DRUG DEVELOPMENT AND INDUSTRIAL PHARMACY, 13(13), 2363-2387 (1987)

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THE PRESENT STATUS OF FORMULATION OF COSMETIC EMULSIONS

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ABSTRACT

Today a cosmetic chemist is challenged to formulate an emulsion in an environment dictated by consumers, regulated by government and influenced by the volatility of the market. Efforts are directed to develop a safe and stable product with desirable aesthetic and tactile properties. An overview of theory of emulsification and widely used and newer raw materials available are presented. Understanding of causes and cures of physical and chemical instability and microbiological integrity are discussed.

INTRODUCTION

Until early 70's most cosmetic companies remained blissfully unconcerned regarding the safety and

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integrity of their product. Products like cationic-nonionic shampoos causing severe eye irritation, bubble bath causing irritation of genital area in children and unsafe hair dyes were developed and marketed, though later withdrawn, without fear of consumer liability suit or action from government regulatory agencies.

Since early 70's the formulation of a new cosmetic product has undergone major changes. Cosmetics industry has been hit hard by the impact of regulatory agencies, consumer awareness, fear of liability suits and fierce competition among U.S. and international companies in a highly volatile market place. These have forced the industry to develop newer products not only with aesthetic attributes like fragrance and color but also functionality, safety and adequate stability.

Great public desire for information and fear of toxic substances and their possible presence in products they eat, drink, or use topically grew by leaps and bounds in late 60's and early 70's. The awareness and importance of one's appearance, health fitness and desire for long life coupled with sophistication in buying habits forced the cosmetic industry to introduce products with unique functional claims.

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Today the cosmetic industry is regulated by several government agencies namely:

Food and Drug Administration

Federal Trade Commission

Consumer Product Safety Commission

Environmental Protection Agency

Occupational Safety and Health Administration

Several changes were brought about by consumer revolution groups like Ralph Nader's Health Research Group, Environmental Defense Fund and George Town University Center for Public Law. Efforts of such groups in discovering carcinogenic or harmful cosmetic ingredients surely precipitated Food and Drug Administration's issuance of its cosmetic product ingredient regulation, issuance of warning label on coaltar hair dyes, removal of hexachlorophene, removal of FD&C Red #2 dye and product experience reporting system. Consumer assault persuaded FDA to verify the safety of cosmetic ingredients, impose standards of bacterial integrity, and enforce a general need to develop safe cosmetics and toiletries.

Advertising rhetoric for cosmetics climbed new heights of exaggeration and inferred claims in the sixties and seventies and forced close monitoring. Today Federal Trade Commission often demands the data substantiating advertising and inferred claims.

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In response to consumer's demand for safe products, the politicians and government created Consumer Product Safety Commission which today also monitors safety of cosmetic products.

Public concern for the environment, quality of air, quality of water and safety of wild life led the Environmental Protection Agency to ban use of chlorinated and fluorinated hydrocarbons in consumer and cosmetic products and forced the industry to reformulate aerosol formulations.

Occupational Safety and Health Administration today demands strict compliance to its guidelines and is responsible for much improved working conditions in the cosmetic industry.

Besides the regulatory environment, the market environment also changed dramatically in the 70's. A larger number of women entered the work force. Special markets were developed for ethnic cosmetics, and mature population and mens cosmetics gained popularity.

It is under this background of requirements dictated by the consumer, regulated by government agencies and influenced by aggressive and volatile markets that the present cosmetic emulsions are formulated.

Emulsification is one of the most useful tools in cosmetic field. Cosmetic emulsions are primarily

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designed to accomplish two tasks: 1) deliver functional benefit; 2) promote psychological well being of the consumer by increasing aesthetic appeal and acceptability.

As product forms, emulsions offer many advantages to cosmetic chemist. They allow incorporation of otherwise impractical combination of ingredients into a single formulation and enable regulation of rheological properties without significantly affecting the efficacy of active ingredients. They also serve as carrier for pigments and as occlusive agents.

