PRODUCT INFORMATION

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UNUSUAL AQUEOUS AEROSOL FOAMS

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Better things for better living ... through chemistry

Unusual aqueous aerosol foams

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In the decade from 1950 to 1960 aerosol foams constituted only a minor proportion of the products on the market; the major foam product was the aerosol shaving lather which appeared in 1950. During this period most of the products were formulated to give foams which were quite similar in their appearance and properties. The foams generally were patterned after aerosol shaving lathers and had a comparable stability and density.

These foams usually were formulated with 8-10% of a propellant 12/propellant 114 blend, or 3.5-5.0% of a hydrocarbon propellant. The rest of the (aerosol) formulation generally consisted of an aqueous phase containing various salts of the fatty acids as the major surface active agents, along with other additives. Some of the earlier attempts to formulate aerosol shampoos with the sodium alkyl sulfates were unsuccessful because of container corrosion.

Later in the 1960's it was recognized that foam properties could be varied considerably from the somewhat standardized products marketed earlier and foams such as "Crazy Foam," a coherent and dry foam designed as a toy for children, the "Sonic" effervescent foams, and various aqueous alcohol foams appeared on the market.

Some new and unusual foams to be described in this paper were selected in order to illustrate the variety of foams that can be obtained by changing the proper variables. Although many of the foams discussed have not yet been utilized for the formulation of commercial products, the variation in properties they offer should make them suitable for many different applications in the cosmetic and pharmaceutical fields.

Foam compositions and properties

Sparkling foam. This product discharges initially as a typical foam with a slightly rough surface. After about 15-30 minutes the surface of the foam starts to disintegrate and appears to be covered with snowy crystals, giving the foam a sparkling appearance. As the foam ages it becomes progressively thinner but the sparkling effect remains for at least eight hours. The stability of the foam is probably due to complex formation between the triethanolamine myristate and lauryl alcohol.

The foam should be useful for displays where long term stability is not necessary. The addition of fluorescent whitening agents to the foam and the use of ultraviolet light illumination might provide some very striking effects. The composition of the foam is:

Lauryl alcohol	0.85 wt. %
Myristic acid	2.00
Triethanolamine	1.35
Water	85.80
Propellants 12/114 (40/60)	10.00

The methods for preparing the various foams are given later in this paper.

Shiny foam. This product discharges as a dense, almost liquid foam with a very shiny surface. In appearance it is similar to cake icing. The consistency of the foam is somewhat unusual and has the feel of marshmallow topping. The shiny appearance of the surface disappears after a few minutes.

This foam should be suitable for cosmetic and pharmaceutical applications; its composition is:

Polyoxyethylene (10) stearyl ether*	3.1 wt. %
Cetyl alcohol	1.1
Water	85.8
Propellants 12, 114 (40, 60)	10.0

* Atlas Chemical Industries

Expanding foam. The foam from this product continues to expand after discharge. It is quite dense and stable for some hours, although the concentration of the surface active agent is relatively low. The stability of the foam results from complex formation between the triethanolamine laurate and lauryl alcohol.

The expansion of the foam after discharge is due to the propellant 114 which has a comparatively high boiling point and low vapor pressure. The transition of the propellant after discharge from a liquid to a gas is slower than with the more conventional, higher pressure foam propellants such as propellant 12/propellant 114 (40/60). The pres-

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ent product discharges as a foamy liquid. The addition of a vapor pressure depressant to the system would probably give a product which discharges as a liquid and then subsequently expands into a foam.

This foam should be useful for pharmaceutical or cosmetic applications where it is advantageous to discharge the product into a relatively confined area. Maximum contact for a fairly long period is subsequently achieved by expansion of the liquid into a foam. The composition of the foam is:

Concentrate	
Part A	
Lauric acid	2.00 wt. %
Lauryl alcohol	1.88
Part B	
Triethanolamine	1.50
Water	94.62
Aerosol formulation	
Concentrate	90.00 wt. %
Propellant 114	10.00

Collapsing foam. The foam from this product is quite unstable and starts to collapse immediately after discharge. The instability results from the presence of propellant 152a which produces unstable foams in some systems, and the use of the relatively poor foaming agent, triethanolamine laurate. The formulation is:

Concentrate	
Part A	
Lauric acid	2.00 wt. %
Part B	
Triethanolamine	1.50
Water	96.50
Aerosol formulation	
Concentrate	90.00 wt. %
Propellant 152a	10.00

Periscope foam. This foam has a combination of the properties of both the expanding and collapsing foams. It discharges as a liquid which immediately expands into a voluminous foam which is stable for only a few minutes and then collapses. An audible hissing noise is evident after the foam has been discharged which is due to the rapid coalescence of the gas bubbles in the foam and subsequent loss of propellant.

