed below.

Formula	Degreasing Base	A	B	C	D
% Soil Removed	22	38	91	82	59

The above results show that amphoterics are the surfactant of choice and work better than nonionics in high alkalinity/electrolyte formulas generally used for I&I cleaners.

Bathroom cleaning is another application area where the amphoterics has shown some performance advantages. Soap scum removal is enhanced by adding amphoteric surfactants in the formula. In order to evaluate the performance of various amphoterics we designed the following formula.

Ingredient	% Wt.
Tetrasodium EDTA	0.30
Potassium hydroxide	0.10
Sodium carbonate	0.10
Glycol ether DPM	0.50
Amphoteric surfactant	1.00
Water	98.00

Various amphoteric surfactants were plugged into the above formula and their performance for soap scum removal was evaluated according to CSMA DCC-16 guideline for evaluating the efficacy of bathroom cleaners. The results are as follows.

Product Tested	% Soil Removed
Base formula without surfactant	25
With lauramidopropyl-hydroxy sultaine	50
With Cocamidopropyl-hydroxy sultaine	75
With Sodium Cocoamphopropionate	50
With Sodium Capryloamphoacetate	100

When formulating glass and all-purpose cleaners, streaking and spotting is a big negative. We evaluated various surfactants for their streaking and spotting performance. A base formula was developed and various surfactants were plugged into the formula at 0.25% level.

Ingredient	% Wt.
Water	89.75
Isopropyl alcohol	6.00
Glycol ether DPM	4.00
Surfactant	0.25

A simple procedure was used to evaluate the streaking and spotting performance of the products. A mirror was cleaned well with laboratory glassware cleaner, dried, then wiped off with isopropyl alcohol and dried again. It was then treated with a fixed amount of each cleaner using above listed formula. The mirror was wiped dry and left for 30 minutes. It was then rated for streaking and spotting on a scale of 1-6. The results are as follows. The lower number means less streaking and spotting and thus is desirable.

Surfactant used	Streaking/Spotting Rating
Nonylphenol 9EO	5.5
Lauramine oxide	4.0
Cocamidopropyl betaine	3.5
Sodium capryloamphoacetate	3.0
Sodium cocoamphopropionate	2.5
Lauramidopropyl hydroxysultaine	2.5
Cocamidopropyl hydroxysultaine	1.5

A hydrotrope is a chemical that has the ability to increase the aqueous solubility of a slightly soluble organic compound. Amphoteric surfactants also act as hydrotropes. The hydrotroping performance of amphoteric surfactants was evaluated using the following formula.

Ingredient	% w/w
Deionized water	64.0
Sodium metasilicate pentahydrate	5.0
Tetrapotassium pyrophosphate	5.0
Potassium hydroxide 30%	24.0
Tritox X-100	2.0

Add all ingredients in the order listed with continuous agitation. This formula will be a white milky dispersion. The nonionic surfactant Triton X-100 would not solubilize because of the presence of electrolyte. Hydrotropes such as sodium xylene sulfonate and amphoteric surfactants were added to obtain a clear solution. The ability to hydrotrope was then rated on a scale of one through 10, with one being the best and 10 being the worst hydrotrope. The results are listed in the following table.

Surfactant used as hydrotrope	Hydrotrope Rating
Disodium cocoamphodipropionate	1
Sodium cocoamphopropionate	2
Disodium cocoamphodiacetate	2

Sodium capryloamphoacetate 3
Lauramidopropyl hydroxysultaine 2
Cocamidopropyl hydroxysultaine 2
Lauramidopropyl betaine 4
Cocamidopropyl betaine 4
Sodium xylene sulfonate 7

Thickened toilet bowl cleaners are formulated with amphoteric surfactants. Tallow dihydroxyethyl betaine is commonly used in this application. We used tallow dihydroxyethyl betaine to increase the viscosity of 10% hydrochloric acid solution. The results are as follows.

Tallow Dihydroxyethyl Betaine added Viscosity (Cps.)

1% 10
3% 650
5% 2000
7% 5000

In conclusion, amphoteric surfactants can be used effectively to formulate mild, biodegradable and high performing products for household, I&I and personal care markets.

Table 1: CMC and Surface Tension Data

Surfactant CMC mg/l

Lauramidopropyl betaine (LAPB) 49.5
Cocamidopropyl betaine (CAPB) 23.7
Cocamidopropyl hydroxysultaine (CAPHS) 21.8
Tallow dihydroxyethyl betaine (TDHEB) 8.7
Sodium lauroamphoacetate (SLAA) 235.2
Disodium lauroamphodiacetate (DSLADA) 119.5
Sodium cocoamphoacetate (SCAA) 17.8
Disodium cocoamphodiacetate (DSCADA) 36.5
C 8-10 amidopropyl betaine (C 8-10- APB) 343.0
Disodium capryloamphodiacetate (DSCpADA) 900.3
Sodium cocoamphopropionate (SCAP) 17.1
Disodium cocoamphodipropionate (DSCADP) 19.1
Table 2: Drave's Wetting Test Results

Surfactant Drave's Wetting Time (sec.)

Lauramidopropyl betaine (LAPB) 48.0
Cocamidopropyl betaine (CAPB) 91.0
Cocamidopropyl hydroxysultaine (CAPHS) 116.0
Tallow dihydroxyethyl betaine (TDHEB) 123.0
Sodium lauroamphoacetate (SLAA) 23.0
Disodium lauroamphodiacetate (DSLADA) 58.0
Sodium cocoamphoacetate (SCAA) 42.0
Disodium cocoamphodiacetate (DSCADA) 98.0
C 8-10 amidopropyl betaine (C 8-10- APB) 478.0
Sodium cocoamphopropionate (SCAP) 46.0
Disodium cocoamphodipropionate (DSCADP) 162.0
Table 3: Cylinder Shake Foam Height Test

Surfactant Foam Height (mm)

Lauramidopropyl betaine (LAPB) 56.0
Cocamidopropyl betaine (CAPB) 58.0
Cocamidopropyl hydroxysultaine (CAPHS) 37.0

Tallow dihydroxyethyl betaine (TDHEB) 52.0
Sodium lauroamphoacetate (SLAA) 53.0
Disodium lauroamphodiacetate (DSLADA) 59.0
Sodium cocoamphoacetate (SCAA) 61.0
Disodium cocoamphodiacetate (DSCADA) 58.0
C B-10 amidopropyl betaine (C 8-10- APB) 45.0
Sodium cocoamphopropionate (SCAP) 55.0
Disodium cocoamphodipropionate (DSCADP) 64.0
Table 4: Viscosity Measurements

Surfactant Cps.

Cocamide DEA 860
Lauramidopropyl betaine (LAPB) 4100
Cocamidopropyl betaine (CAPB) 400
Cocamidopropyl hydroxysultaine (CAPHS) 120
Tallow dihydroxyethyl betaine (TDHEB) 5200
Sodium lauroamphoacetate (SLAA) 1300
Disodium lauroamphodiacetate (DSLADA) 720
Sodium cocoamphoacetate (SCAA) 830
Disodium cocoamphodiacetate (DSCADA) 390
C 8-10 amidopropyl betaine (C 8-10- APB) 50
Sodium cocoamphopropionate (SCAP) 470
Disodium cocoamphodipropionate (DSCADP) 25

For more information regarding amphoterics and their uses in household and industrial and institutional cleaning formulas, please call Shoaib Arif at 614-764-6684 or E-mail at shoaib.arif@us.goldschmidt.com.