

# A NEW FAMILY OF AMPHOTERIC SURFACTANTS: FATTY AMINO ACID DERIVATIVES\*

By D. L. ANDERSEN and A. J. FREEMAN

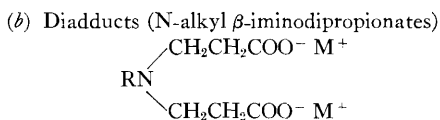
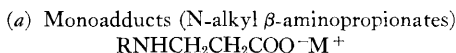
*General Mills, Inc., Minneapolis 13, Minn.*

THE FORMULARY of the modern cosmetic chemist has become exceedingly complex. The multicomponent systems comprising today's cosmetic products are a far cry from the "tincture of green soap" of yesterday. The trend in cosmetic formulations is to specificity of functionality—each component performing a particular task: foam stabilization, emulsification, solubilization, softening. The fundamental precepts remain. A shampoo is compounded to clean the hair and scalp; a hand lotion to soften the skin of the hands. However, the shampoo must do more than cleanse the hair and scalp; the hand lotion must do more than soften the hands. Competitive emphasis is on the "plus" features—shampoos that kill dandruff or that leave the hair more manageable; medicated hand lotions.

To meet this tremendous increase in emphasis on specific functionality, the synthetic detergent manufacturers have kept pace with an ever increasing number of products—each chemically conceived to perform a specific task or combination of tasks. The list of commercially available surface active agents has grown from a handful to hundreds.

## PRODUCTS

A new family of surface active agents, the fatty amino acid derivatives, has been developed to meet the growing need of the cosmetic industry. These products are known under the trade name Deriphats.† Chemically these products divide into two major classes:



\* Presented at the May 10, 1957, Meeting, New York City.

† Available commercially from General Mills, Inc., Chemical Division, Kankakee, Ill.

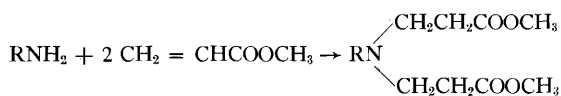
The "R" group represents any fatty-based alkyl chain, more commonly lauric, coco and tallow. The "M" group represents any neutralizing base, commonly sodium or triethanolamine. In Table I are listed the commercially available products and their structures.

TABLE I—FATTY AMINO ACID DERIVATIVES

Product	Physical Form	Mono- or Diadduct	Fatty Chain	Neutralizing Base
Type 170	98% active flake	Mono-	Lauryl	Sodium
Type 170B	50% (aq.) solution	Mono-	Lauryl	Triethanolamine
Type 180	98% active flake	Di-	Lauryl	Sodium
Type 151	98% active flake	Mono-	Coco	Sodium
Type 157	98% active flake	Mono-	Tallow	Sodium
Type 154	98% active flake	Di-	Tallow	Sodium
Type 152	98% active flake	Mono-	Stearyl	Sodium

### SYNTHESIS

The fatty amino acid derivatives are manufactured via the condensation of a fatty primary amine and methyl acrylate. The aminopropionic ester obtained thereby is then hydrolyzed to the appropriate water soluble carboxylic salt.



Primary amines are capable of adding one or two moles of methylacrylate. Hence, the terminology, monoadducts and diadducts.

### ELECTROCHEMICAL PROPERTIES

Surface active agents derive their chemical, physical and performance characteristics from their electrochemical nature. Generally, synthetic detergents are described as monofunctional and are characterized as anionic, nonionic or cationic based on their electrochemical structure in solution. It has only been in the past few years that the terms ampholytic or amphoteric have been used to describe a new class of surface active materials. Amphoteric surfactants are polyfunctional and can exhibit anionic, cationic or nonionic characteristics depending on whether the system is alkaline, acidic or neutral.

The fatty amino acid derivatives are almost classically simple examples of amphoteric surfactants. They contain the fatty amine functionality and the carboxylic acid functionality and as such are capable of fatty amine salt characteristics in acid systems, carboxylic acid salt characteristics in alkaline systems, and inner salt (zwitterion) or nonionic characteristics in neutral systems.

As is the case with all surface active agents, hydrophilic-hydrophobic balance is an important factor in the electrochemical and performance characteristics of the fatty amino acids. The availability of a wide variety of fatty chains (obtained readily through fractionation of natural products) and of monoadduct and diadduct forms makes possible a very wide range of hydrophilic-hydrophobic balance. A given fatty chain can be balanced with an amine and one or two carboxylic groups. Also, blends are possible.