THEORY OF EMULSIONS

An emulsion is defined as a dispersion of one immiscible liquid in another, stabilized by a third component, the emulsifying agent. The immiscible materials are usually water and oil, or fat. One liquid is dispersed as fine globules in the other and is referred to as the dispersed, discontinuous or internal phase. The surrounding liquid is known as the continuous or external phase.

When two such immiscible liquids are mixed together, the droplets tend to coalescence and liquid separate rapidly into two defined layers. This separation occurs because the cohesive forces between

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molecules of each liquid is greater than the adhesive forces between two liquids. The cohesive force of individual phase is manifested as an interfacial tension at the boundary between the two liquids.

When an emulsifying agent is introduced into such a thermodynamically unstable mixture, it forms a film around the dispersed globules and prevents or reduces coalescence. This film known as interfacial film may be monomolecular, multimolecular or particulate in nature depending on the emulsifier and its characteristics.

Stable emulsions are achieved when closely packed condensed film is formed from two components, one oil soluble and the other water soluble. These two molecular species exhibit affinity for each other, both being held at interface and oriented with polar group in water and hydrocarbon (nonpolar) groups in oil phase depending on their Hydrophilic Lipophilic Balance (HLB) value.

Some desirable attributes of a cosmetic emulsion are:

1. It must be nonirritating and nonsensitizing.
2. It should be physically, chemically and microbiologically stable.
3. It must possess desired functional properties like moisturization, softening, cleaning, protection, etc.

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4. It must possess good tactile properties like smoothness, silky velvety feel and rub out.
5. It should have desirable rheological properties.
6. It should have pleasant smell and appearance.

FORMULATION OF A COSMETIC EMULSION

Formulation of an emulsion involves the following steps:

1. Raw Material Selection
2. Optimization of Manufacturing Conditions
3. Stability Testing
    a. Physical
    b. Chemical
    c. Microbiological
4. Safety and Efficacy Testing

RAW MATERIAL SELECTION

Since cosmetic products come in contact with various organs and tissues of the human body, the most important consideration for choosing an ingredient in cosmetic emulsion is their medical safety. Many preparations are left on the body for a long period of time and should therefore be free of allergens,

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sensitizers and irritants. Skin is permeable to many materials so ingredients used in cosmetic emulsion should also be free of impurities that may have systemic toxicity. To minimize such risk, trend is towards using macromolecular substances in the development of cosmetic emulsion. Additionally, ingredients are selected to improve stability, improve tactile properties, enhance preservation and impart functional properties such as moisturization, skin softening, etc.

Most cosmetic emulsions contain 20-40% oil, a few percentage of emulsifier and a water phase with some "active ingredients" dissolved in water or oil phase.

Oil Phase

The oil phase seldom is a single entity rather it is a combination of several ingredients. Oil phase contributes to the emollient properties of an emulsion. Additionally, it serves as occlusive agent, and acts as barrier against water loss from the skin.

There are over 450 emollients available in the U.S., many with the same or similar chemistry.[1-2] Despite large number, vast majority fall into one of the following categories namely:

a. Solid & Liquid Petroleum Derivatives, e.g. mineral oil, petrolatum.

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b. Aliphatic Alcohols, e.g. cetyl alcohol, stearyl alcohol, lauryl alcohol, oleyl alcohol.

c. Aliphatic Acids, e.g. oleic acid, palmitic acid, myristic acid, stearic acid.

d. Aliphatic Esters, e.g. isopropylmyristate, glyceryl monostearate, polyethylene glycol 6000 distearate.

e. Natural Oils & Waxes, e.g. squalene, lantin, triglycerides, almond oil, beeswax, spermwax.

f. Synthetic Oils & Waxes, e.g. silicone oil, syncro wax.

g. Proprietary Mixtures of these Categories.