The liquid discharge and rapid expansion of the liquid to a foam is achieved by the use of a high concentration of propellant 114. The subsequent collapse results from the low concentration of a surfactant which gives comparatively unstable aerosol foams at the concentration at which it is used.

The product can be demonstrated effectively by moving the container fairly rapidly as the product is being discharged so that a narrow ribbon of the liquid is deposited. The foam should be useful for cosmetic or pharmaceutical applications when it is desirable to discharge a liquid into a confined area where the foam can expand to achieve maximum contact and then collapse to minimize discomfort. The composition of the product is:

Water	48.0 wt. %
Tergitol XD*	2.0
Propellant 114	50.0

* Union Carbide Corporation

Bouncy foam. This foam is a very coherent, dry foam that can be molded or fashioned into various shapes such as a ball. The dryness and coherence of the foam are due to the high concentration of surfactant and of propellant. Increasing the propellant concentration[1] increases foam stiffness and decreases foam density.

This product is useful for demonstration purposes. Its properties are somewhat similar to those of the product Crazy Foam, the toy foam for children. The formulation is:

Concentrate	
Part A	
Stearic acid	11.05 wt. %
Coconut fatty acid	2.77
Mineral oil	0.20
Part B	
Triethanolamine	9.04
Polyethylene glycol 400	1.84
Water	75.10
Aerosol formulation	
Aqueous concentrate	50.00 wt. %
Propellants 12, 114 (40/60)	50.00

Snowflake foam. This foam consists essentially of a basic shaving lather concentrate formulated with a high concentration of propellant. The sample is equipped with a spray actuator instead of a foam actuator. When the sample is sprayed into the air the stream breaks up into snowflakes so that the discharge looks like a heavy snowfall. This product should be useful to simulate snowfalls. The composition is:

Concentrate	
Part A	
Stearic acid	7.1 wt. %
Coconut fatty acid	1.7
Part B	
Triethanolamine	4.4
Glycerin	2.0
Water	84.8
Aerosol formulation	
Concentrate	30.0 wt. %
Propellants 12 114	70.0

Crackling foam. The crackling foam is relatively unstable and starts to collapse as soon as it is discharged. When collapsing, or when rubbed on the skin, the foam makes an audible, crackling sound. One of its unusual features is the very high concentration of propellant 114 which gives the foam its crackling characteristics.

The crackling foam has somewhat similar properties to the "Sonic" foams already on the market. This type is suitable for such products as aftershaves, skin fresheners, skin moisturizers, etc. The composition is:

Water	10.0 wt. %
Tergitol XD	1.0
Propellant 114	89.0

Methods of preparation

1. Sparkling, shiny foams. These are prepared by mixing together all of the ingredients except the propellant and heating with stirring to about 130-140° F. The mixture is then allowed to cool to room temperature with stirring and the resultant concentrate is loaded into containers. After removal of air by evacuation or purging, the valve is crimped and the propellant is pressure loaded.

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2. Periscope, crackling foams. The water and wetting agent are stirred together until the surfactant dissolves; heating will increase the rate of solution. The concentrate is loaded into the containers, the samples evacuated or purged, the valve crimped, and the propellant pressure loaded.

3. Expanding, collapsing, bouncy, snowflake foams. In these products the concentrate is divided into two parts, A and B. The concentrate is prepared by heating Parts A and B separately to about 130-140° F. Part B is then added slowly with gentle stirring to Part A. After the addition is complete the concentrate is allowed to cool to room temperature with stirring. It then is loaded into the aerosol container, the air removed by purging or evacuation, and the propellant pressure loaded.

Summary

The compositions and properties of eight aqueous foams with unusual properties are given. These foams should be suitable as the basis for a variety of aerosol cosmetic and pharmaceutical products. It should be recognized that the incorporation of active ingredients and other additives to the foam systems may change their properties. In addition, before any products prepared from these basic systems are marketed, adequate storage stability tests should be carried out and the patent situation should be investigated.

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The first aerosol foam product, shaving lather, appeared on the market in 1950. It became popular almost immediately, and although many other aerosol foam products subsequently were developed and successfully marketed, aerosol shaving lather is still the largest selling aerosol foam product. In 1967, approximately 159 million units were produced in the United States, which placed the shaving lathers sixth in volume among the various categories of aerosol products reported for that year[1].

