# The Use of Fatty Acid Derivatives in Cosmetics and Toiletries[1]

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## ABSTRACT

A large variety of fatty acid derivatives are utilized by the cosmetics and toiletries industry to fulfill many functions in their products. These ingredients, based on renewable resources are reviewed with respect to source and method of manufacture, physical and functional properties, and the place they find in all types of cosmetic products.

## INTRODUCTION

The cosmetics and toiletries industry has long depended on a large and varied supply of fatty acid derivatives for use in virtually all types of their products. Although there are varying definitions and distinctions drawn between the terms cosmetics and toiletries, it is generally accepted that cosmetics fulfill a more decorative function, while toiletries are more utilitarian. For example, makeup, nail polish, and eye products are cosmetics, while shampoos, deodorants, and antiperspirants are classified as toiletries. In this paper, the more general term cosmetics will often be used to encompass the toiletries segment.

This is not a marketing presentation as such, but a few sales volume figures are necessary to illustrate the relative importance and impact of various fatty acid derivatives in the marketplace. These figures are only to be considered very general approximations and estimates due to the difficulty in obtaining exact information. The total market for cosmetics and toiletries in 1976 has been variously estimated as $7.6 billion (1) to $9.8 billion (2).

The field of fatty acid derivatives as applied to the cosmetic industry is readily divided into three categories. First are those products containing only carbon, hydrogen, and oxygen, primarily the fatty acids themselves, and their esters. The nonionic surfactants derived by ethoxylation and esterification of fatty acids are also included in this category. The second category is the fatty nitrogen-containing derivatives. All four charge types of surfactants can be found in this category and will be discussed in the following order: anionic, nonionic, cationic, and amphoteric. The final category is "other than the above" which encompasses mainly sulfur-containing derivatives.

The principal sources of fatty acids applicable to the cosmetic and toiletries industry are tallow, soybean oil, coconut oil, tall oil, and wool wax or lanolin. Lanolin and its derivatives are omitted from this paper.

One of the major advantages of the extensive use of fatty acid derivatives is the renewable nature of this resource. This is important in view of the increasing scarcity of the petrochemical feedstocks as well as their skyrocketing prices.

The cosmetic industry has historically been very secretive about the ingredients used and process methods employed in producing their finished products. Recent implementation of the Cosmetic Ingredient Labelling Regulations by the Food and Drug Administration is beginning to change this. However, since ingredient declarations that are already appearing on a significant portion of products now on store shelves are written in "CTFA-ese," the general public, as well as a large fraction of organic chemists, will need help in decoding the labels. The FDA has designated the "Dictionary of Cosmetic Ingredients" compiled by the CTFA (Cosmetic, Toiletry and Fragrance Assoc.) as the primary source of names for label identification. Thus, names such as cocotrimonium chloride are found on hair conditioner products indicating that the alkyltrimethyl ammonium chloride where the alkyl group is derived from coconut fatty acid is an ingredient. The naming of more complicated quaternaries, such as the dialkyldimethyl ammonium chlorides are given an arbitrary Quaternium number designation. These along with a couple of other extreme examples are indicated in Table I.

## CLASS I: DERIVATIVES CONTAINING ONLY C, H, O

### Fatty Acids

Over 31 million lb of fatty acids were used by the cosmetic and toiletries industry in 1971. This volume will be in the range of 40 million lb in 1977. The fatty acids are used alone for emollient and superfatting effects such as stearic and oleic, and are most often converted to soaps by reactions with base such as sodium or potassium hydroxide, amines, and alkanolamines. They are incorporated into numerous products including toilet soaps, shaving creams, hand and body lotions and creams, and hair colorants. The large preponderance of fatty acids used are tallow fatty acids, usually sold as so-called triple-pressed stearic acid which contains 45% stearic and 55% palmitric acids.

In toilet soaps, stearic acid acts as a superfatting agent which reduces alkalinity and defatting of the outer lipid layers of the skin. Aerosol and nonaerosol shave creams generally consist of heavy soap gels formed by the saponification of stearic acid with an alkali such as potassium hydroxide. The aerosol formulation uses triethanolamine (TEA) or related amines to neutralize the fatty acid.

Face creams are often based on the TEA salt of stearic acid which, when properly formulated, leaves a dry and nongreasy film on the skin which is transparent enough to give the illusion of vanishing – thus vanishing creams. Hand lotions and creams are often composed of emulsions of mineral oil and fatty acid esters with sodium stearates as the emulsifier.