Branched chain fatty alcohol and their esters and fatty acids are new entry to the market. Branching of molecular structure decreases intermolecular attraction and makes higher branched chain alcohol liquid at room temperature. Such materials provide excellent oxidation and color stability and exhibit unique emollient and lubricating properties.[3]

Even though many emollients are available, a formulator can blend few oil soluble materials like liquid and solid petrolatum, isopropyl myristate, isopropyl palmitate, cetyl, myristyl and stearyl alcohols to yield any degree of oiliness, dryness, ease of rub-in, plasticization, moisturization, velvety

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character and an overall general degree of cosmetic elegance. Inspection of leading products like Vaseline Intensive Care, Wondra, etc., will attest to the nature and importance of few emollients. They are in the biggest sellers, commodity lotions and creams, exotic and prestige cosmetics, the old standby and newest creations.

Aqueous Phase

Aqueous phase consists of water and water soluble functional ingredients like humectant, cosolvent, preservative, color, chelating agent, viscosity builder, etc. Humectants prevent water loss or drying of emulsion and most are reported to attract moisture from the environment. There are about 70 or so humectants but most widely used ones are glycerin, sorbitol, propylene glycol, butylene glycol, ethoxylated polyols, lactates, etc. Cosolvents are used to solubilize water insoluble materials like fragrance or preservative. Chelating agents like EDTA and its salts chelate divalent ions and improve the stability of emulsion.

Emulsifier

Of the three necessary components in an emulsion, emulsifier selection is the most vital. This is

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because emulsifiers are incorporated to perform a specific, often difficult physical task vital to the products performance and stability. The final formula may include one or more primary emulsifiers and auxiliary emulsifiers.

Emulsifier list is so long that it is published in two complete separate works.[1] Broad categories of widely used and new emulsifiers are:

a. Soaps
b. Nonionic Ethoxylates
c. Esters of Sucrose, Glucose, Glycerin and Orthophosphoric Acid
d. Block Copolymers
e. Protein Condensates
f. Cationics
g. Silicones
h. Natural Emulsifiers

New Functional Raw Materials

A number of new cosmetic raw materials with exotic and functional claims have been introduced.[4-6] Some have novel structure previously not available. Others offer exceptional efficacy claims of skin softening effect, younger looking skin, velvety feel, skin hydration and skin repair.

Topical use of Vitamin E has high degree of consumer recognition. It has been reported that

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Vitamin E protects cell membrane and helps increase skin elasticity. Vitamin A or retinoic acid has shown considerable promise in wrinkle treatment. It appears to stimulate collagen synthesis, increases the blood flow and normalize the cell structure.[4]

Use of exotic oils of jojoba, aloe, musk and turtle, fatty extracts of various fruits and vegetables, herbal extracts, sesquiterpene and triglyceride of vegetable oils with various advertising claims are found in some of the latest creations.[5-6]

While use of glycerin as "moisturizer" is old, it still is ingredient of many large selling cosmetic lotions. Other commonly used newer moisturizers include exotic materials like placenta which is comprised of cystine, nucleic acids and enzymes, soluble collogen and elastin. High molecular weight hyaluronic acid continues to find considerable use due to its extensive hydration capabilities.

STABILITY OF COSMETIC EMULSION

Stabilization of emulsion is a critical part of cosmetic formulator's assignment. Emulsions are thermodynamically unstable system and possess an inherent tendency to undergo spontaneous change after preparation. In spite, cosmetic emulsions should have

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shelf life of two years. Additionally, cosmetics are used from Alaska to Sahara and must withstand extremes of weather during transportation from place of manufacture; to warehouse; to store; and to consumer. Further, a formulator must also be able to predict the stability of emulsion during expected shelf life.

The problem is further compounded as most cosmetic emulsions have relatively short market life span. With a few exceptions, they last 2-5 years on the market and give way to next generation of products. Cosmetic chemists, unlike their pharmaceutical counterparts, do not have the luxury of long product development periods.

Physical Stability

Physical stability of cosmetic emulsion is characterized by absence of: coalescence; sedimentation of internal phase; creaming; flocculation and disproportionalization and maintenance of elegance with respect to appearance, color, odor and other physical attributes. The most common physical instabilities are due to gravitational separation and lead to sedimentation, creaming and coalescence.