Aerosol foams have been utilized to an increasing extent in recent years for topical applications. There are a number of reasons for this. In the first place, foams have an aesthetic appeal which cannot be matched by any type of spray. In addition, foams can be applied directly to the desired area, without the waste or overspray that often accompanies conventional spray applications. Also, the foam system provides an efficient method for packaging and applying products, since the concentration of propellant generally is low and, consequently, the proportion of active ingredient is high. Finally, the properties of foams can be varied over a wide range by proper formulation techniques to suit different applications. Foams can be obtained which break almost immediately after discharge or are stable for weeks. Some foams make a crackling noise when spread, while others are so coherent that they can be molded into any desired shape.

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AEROSOL FOAMS

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A foam can be defined simply as a coarse dispersion of a gas in a liquid. In conventional, nonaqueous foams, the dispersed gas usually is air, but in aerosol foams it consists of vaporized propellant. The propellant may be a fluorinated hydrocarbon such as Freon® 12 or Freon® 114, a hydrocarbon such as isobutane, or a blend of these propellants. The liquid phase in which the propellant vapor is dispersed is the continuous phase, and the liquid films separating the bubbles are called lamellae. The composition of the continuous phase determines the class to which the foam belongs. If the continuous phase is water, the foam, of course, is an aqueous foam. When the continuous phase consists only of organic liquids such as propylene glycol or mineral oil, then nonaqueous foams are produced. A special class of foams known as aqueous alcohol foams is obtained from certain mixtures of water, ethyl alcohol and propellant, where the proportions are such that the components are mutually soluble.

Aerosol foam products are called aerosol foams regardless of whether it is the aerosol package that is referred to or the product after discharge. However, these products are foams only after discharge. In most cases, aerosol foams are packaged in the container as emulsions, with droplets of the liquefied propellants dispersed throughout the continuous phase. When the product is discharged, the liquefied propellant droplets vaporize and form the gas bubbles of the foam. It can readily be seen that when the foam is obtained from an emulsion system, the foam will, of necessity, inherit many of the characteristics of the parent emulsion. Thus, the interfacial properties of the emulsion undoubtedly influence the interfacial properties of the foam. Unfortunately, there have been relatively few basic studies of aerosol emulsions as yet. This is primarily because aerosol emulsions exist only under pressure, and the specialized microscopic equipment required for viewing such emulsions is not yet available. Much of the information about aerosol emulsions has been deduced from the properties of the foams produced by the emulsions.

Foam Stability

Foams, like emulsions, are inherently unstable. There are three major ways in which a foam manifests its instability. These are drainage, rupture of the liquid films with consequent coalescence of the gas bubbles, and change in bubble size[2]. A foam drains when the continuous liquid phase settles to the bottom of the foam. This occurs because of gravitational and capillary forces acting on the liquid phase[3]. Drainage causes the liquid films separating the gas bubbles to become thinner, and eventually this can lead to coalescence of the gas bubbles and complete collapse of the foam structure. These processes are illustrated in Figure 1.

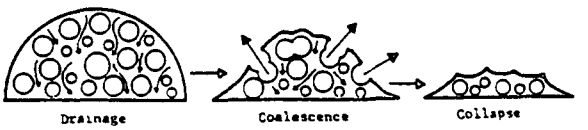

Figure 1. Stages of Foam Instability

Another phenomenon that may occur in foams is a change in the size of the dispersed gas bubbles. The diameters of the bubbles in any foam vary considerably and, as the foam ages, the small bubbles become

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smaller and the large bubbles may grow larger. This change takes place because the pressure inside a gas bubble in a foam is a function of the diameter of the bubble. The pressure inside a small bubble is greater than the pressure in a larger bubble, and the pressure differential between the bubbles causes the gas molecules in the smaller bubbles to diffuse through the liquid films into the larger bubbles.

The total pressure, P_t, in a gas bubble in a foam is equal to atmospheric pressure, P_a, plus a factor, $\triangle P$.

$$P_t = P_a + \triangle P$$

The magnitude of the factor, $\triangle P$, is determined by the surface tension, γ, and the radius of the gas bubble, R.

$$P = \frac{2\gamma}{R}$$

Therefore, the total pressure inside the gas bubble is:

$$P_t = P_a + \frac{2\gamma}{R}$$

It can be seen from the above equation that the pressure inside a bubble with a small radius will be higher than that inside a bubble with a larger radius.