Oleic acid, produced by distillation or fractional crystallization of hydrolyzed animal fats, is utilized in shampoo-in hair dyes and tints, generally saponified by ammonium hydroxide or triethanolamine.

Coconut fatty acids, or their fractionated components, lauric and myristic acids, are utilized in hand and shaving soaps, and face and body lotions and creams. However, the largest use of fatty acids is in the production of the derivatives to which the balance of the paper is devoted.

Metallic stearates are insoluble metal soaps manufactured by reacting a metal salt in solution with sodium stearate. The zinc, magnesium, sodium, and aluminum salts are the major products in this classification. The properties these materials bring to cosmetic products include lubricity, water repellency, adhesion, gelation, and anti-caking. They are incorporated into face powders, cleansing lotions, dusting powders, deodorant and cologne sticks. About 1.2 million lb of metallic stearates were sold in 1972, with an estimated growth to just under 1.5 million in 1977. The major use is for zinc and magnesium stearates in face and dusting powders, while sodium stearate is principally used for gelling ethanol for stick deodorants and colognes. Aluminum stearate acts as a viscosity modifier in cleansing lotions and shampoos, and calcium stearate can be an emulsifier in hair grooming preparations.

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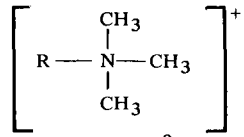
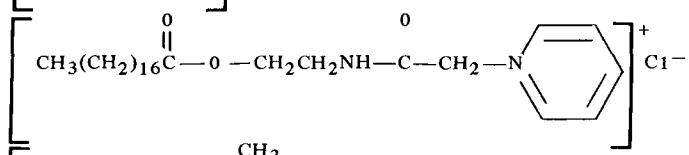
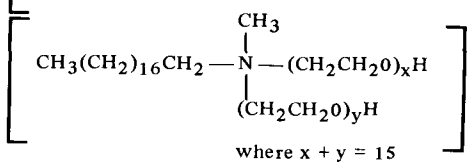
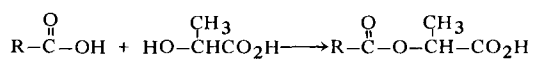
TABLE I

CTFA Nomenclature

| CTFA name | Chemical structure |
|---|---|
| Cocotrimonium Chloride |  |
| Quaternium-7 |  |
| PEG-15 Stearyl Quaternium-4 |  |

### Esters

The acyl lactylates are anionic esters formed between fatty acids and lactic acid or its polymers. These emulsifiers, used in the food industry for 20 years are now being used by the cosmetic industry. The benefits include safety, availability, acidic pH, and a favorable cost/performance analysis (3). The range of surfactant properties available is illustrated by the span of hydrophilic-lipophilic balance (HLB) from 5 to 15.



These surfactants are claimed to require less oil phase for the same cosmetic effect in emulsions as conventional emulsifiers. Their compatibility with the increasingly more popular slightly acidic formulations has also been pointed out. Thus an anionic emulsifier can be used at less than a pH of 7 in emulsion creams and lotions.

With the current trend and emphasis on "natural" or "organic" products, these lactate derivatives can rightly claim to be composed of "all natural ingredients."

### Esters of Monohydric Alcohols

Isopropyl, isobutyl, and normal butyl esters of fatty acids form an important area of cosmetic ingredients. In 1972 about 15.2 million lb were produced. This market was hit hard by the decline in aerosol sales due to the ozone controversy. Since one of their principal uses was in aerosol antiperspirants, the sales of isopropyl myristate (IPM) and palmitate (IPP) were reduced significantly. In antiperspirants the ester (IPM or IPP) was used to suspend the finely divided aluminum chlorhydroxide powder to provide greater substantivity to the skin, increase skin lubrication, provide longer time of action, reduce skin irritation, and minimize can corrosion.

These esters function principally as emollients which restore and maintain the natural softness of the skin. They are thought to function by lubricating the upper levels of the skin known as the stratum corneum, and by retarding the transpiration of water through the skin, a major cause of dry, flaky, itchy skin.

The other major use of these esters is in floating and dispersible bath oils. Less important uses include pre-shave lotions, creams and lotions, lipsticks, and any other application when a non-oily, low viscosity oil is needed.