The disproportionalization is a result of diffusion process. The material contained in small droplet will diffuse to a larger droplet where

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thermodynamic potential is lower. As time goes on, emulsion becomes coarser. The less uniform the original droplet size distribution, the more pronounced will be the effect of disproportionalization.[3]

More subtle changes can also endanger emulsion stability. A slight change in droplet size can alter the rheological behavior of emulsion and its viscoelastic properties which have a profound effect on consumer perception of various attributes.

The majority of factors which govern the physical stability of an emulsion are depicted by Stoke's law:[7]

$$V = \frac{d^2(\Delta P)g}{18\ n}$$

where,

V = velocity of sedimentation of dispersed droplets

g = gravitational constant

d = diameter of dispersed droplets

Δ P = density difference between dispersed phase and continuous phase

n = viscosity of external phase

Hence, emulsion stabilization can be achieved by: a) increasing the viscosity of external phase; b) decreasing the particle size and obtaining a uniform particle size distribution of the dispersed phase.

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Increasing the Viscosity of External Phase

Viscosity of external phase may be increased by use of suitable natural or synthetic hydrocolloids/polymers or inorganic thickeners.

The commonly used hydrocolloids are water or alcohol soluble polymers which may be either nonionic or ionic in nature e.g. cellulose derivatives like hydroxypropyl methylcellulose (Methocel), ionic polymers of acrylic acid, polysaccharides like acacia, carageenan, guar gum, xanthan gum, locust bean gum and alginates. Inorganic thickeners in common use are Veegum (magnesium aluminum silicate), bentonite gel and laponite (sodium magnesium silicate).

Synthetic polymers are popular as they exhibit high electrolyte and pH tolerance and consistent viscosity performance. Clays are excellent suspending agents and provide smooth skin feel.

Decreasing the Particle Size and Obtaining Uniform Particle Size Distribution of Dispersed Phase

The particle size of dispersed phase is influenced by choice of emulsifier, placement of emulsifier, concentration of emulsifier and processing conditions.

Emulsifier may be chosen from broad categories as discussed earlier. Selection is based on the required HLB of oil phase, phase inversion temperature,

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solubility of emulsifier and cost. Emulsifier should be placed in the phase in which it is most soluble. An emulsifier with low HLB value is added to the oil phase and the one with high HLB is added to the water phase. The concentration of emulsifier should be adequate to fully cover the interface. Additionally, it should also compensate for migration of emulsifier from the interface to the continuous phase. Also, the concentration should be adequate enough to have high phase inversion temperature.

Physical stability is further enhanced by improving the strength of the interfacial film and preventing particle interaction. Prevention of particle interaction is achieved by formation of liquid crystals.[8] Liquid crystals are defined as "highly anisotropic fluid that exists as a result of long range orientational ordering among constituent molecules".[9] This ordering is adequate to provide for increased viscosity, but not strong enough to prevent flow. Hence, liquid crystals can be considered viscous liquids and exhibit dualism of physical structure.

Liquid crystals stabilize an emulsion by two mechanisms: 1) They form a barrier around the emulsion droplets and strengthen the o/w interface thus reducing the likelihood of coalescence. 2) They form a "gel network" extending from the surface of the emulsion droplet into the continuous phase. This structure

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increases the viscosity and impedes emulsion droplet movement thus inhibiting coalescence.[8]

Chemical Stability of Emulsions

Most excipients of cosmetic emulsions are organic in nature with a variety of functional groups like alcohol, aldehyde, ester, phenol, mercaptan, ether, primary, secondary or tertiary amine, amide, unsaturated compounds, etc. They undergo degradation via one or more of the following routes:[10] hydrolysis, oxidation, photolysis, racemization, complexation, etc. and lead to changes in the chemical, physical, and microbiological attributes of the emulsion.

Chemical stability of an emulsion can be improved by elucidating the degradative pathway(s) and inhibiting or circumventing them. It may involve processing or packaging steps such as adjusting the pH to retard the rate of hydrolysis, use of antioxidant to retard oxidation of unsaturated and phenolic compounds, use of chelating agents to prevent inactivation of preservatives and oxidation of unsaturated compounds and selection of appropriate package for protection of the product from light and photolysis.