Foam Stabilization

Foams are unstable by nature, but they can be stabilized by incorporating various additives, such as surface-active agents, into the foam structure. Although surface-active agents by themselves can be quite effective as foam stabilizers, the molecular complexes that are formed between surface-active agents and long-chain alcohols or acids generally have a much greater stabilizing effect. Typical examples of combinations that form complexes are sodium lauryl sulfate–lauryl alcohol and triethanolamine stearate–stearyl alcohol. Complexes are also formed between the salts of the fatty acids and free fatty acids. One of the best-known examples of this type is the sodium stearate–stearic acid complex. Recent evidence indicates that complex formation also occurs between the triethanolamine salts of the fatty acids and the free fatty acids.[3]

The complexes function as foam stabilizers in a number of ways. They increase the viscosity of the system, and this decreases the drainage resulting from gravitational forces. Many complexes form strong, condensed interfacial films around the gas bubbles, and this prevents coalescence of the bubbles, even if they come into contact. In addition, the presence of an interfacial film may retard the change in bubble size that occurs during aging. This stabilizing effect results from the lower permeability of the interfacial film to the gas molecules, which decreases the diffusion of the gas molecules from one bubble to another.[4]

Another stabilizing factor is the repulsion that can occur between gas bubbles with the same electric charge. The repulsion results from the presence of electric double layers, which form around gas bubbles in a foam through adsorption of a surface-active agent or some other ion at the interface. This is similar to the formation of electric double layers in an emulsion. However, although the repulsion from the electric charge can have a stabilizing effect, the overall importance in foams is probably less than that in emulsions. In the usual foam system, formulated with no more than 10% propellant, the bas bubbles initially are too far apart for the repulsive forces to be effective. However if drainage takes place, the liquid films separating the bubbles become thinner, and ultimately the bubbles approach close enough to each other so that a repulsion arises between the bubbles. This type of system, where stabilization does not take place until after an initial period of drainage, is referred to as a pseudo-stable system.[4] The fact that drainage occurs at all indicates that the foam is not stable.

In systems formulated with very high concentrations of propellant, i.e., 85-90%, electrical repulsion may be a significant factor, however. Even initially the liquid films between the bubbles are very thin and, consequently, stabilization depends mostly upon electrical repulsion. If such foams are mechanically disturbed by rubbing or spreading, the bubbles coalesce rapidly and the foam collapses, indicating that the foam has essentially a pseudo-stable structure.

Foam Properties

It is desirable to be able to describe foams and characterize them, not only for reference purposes, but also to determine how changes in formulation have affected foam properties. Although there are a number of physical measurements that can be made upon foams, a considerable amount of qualitative information can be obtained in a few minutes merely by discharging the foam onto a paper towel and observing it. The rapidity with which the foam wets the towel is an indication of its drainage properties, and the rate at which the foam collapses is another indication of its stability. The ease with which a foam may be spread on the hand and the feeling that it leaves may be only qualitative aspects of foam properties, but they are important because they are the ones that the consumer notices.

Various physical measurements can also be carried out with relative ease. Foam density can be obtained by filling a container of known volume with the foam and determining the weight of the foam. A number of equations for calculating foam density have been published.[7,8] The following equation was developed by Becher[2] simply from the relationship that density is equal to weight divided by volume. W_a is the weight of the aqueous phase, W_p is the weight of the propellant, M is the molecular weight of the propellant, and V_a is the volume of the liquid phase.

$$D = \frac{W_a + W_p}{\frac{22{,}400\, W_p}{M} + V_a}$$

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Foam stiffness, or the resistance of a foam to penetration or deformation, is a function of foam viscosity and can be measured with an instrument such as the Cherry-Burrell Curd Tension Meter.[9] Foam stiffness is measured by placing a dish filled with foam on a scale located directly underneath a motor-driven curd knife. The knife is driven into the foam at a constant rate of speed and the resistance of the foam to penetration by the knife causes the scale platform to depress. This is recorded on the scale dial in grams. A typical shaving lather foam will have a stiffness in the range of 60-100 grams. More sophisticated methods of measuring foam viscosity have been described by Shangraw and Richman.[10]

The rate of foam drainage can be obtained simply by discharging a known weight of foam into a glass funnel located over a graduate. The amount of liquid which collects in the graduate can be measured at predetermined time intervals. The correlation between foam drainage and wetting generally is quite good.