### Alkylene Glycol Esters

The products of esterification of propylene, ethylene, or diethylene glycols with a fatty acid form an important group of cosmetic raw materials. The monostearate esters are most important and accounted for over 1 million lb of business in 1971, and it has probably grown to almost 2 million lb in 1977. These esters function as emulsifiers, opacifying agents, body or thickening agents, stabilizers in skin creams and lotions, cream rinses, shampoos, and conditioners. Ethylene glycol monostearate is used as an opacifier/pearlescent agent in cream and lotion shampoos.

### Glycerol Esters

The largest selling fatty acid ester is glycerol monstearate (GMS). In 1971 about 3.5 million lb were sold, and it is estimated that the 1977 total will be close to 5 million. GMS functions as an emulsifier, stabilizer, thickener, opacifier, or emollient in products such as skin creams and lotions, antiperspirant creams and roll-ons, shampoos, cream hair rainses and conditioners, as well as suntan creams and lotions.

### Sorbitan Esters and Ethoxylated Sorbitan Esters

The esterification of 1,4-sorbitan by fatty acids can form sorbitan esters with 1 to 4 fatty acid radicals attached. These products, along with their ethoxylated derivatives were first developed in the 1930s (4) and have since found widespread use (5). The esters are generally lipophilic with low HLBs, while the ethoxylated derivatives containing generally 4-20 moles of EO have correspondingly more hydrophilic character.

The low irritancy potential and the wide range of surfactant character available with these materials has led to their widespread inclusion in a variety of products, including baby shampoos, shave creams, antiperspirants, suntan lotions, as well as the whole variety of creams, lotions, and other emulsion products manufactured. Polysorbate 20, the 20 mole ethoxylate of sorbitan monolaurate is used in the leading No-Tears baby shampoo to increase viscosity and foam without adding eye irritancy.

The 1971 utilization of the sorbitan esters was about 1 million lb with a 1977 figure close to 1.5 million. The ethoxylates amounted to 5 million in 1971 (3.5 to 4 in baby shampoos), and this figure has been estimated to be in the range of 8 million in 1977. The astounding success of the J&J product accounts for much of this rise.

### Sucrose Esters

Sucrose esters have been around for a long time, but the use of dimethylformamide (DMF) in their production has led to fears of residual DMF amounts in the final product.

TABLE II

Fatty Esters

| | |
|---|---|
| Monohydric alcohols | Isopropyl myristate |
| | Isopropyl palmitate |
| | Butyl stearate |
| Glycols | Propylene glycol monostearate |
| | Ethylene glycol monostearate |
| | Diethylene glycol monostearate |
| Glycerine | Glyceryl monostearate |
| | Glyceryl monopalmitate |
| | Glyceryl monolaurate |
| Sorbital | Sorbitan monooleate |
| | Sorbitan monopalmitate |
| | Sorbitan sesquioleate |
| | POE (20) sorbitan monolaurate |
| Lactic acid | Sodium stearoyl-2-lactylate |
| | Sodium lauroyl lactylate |

Thus use in cosmetics, pharmaceuticals, and foods was quite small. Croda now produces sucrose esters by a patented process (USP 3,480,616) using no toxic solvent and markets them under the CRODESTA trademark.

Sucrose has three methylhydroxyl groups available for esterification. Thus, by selectively esterifying 1, 2, or 3, a wide range of lipophilic or hydrophilic surfactants are formed. The HLB range is from 3-15, which is remarkable for a product containing no ethylene oxide. In fact, it is the absence of ethylene oxide and its inverse solubility characteristics and potential irritation properties that are cited (6) as beneficial and unique characteristics of these sucrose esters. Currently, esters of tallow fatty acids, stearic, lauric, and an acetulated stearic are available. Low irritation potential to skin and eyes as well as compatibility with germicidal preservatives and antioxidants are all attributed to the absence of EO. Currently the laurate mono-ester is used in a washing product designed for the nursery for use in washing baby bottles and dishes as well as vegetables. A recent article in *Cosmetics and Toiletries* (7) claimed bacteriostatic action toward both gram positive and, to a lesser extent, gram negative organisms at low concentration. The activity is claimed over a wide pH range, but best at less than pH 6.0.