Microbiological Stability of Emulsions

Cosmetic emulsions come into prolonged contact with tissues and organs of human body and therefore

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must meet very high standards of hygiene. Products used in the area of eye or oral cavities are required to be practically sterile. All cosmetics and toiletries must be free of pathogens like Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Candida albicans, Aspergillus niger and Salmonella species.

Presence of microorganisms may also bring about physical and chemical changes in emulsions. These changes may include physical separation of phases, discoloration, gas and odor formation and changes in the rheological properties of emulsion. For the safety of consumers and integrity of the product it is imperative to have adequate preservation.

Preservation of cosmetic emulsion constitutes several problems to a formulator; especially in a contemporary emulsion. Most emulsions today contain lipids, carbohydrates, polysaccharides, proteins, gums, vitamins, amino acids, phytosterols, etc., which are excellent nutrients for the growth of microorganisms. Processing containers, equipment, packaging components and operators also contribute to microbial contamination of the product.

Cosmetic emulsion therefore should contain an antimicrobial preservative that eliminate infecting microorganisms (bacteria, yeast and fungi) and should

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be manufactured and packaged in accordance with Good Manufacturing Practices.[11]

Factors affecting the efficacy of a preservative include; solubility in aqueous phase; partitioning between lipid and aqueous phase, dissociation due to change in pH and interaction with other ingredients in the formula. Though none exists, an ideal preservative should: have broad spectrum of activity, be capable of sustained action, have few chemical or physical incompatabilities, be effective over a wide pH range and not influence the pH of product, be nontoxic, nonirritant and nonsensitizer, be colorless, odorless or nearly so, be water soluble, be economical and be easily formulated.[12]

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Preservative Selection

From a large number of available preservatives, a formulator chooses a preservative system for a particular product. Formulator is aided by the knowledge of few basic guidelines during each stage of development such as history of similar raw materials and formula, area of application, package design, frequency of use, manufacturing process and product life.

A preservative system usually involves use of a combination of preservatives to ensure microbial

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integrity of the emulsion in case one of the preservatives is inactivated either by a contaminant in the emulsion or by one of the challenge organisms.

In a broad chemical sense, a preservative may be an alcohol, acid, ester, quarternary ammonium compound, phenol or its derivatives including halogenated phenols or formaldehyde and formaldehyde donors.[12] The formaldehyde donors in combination with parabens are most frequently used preservatives in cosmetic emulsions.

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Adequate Preservation

A product is adequately preserved if it withstands a laboratory challenge test and resists microbial insults during manufacture and consumer use. Preservative efficacy testing enables the manufacturer to ensure microbial integrity of the product. In recognition of the importance of preservative efficacy testing, several official and nonofficial guidelines have been developed such as Guidelines of U.S.P.[13], Guideline of CTFA[14], Guidelines of American Society of Testing Materials[15] and Linear Regression Method of Preservative Efficacy Testing[16], etc.

Predicting Stability

Ideally a cosmetic emulsion should undergo stability storage tests comparable to product shelf

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life prior to marketing. However premarket storage test for the entire length of shelf life of product (about 2-3 years) are impractical and cosmetic emulsions are subjected to accelerated stability testing in an attempt to predict their shelf life.

The stability protocol depends on the product category and vary from manufacturer to manufacturer. Generally, emulsions are stored at 4°C, room temperature, 35°C or 40°C, and 45°C or 50°C for accelerated stability testing. Stability at 35° or 40°C for 3 months is generally considered minimal. Concurrently, the emulsion is also subjected to several freeze and thaw cycles to test the effect of extreme cold. Since physical instability is primarily due to gravitational forces, centrifugation has been explored as a possible method of predicting emulsion stability. However, to date no reliable correlation has been established between behavior of emulsion at elevated temperature or emulsion stability against gravitational forces with long term stability of emulsion products. Predicting long term stability from accelerated tests still remains an elusive goal.

Results of stability testing for the preservative from accelerated laboratory tests is reliable provided the product is analyzed chemically and is also subjected to biological efficacy tests at appropriate time intervals.