### PERFORMANCE CHARACTERISTICS

Basically, surface active properties are derived more or less directly from the electrochemical nature of the surfactant. In the case of the fatty amino acid derivatives, this dependence is especially pronounced. Properties based on fatty chain length and chemical structure (monoadduct or diadduct, type of salt) can be modified or even altered drastically with changes in pH. High-foaming products can be changed to low-foaming, good wetting to poor wetting, nonsubstantive to substantive, etc.

*A. Solubility.* Commercially, these materials are available as sodium

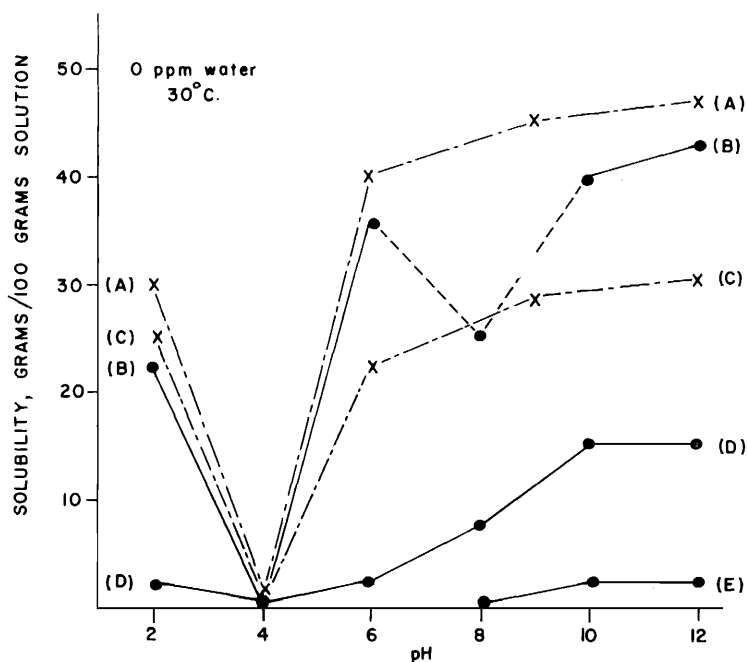


Figure 1.—Solubility vs. pH of typical fatty amino acid derivatives. (A) Disodium N-lauryl  $\beta$ -iminodipropionate. (B) Sodium N-lauryl  $\beta$ -aminopropionate. (C) Disodium N-tallow  $\beta$ -iminodipropionate. (D) Sodium N-tallow  $\beta$ -aminopropionate. (E) Sodium N-hydrogenated tallow  $\beta$ -aminopropionate.

salts (flaked solids) or triethanolamine salts (aqueous solutions). The sodium salts are quite alkaline in reaction, much as are the fatty acid sodium soaps. The triethanolamine salt solutions are highly self-buffered at a pH of about 8. The fatty amino acids, as the sodium salts, are generally quite water soluble, with the diadducts exhibiting significantly greater solubility than the monoadducts. In addition to the influence of the fatty chain and that of the monoadduct or diadduct, pH is a very important factor in determining solubility. Typical solubility characteristics are outlined in Fig. 1.

*B. Compatibility.* By nature of their amphoterism, the fatty amino acid salts exhibit compatibility over wide ranges with most other surfactants. This compatibility is of special importance in the formulation of cosmetic products. The alkyl aminopropionates are compatible completely with nonionic surfactants. They are compatible with soluble fatty acid soaps in all but the higher soap-to-amino-acid ratios. They are compatible with most anionic surfactants except in relatively narrow ranges at or near equal ratios of amino acid and anionic product. One of the outstanding compatibility characteristics of the amphoteric products described here is their compatibility with cationic surface active agents. The alkyl aminopropionates do not complex or precipitate cationics as do the anionic surfactants. This compatibility is not limited to physical form, but is shown in the fact that the substantive nature or germicidal effectiveness of the cationic is not interfered with even in formulations containing as much as a 15 to 1 ratio of fatty amino acid salt to cationic. Hence, it is possible to formulate products exhibiting specific cationic properties containing quite low concentrations of cationic surfactant.

*C. Foam.* Sodium lauryl  $\beta$ -aminopropionate represents a very high foaming synthetic detergent ideally suited to the formulation of all types of shampoos. This product, either as its sodium or triethanolamine salt, exhibits a high degree of hard water stability (clear solutions and unimpaired foaming in 300 ppm. water). Foam volume is maintained over a wide range of concentration and pH. The corresponding diadduct, disodium lauryl  $\beta$ -iminodipropionate, is an excellent foaming agent, although exhibiting a somewhat lower overall foaming power than the monoadduct. The coco and tallow derivatives evidence proportionately less foaming power as might be expected from their longer fatty chains.