## CLASS II: DERIVATIVES CONTAINING NITROGEN

### Acylsarcosinates

The only anionic members of this category with significant sales are the acylsarcosinates. The reaction of a fatty acid chloride, cocoyl, or lauroyl generally, with sodium sarcosinate yields the acylsarcosinate.

$$R-\overset{O}{\overset{\|}{C}}-Cl + CH_3NHCH_2\overset{O}{\overset{\|}{C}}-O^-Na^+ \xrightarrow{NaOH} R-\overset{O}{\overset{\|}{C}}-\overset{CH_3}{\overset{|}{N}}-CH_2\overset{O}{\overset{\|}{C}}-O^- Na^+$$

The principal uses of sarcosinates are in shampoos and dentrifices where they act as very mild foaming agents. In shampoos, sodium lauroyl sarcosinate is utilized for cleansing, conditioning, antistatic, and for a unique "feel" when shampooing.

### Alkanolamides

This group of nonionic nitrogen derivatives include the simple amides, fatty alkanolamides, and their higher ethoxylates. Simple amides are formed by reaction of ammonia with the fatty acid and dehydration of one mole of water. Such products are used in shampoos as thickeners and foam boosters, as well as in emulsion creams for high temperature stability and viscosity control. The alkanolamides, however, have a much larger usage. In 1972 about 11.6 million lb were sold with an estimated market of 15.5 million this year. Alkanolamides can be formed in two ways. Condensation of the alkanolamine with the desired

$$R-\overset{O}{\overset{\|}{C}}-OH + (HOCH_2CH_2)_2NH \longrightarrow R-\overset{O}{\overset{\|}{C}}-N(CH_2CH_2OH)_2 + H_2O$$

fatty acid yields a product of 40-60% activity. These are the so-called regular amides. Superamides of 92-95% activity are formed by reacting equimolar quantities of the methyl ester of the fatty acid with the alkanolamine. The methanol is stripped off, and the resulting high activity product is ready to go. The super-amides represent over 90% of the amide market.

$$R\overset{O}{\overset{\|}{C}}-OCH_3 + (HOCH_2CH_2)_2NH \longrightarrow$$

$$R-\overset{O}{\overset{\|}{C}}-N(CH_2CH_2OH)_2 + CH_3OH$$

The fatty acids used are either the whole coco or coco fractions, particularly the lauric. The alkanolamides, over 80% of which end up in shampoos, are utilized as thickeners, hair conditioners, and foam stabilizers. Their use in bath and shaving products is generally as foam boosters and stabilizers as well as for their emollient properties.

Addition of more then 2 moles of ethylene oxide to a simple amide results in ethoxylated amides which are used as emulsifiers, thickeners, and emulsion stabilizers.

### Cationic Fatty Nitrogen Derivatives

Under the category of cationic nitrogen-containing derivatives comes a wide variety of chemical types including alkyl quaternaries, pyridinium halides, amine oxides, ethyoxylated quaternaries, ethoxylated amines, amidoamines, and amidoamine quaternaries. The total usage of cationic nitrogen derivatives was 4.1 million lb in 1971 with an estimated 1977 consumption of 7.0 million lb. Quaternary ammonium salts account for about 75% of the total.

The higher molecular weight alkyl and dialkyl quaternaries derived from tallow are widely used as hair conditioning and anti-static agencts to impart softness and combability to hair. They also promote the formation of oil-in-water emulsions in other cosmetic products. Their antibacterial activity often reduces if not eliminates the need for additional preservatives to be added to the formulation.

These products are produced from the fatty primary, secondary, or tertiary amines by alkylation with methyl halide or dimethylsulfate. They are available usually dissolved in aqueous isopropanol or in the case of the monoalkyl derivatives, at lower concentrations in water alone.

$$R_1R_2NCH_3 + CH_3Cl \longrightarrow R_1R_2\overset{+}{N}(CH_3)_2\ Cl^-$$

The product when $R_1$ is stearyl and $R_2$ is benzyl is widely used in hair cream rinses and conditioners. Just a few years ago, almost all of the pearly type cream rinses on the market consisted of a few percent of stearyldimethylbenzylammonium chloride along with cetyl or stearyl alcohol, possibly some mineral oil in an aqueous system.