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SAFETY AND EFFICACY

Safety and efficacy testing are an integral part of cosmetic emulsion development. The final product must be free of any toxic effects. A product is generally tested for eye and skin irritation, acute oral toxicity, acute dermal toxicity and skin sensitization in animals and later in human subjects as per the guidelines from CTFA and/or FDA or in-house protocols.[17]

Some cosmetics like sunscreens, antidandruff shampoos, and antiperspirants are classified as over the counter drug products. They must be efficaceous. Other products which make claims also need efficacy testing or substantiation of claim. Several instruments and techniques have been developed to measure efficacy of various cosmetic products.

CONCLUSION

In the last decade much progress has been made to improve physical stability of emulsion. This is due to better knowledge of physicochemical properties of raw materials, optimization of processing conditions and deeper understanding of the emulsification process including influence of liquid crystals, phase inversion

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temperature, concentration of emulsifier on the rigidity of interfacial film and microemulsion phenomenon.[8,18] These have led to the development of new concepts which have been reduced to practice and brought to the market place. In spite of this, a concerted effort is needed to develop experimentally validated scientific schemes that are capable of predicting long term emulsion stability.

Today most cosmetic emulsions can be well preserved if prepared under strict guidelines of Good Manufacturing Practices and have adequate preservative system. Formaldehyde donor type compounds in combination with parabens perform well in most cases.

In the past, industry has met the challenges of government regulations. I see no decline in government's attitude towards development of safe, efficaceous and stable product for consumer protection. If anything, government regulations will be even more stringent in the coming years.

Everyone is happy with the progress to date but lot needs to be done in the coming years. These challenges will offer opportunities to cosmetic, physical and colloid chemists.

ACKNOWLEDGEMENTS

The author wishes to thank Mr. B. Oza and Mr. H. Bhagat for their assistance in editing the manuscript and Mrs. Linda MacLellan for her assistance in the preparation of this manuscript.

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REFERENCES

1. "McCutchen's Detergents and Emulsifiers", Allured, Ridgewood, N.J.

2. H.N. Bhargava and M.J. Pieloch, Cosmetic Technology, 1, 33 (1980).

3. M.M. Breuer, in "Encyclopedia of Emulsion Technology", Vol. 2, P. Becher, ed., Marcel Dekker, New York, N.Y., 1985, p. 385.

4. B. Idson, Drug and Cosmetic Industry, 140(1), 26 (1987).

5. R.L. Goldenberg, Drug and Cosmetic Industry, 138(5), 16 (1985).

6. D.A. Davis, Drug and Cosmetic Industry, 140(1), 34 (1987).

7. A. Martin, J. Swarbrick and A. Cammarata, "Physical Pharmacy", Lea and Febiger, Philadelphia, PA, 1983, p. 544.

8. S. Friberg and I. Wilton, American Perfumer and Cosmetics, 85(12), 27 (1970).

9. "Kirkothmer Encyclopedia of Chemical Technology", Vol. 14, John Wiley, New York, N.Y., 1980, p. 395.

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10. L. Lachman, P. Deluca and M.J. Akers, in "The Theory and Practice of Industrial Pharmacy", L. Lachman, ed., Lea and Febiger, Philadelphia, PA, 1986, p. 760.

11. Federal Register, 36, 133, 1971.

12. H.N. Bhargava and A. Anaebonam, Soap/Cosmetics/Chemical Specialties, 59(10), 39 (1983).

13. "The United States Pharmacopeia XXI and National Formulary XVI", Mack, Easton, PA, 1985.

14. "CTFA Technical Guidelines", CTFA Inc., Washington, D.C., 1974.

15. "Annual Book of A.S.T.M. Standards - Part 46", A.S.T.M., Philadelphia, PA, 1980, p. 452.

16. D.S. Orth, J. Soc. Cosmetic Chemists, 30, 321 (1979).

17. A.A. Fisher, in "Cosmetic Science and Technology", Vol. 3, M.S. Balsam, ed., John Wiley, New York, N.Y., 1974, p. 311.

18. H.N. Bhargava, A. Narurkar and L.M. Lieb, Pharmaceutical Technology, 11(3), 46 (1987).

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