*D. Substantivity.* Of very great interest in the realm of cosmetic chemistry is the affinity of the fatty amino acid molecule for the skin or hair. This affinity is most likely attributable to the similarity in amphoterism of the epidermis and the fatty amino acid. This affinity is manifested in a series of interesting and useful properties. These products exhibit substantivity to the hair, thereby imparting manageability or softness. By virtue of being substantive and because of their ability to exhibit cationic

properties, these amphoteric exhibit some degree of bacteriostatic action. Although exhibiting a relatively high degree of substantivity to the skin, the fatty amino acid derivatives are essentially innocuous to the skin. This mildness probably is a result of their general chemical relationship to the amphotericism of the skin.

*E. Hydrotropic Properties.* The alkyl  $\beta$ -iminodipropionates (diadducts) exhibit definite solubilizing action on certain organic and inorganic materials. The chlorinated germicides, for example, can be solubilized at neutral pH's with the iminodipropionates. This suggests the solubilization of other poorly soluble organic materials as additives to specialized cosmetic products. In the field of inorganic materials, considerable success has been had in formulating liquid heavy duty detergent formulations containing concentrations of polyphosphates well in excess of the normal solubility and compatibility of polyphosphates and syndets.

*F. Emulsification.* In general, single component surfactant systems are not considered optimum for emulsification. Hence the fatty amino acid derivatives are of interest in emulsification in two ways. They, being amphoteric in nature, offer promise because of their inherent polyfunctionality. In addition, their compatibility with a wide range of other products offers multicomponent systems heretofore impossible. The coco and tallow-based amino acids are particularly interesting in emulsification problems.

*G. General Properties.* Aside from the specific properties discussed so far, the versatility of these amphoteric extends to the surface active properties of detergency, wetting, surface and interfacial tension lowering, etc. Combinations and judicious use of monoadducts, diadducts and various fatty chains, coupled with pH control, allow selection of virtually any degree of effectiveness desired. Controlled cleaning and controlled wetting are possible. Surface or interfacial tensions can be adjusted.

Another somewhat unusual property of interest to cosmetic chemists is corrosion inhibition. These amphoteric have demonstrated their applicability as corrosion inhibitors in aqueous oil systems at concentrations as low as 5 ppm. Even at relatively high aqueous concentrations (such as encountered in a typical cosmetic formulation), these products are virtually noncorrosive, attacking iron only very, very slowly. Hence, the fatty amino acid derivatives are suggested as prime ingredients in aerosol formulations.

#### APPLICATIONS

By virtue of its extreme versatility, the amphoteric molecule offers potential applicability to virtually any cosmetic formulation wherein specific surface active properties are required. The family of products possible through the various fatty chain lengths, the monoadducts, and the diadducts, allows the selection of a particular product to perform a specific

function or series of functions. Shampoos, conditioning rinses, synthetic bar soaps, face creams, hand lotions, etc., are all possible with the use of one or more of the fatty amino acid derivatives.

#### SUMMARY

A new family of amphoteric surface active agents based on the condensation of a fatty primary amine and methyl acrylate have been made available commercially in both monoadduct and diadduct forms and in a variety of fatty chain lengths. Their flexibility as to chemical structure and their amphoteric polyfunctionality combine to provide an extremely versatile family of products offering promise in a wide variety of applications. These fatty amino acid derivatives are particularly adapted to cosmetic formulations, offering controlled surface active properties, compatibility with a wide range of products, mildness and polyfunctionality.

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## ROTATIONAL METHODS OF FLOW MEASUREMENTS\*

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A LARGE NUMBER of various types of rotational viscometers are obtainable commercially, and many more are described in the current literature. Some special advantage over available apparatus is usually claimed for each new instrument which is described. Often a very specialized knowledge of the field of rheology and the specific application of a given instrument is consequently required before an adequate choice of apparatus and the results which it may be expected to yield can be made. To aid in this choice, it is pertinent to consider the various aspects of rotational viscometers, and those related to them, and to determine their advantages and limitations. With this background a more adequate choice of commercial apparatus can be made, or the design of special equipment to meet specific needs can be more rapidly accomplished.

Although today rheology is playing an important and ever increasing role in industrial control and research, it was not until the latter part of the 18th century that Coulomb (1) laid the foundation for rotational type viscometers. In order to substantiate the derivations earlier carried out by Newton (2) for viscous flow, he suspended a circular plate from a

\* Presented at the October 4, 1956, Seminar, New York City.