The use of distearyl or dihydrogenated tallow quaternary ammonium salts in creme rinse/conditioner products has increased in recent years. Superior performance as an antistat and hair conditioner with reduced eye irritation are cited as principal reasons for the change. Also the use of the lower alkyl quaternaries, both mono- and dialkyl has seen a recent sudden upsurge with the appearance of clear cream rinse products. These formulations often utilize a cationic polymer in combination with one or more of the water soluble quaternaries to achieve a so-called "oil-free," clear and effective product (8).

Quaternaries are utilized to some extent in emulsion systems as primary or supplementary emulsifiers with desirable skin feel properties as well as preservation against microbiological degradation of the product.

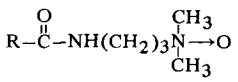
Ethoxylated quaternaries are used to a limited extent currently, but their flexibility in solubility and degree of

cationic character as a function of degree of ethoxylation make them potentially attractive ingredients in hair and skin care products.

### Amine Oxides

Fatty amine oxides can be classified as either cationic or nonionic surfactants depending on the pH of the system in which they are incorporated. The three general types of amine oxides of interest to the cosmetic chemist are shown below. They are formed from the corresponding tertiary amine by oxidation with concentrated hydrogen peroxide and are generally supplied as 30-50% active materials in aqueous isopropanol or in water alone.

Dimethylamine Oxide Bis(2-hydroxyethyl)Amine Oxide



Dimethylamidoamine Oxide

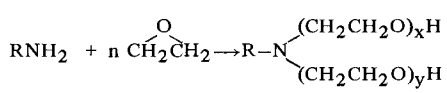
The amine oxides function as foam boosters and stabilizers in shampoos, shaving creams, and bubble bath products. They have found utilization in the so-called acid-balance or natural pH shampoos enabling a formulation based on an anionic surfactant such as sodium lauryl ether sulfate to remain clear and homogenous at pH's in the 4-5 range. The volume of amine oxide currently sold is relatively small with 430 thousand lb sold in 1972 and probably somewhat less than a million lb in 1977.

The use of amine oxides, particularly stearyldimethylamine oxide, as the primary emulsifier in cosmetic products has been reported (9). Compatibility of quaternary preservatives with the amine oxide can eliminate many of the preservation problems caused by inactivation of standard preservatives by anionic and nonionic emulsifiers. At least one product now on the market uses an amine oxide as the primary emulsifer.

In shampoo and bath products, amine oxides are mild to skin, impart lubricity and emolliency, have antistatic and conditioning effects on the hair, are resistant to hard water precipitation, and have good lime soap dispersing properties (10).

### Ethoxylated Amines

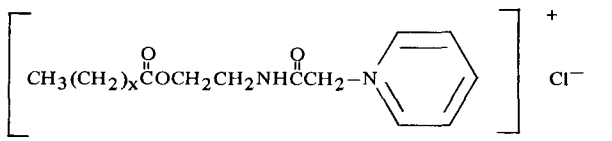
Ethoxylated fatty amines formed by ethoxylating primary amines are used to a limited extent in cosmetic products. They are excellent wetting agents and emulsifiers which are exceptionally stable to hydrolysis over a wide pH range. They find use as a wetting agent in hair dyes and as neutralizing agents for Carbopol resin. BF Goodrich produces Carbopol 914 for use as a thickener and gelling agent, and it contains acidic groups that are usually neutralized with sodium hydroxide, ammonia, or alkanolamines for maximum thickening effect. It has been found that the 15 mole ethoxylate of cocoamine yields desirable flow and feel properties to lotions when used to neutralize Carbopol.



$x + y = n = 2$ to 50

### Pyridinium Halides

Another class of cationic nitrogen derivatives are the alkylpyridinium halides. Two products in this class, the lauroyl and stearoyl derivatives, are gaining wide acceptance in the cosmetic industry. These products have been available for over 25 years, but recently the trend toward natural pH products has stimulated their use in the formulation of stable, acid-pH creams, and lotions. The manufacturer emphasizes the so-called "cationic" feel which these emulsions impart to the skin (11). Similar claims have been made for the other cationic emulsifiers for use in cosmetic and toiletry products.



These products are now appearing widely in cosmetic products such as cream rinses and conditioners, skin and body creams and lotions, and shampoo products, among others. Their low toxicity and irritation potential compared to other quaternaries is claimed as a plus by the manufacturer (12).

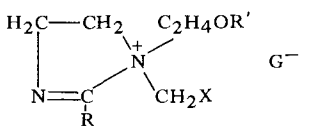
### Amphoteric Compounds

Amphoteric surfactants exhibit either anionic or cationic behavior depending on the pH of the system. Often amphoterics combine good foaming and cleaning properties with very low eye and skin irritation.

There are two main types – the cyclic imidazolines with about 90% of the market (which was 8.5 million lb in 1972) and the substituted betaines. The 1976 market was 25 million lb on an as-sold basis.

The major use for amphoterics is in nonirritating shampoos, most specifically baby shampoos with the no-sting claim. The imidazolines used to have this market almost exclusively, but this is changing, and the substituted betaines are making greater inroads the past couple of years.

The imidazolines were originally manufactured under protection of a comprehensive patent (13) which has now expired, and several firms offer similar products. The general structure of the imidazoline is shown below:



R = Fatty Acid Radical
R′ = H, Na, $-CH_2CO_2M$
X = $-CO_2M$, $-CH_2CO_2M$, $-CH(OH)-CH_2SO_3M$
M = Na, H, Organic Base
G = OH, Acid Salt, Salt of Alkyl Sulfate or Sulfonate

Among the features claimed for this class of compounds is very low toxicity, complete biodegradability, no skin or eye irritation, with one version (2MCA Modified) with no eye sting, excellent foaming, compatibility with soap, excellent wetting properties, pH stability over a wide range, hard water stability, lime soap dissolving properties, compatibility with quaternary germicides as well as with cationic, anionic, and nonionic agents (14).

There is a good body of experimental evidence that some imidazoline derivatives can actually reduce the skin and eye irritation caused by other components of a formulation. When G is lauryl sulfate and R is lauryl, Miranol 2MCA is formed which has the no-sting and anti-irritation characteristics necessary for the No-Tears baby shampoo.

Other imidazoline amphoterics are recommended for creme hair rinses and in combination with cationic resins in

combined shampoo/creme rinse formulations. The imidazoline can act to stabilize a mixture of cationic and anionic agents that would react to form an insoluble precipitate by themselves.

### Betaines

Two general types of substituted betaines – the amino– and amidobetaines– are usually derived from tallow or coconut fatty acids. They are manufactured by a patented process (15) by which first an amidoamine is formed by reacting a low molecular weight diamine (usually dimethylaminopropyl amine) with a triglyceride or fatty acid.

$$RCO_2H + H_2NCH_2CH_2CH_2N(CH_3)_2 \longrightarrow R{-}\overset{O}{\overset{\|}{C}}{-}NHCH_2CH_2CH_2N(CH_3)_2 + H_2O$$

The amidoamine is reacted with sodium chloroacetate to form the amidobetaine.

$$R\overset{O}{\overset{\|}{C}}NHCH_2CH_2CH_2N(CH_3)_2 + ClCH_2CO_2Na \longrightarrow R\overset{O}{\overset{\|}{C}}NHCH_2CH_2CH_2\overset{CH_3}{\overset{|}{\overset{+}{N}}}{-}CH_2CO_2^- + NaCl$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad CH_3$$

The market for betaines was about 300,000 lb in 1972 and grew to over 2.5 million lb in 1976.

The appearance of a patent in 1976 (16) on nonirritating detergent compositions which are combinations of a betaine, an anionic surfactant, and a polyoxyethylene nonionic surfactant has led to general speculation that imidazolines may be on the way out in the product which made No-Tears a household word. The betaines in the favored formulations are cocoamidobetaines, while an ethoxylated tridecylalcohol sulfate (3-5 moles EO) and a PEG 44 sorbitan monolaurate are the two other major constituents.

General Mills manufactures a line of amphoteric surfactants under the trade name of Deriphat. These products are condensation products of a fatty amine with acrylic acid. They are mild but effective detergents for use in shampoos, hair color shampoos, as well as germicidal systems. They are also claimed (17) to function as other amphoterics in making mixed ionic systems compatible such as with anionic surfactants and cationic polymers. The low skin and eye irritation potential associated with other amphoterics is said to hold true for these products also. Current sales volume is estimated to be in the range of a few hundred thousand pounds.

$$RNH_2 + CH_2{=}CHCO_2H \rightarrow RNHCH_2CH_2CO_2H$$

### Ammonio-amidates

A unique group of amphoterics more commonly known as aminimides have recently been introduced as commercial products, though only in limited quantities (18). Aminimides carry both positive and negative charges on nitrogen atoms. They exhibit nonionic-like behavior, and are compatible with anionic, cationic, and nonionic surfactants (19-21). They have a high degree of surface activity in water, a low order of toxicity and irritation, substantivity to hair and skin, antimicrobial (22) and antistatic properties, as well as claimed good emulsification and foaming properties. One of the key ingredients, unsymmetrical dimethylhydrazine is currently available only at an extremely high price which makes the aminamides uneconomical for all but the most specialized uses.

$$R{-}\overset{O}{\overset{\|}{C}}{-}\overset{-}{N}{-}\overset{+}{N}\begin{matrix}\diagup CH_3 \\ \diagdown CH_3\end{matrix}{-}CH_2\overset{OH}{\overset{|}{C}}HCH_3$$

$R = C_{12}–C_{18}$

## CLASS III: MISCELLANEOUS DERIVATIVES

This class of fatty acid derivatives consists of those containing elements in addition to C, H, O, and N. Two anionic and one nonionic/amphoteric hybrid will be covered. These materials, manufactured by the GAF Corp., represent some of the largest selling members of this class.

### Acyl Isethionates

These materials are formed by reaction of a fatty acyl chloride with sodium isethionate.

$$HOCH_2CH_2SO_3Na + R\overset{O}{\overset{\|}{C}}Cl \longrightarrow R\overset{O}{\overset{\|}{C}}OCH_2CH_2SO_3Na + HCl$$

The surfactants formed when the fatty acid is coco or myristal are recommended for synthetic detergent/soap bars, sudsing lotions and cleansers, bubble baths, and cosmetic cleaning bars (23). Being anionic, they are compatible with fatty acid soaps, and their unusually good hard water compatibility and lime soap dispersing properties alleviate many of the drawbacks of soap bars. The market in 1972 was about 16.4 million lb and the 1977 volume should be slightly under 20 million lb, 90% of it being in toilet soaps.

### Acyl Taurates

This group of anionic surfactants is manufactured by first reacting methyl amine with sodium isethionate to form methyl taurine.

$$HOCH_2CH_2SO_3Na + CH_3NH_2 \longrightarrow CH_3NHCH_2CH_2SO_3Na$$

The methyl taurine is subsequently reacted with a fatty acyl chloride to form the N-acyl-N-alkyltaurate.

$$CH_3NHCH_2CH_2SO_3Na + R\overset{O}{\overset{\|}{C}}Cl \longrightarrow R\overset{O}{\overset{\|}{C}}{-}\overset{CH_3}{\overset{|}{N}}{-}CH_2CH_2SO_3Na$$

These compounds exhibit good stability over a wide pH range, good foaming, detergency, and excellent hard water performance. Their chief uses are as foaming agents in shampoos and bubble baths where they provide conditioning as well as a cleansing effect (23). The current volume is in the 1 million lb range.

### Nonionic/Amphoteric Hybrid

The only amphoteric product in this class to be covered is manufactured by GAF Corp. under the trade name Antaron PC-37. Although only identified as a sulfated fatty polyoxyethylene quaternary nitrogen compound by the manufacturer, the structure below is believed to be close to the actual one.

$$R{-}\overset{+}{N}\begin{matrix}\diagup (CH_2CH_2O)_xH \\ \diagdown CH_2CH_3\end{matrix}{-}(CH_2CH_2O)_yCH_2CH_2OSO_3^-$$

R = coco $\qquad$ x + y = 14

Although it is a true amphoteric, the manufacturer prefers to call it a nonionic/amphoteric hybrid. Several unique properties are claimed for this product, including outstanding mildness, excellent water solubility even at the isoelectric point, and outstanding compatibilizing power for heretofore antagonistic surfactants and/or polymers (24).

Antaron PC-37 has been formulated into both a nonirritating baby shampoo and a no-tears shampoo/creme rinse combination. Eye irritation data (24) indicate that at full strength (75%) Antaron PC-37 is a nonirritant, while the leading imidazoline surfactant at its 38% full strength level is a severe eye irritant.

Thus, we have seen that a large number of fatty acid derivatives are used for a wide variety of functions in cosmetics and toiletries. These materials derived from renewable resources should become even more important as petrochemically derived feedstocks become less available.

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