The rate of foam collapse can be determined by discharging the foam onto a paper towel and observing it against a background of horizontal lines drawn at intervals. If the original height of the foam is noted immediately after discharge, the foam collapse that occurs during any given aging period can be determined from the change in foam height.

Aqueous Foams

Aqueous foams constitute the largest group of foam products on the market at the present time and will continue to dominate the foam market in the foreseeable future. Some typical aqueous foam products available in the United States are listed in Table I.

Table I
Typical Aqueous Foam Products

1. After-Bath Products	6. Hand Creams
2. After-Shaves	7. Shampoos
3. Colognes	8. Shaving Lathers
4. Disinfectants	9. Skin Moisturizers
5. Facial Make-up Foams	10. Toy Foams

The propellant concentration in aqueous foams varies from about 3.5% to as high as 89%, depending upon the type of product. In shaving lathers, and in most foam products, the propellant concentration generally does not exceed 10% by weight. When aerosol foam products are formulated with the fluorinated hydrocarbon propellants, blends of Freon® 12 and Freon® 114 are normally used, with the ratio of Freon® 12 to Freon® 114 being adjusted to produce the pressure desired. Freon® 12/Freon® 114 (15/85) is used commonly for glass-bottle products, and Freon® 12/Freon® 114 (40/60) for products in metal containers. If the aqueous concentrate contains significant proportions of a vapor pressure depressant, then propellant blends with correspondingly higher vapor pressures may be used.

The simplest aerosol foam system consists of water, surface-active agent, and propellant. A typical aqueous foam formulation is given in Table II. This formulation produces a rich, stable foam that can be used as the starting point for many aerosol products.

Table II
Basic Aqueous Foam System

Aqueous Concentrate	wt. %
Stearic Acid	6.3
Coconut Fatty Acid	1.6
Triethanolamine	5.2
Water	86.9
Aerosol Formulation	
Aqueous Concentrate	90.0
Freon® 12, Freon® 114 (40/60) Propellant	10.0

The type of discharge and also the type of foam can be varied to some extent by using different propellants. If a liquid discharge which subsequently expands into a foam is desired, Freon 114 alone is used as the propellant. Freon® 114 has a relatively high boiling point and, consequently, vaporizes more slowly after discharge than blends containing the lower boiling Freon® 12. Propellants 142b and 152a are used to a limited extent in some formulations where their lower densities and quick-breaking foam properties are desirable. Freon® 11 is not used in aqueous foam products, particularly in metal containers, because of its tendency to hydrolyze in aqueous systems with consequent corrosion of the metal containers.

Varying the propellant concentration has a marked effect upon foam properties. Increasing the concentration increases the coherence of the foam, and propellant concentrations of 30% or more give dry foams. A few years ago, a very coherent foam was marketed with considerable success. This product was designed as a toy foam for children and could be molded into various shapes.

Increasing the propellant concentration even further to about 85-90% produces a foam structure which consists mostly of gas bubbles with very thin liquid films in between. Since the bubbles are quite close together, the foam is very sensitive to mechanical shock and when the foam is rubbed or spread, the bubbles coalesce readily with an audible, crackling noise. A line of foam products based upon this principle has already appeared on the market in the United States. The product line includes skin fresheners, after-shaves, and colognes.

The type of surface-active compound that is present is another factor that determines foam properties. The triethanolamine salts of the fatty acids are used commonly, but many other types of surface-active agents, including nonionics, are also included in aerosol formulations. The effect of complex formation between surface-active agents and long-chain alcohols

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or acids upon such properties as foam drainage, viscosity and collapse was mentioned previously. In addition, complex formation usually results in a marked decrease in the bubble size of the foam.[5]

Recent evidence suggests that complexes may also form between certain nonionic polyoxyethylene fatty ether surface-active agents and long-chain alcohols or acids. Some combinations, such as polyoxyethylene 10 cetyl ether–cetyl alcohol, exhibit the properties of liquid crystals in aqueous solution, and produce pearlescent systems with high consumer appeal. The aerosols are pearlescent in the bottle, but the resulting foams do not retain the pearlescence.[11]

The aqueous ethyl alcohol foam system is unique in a number of respects, and for that reason is considered separately.[12,13] The simplest aqueous ethyl alcohol foam is formulated with a combination of water, ethyl alcohol, Freon 12 Freon® 114 (40/60) propellant and a surface-active agent which is usually "Polawax".* A typical formulation is given in Table III.

Table III
Composition of a Typical Aqueous Ethyl Alcohol Foam

	wt. %
Water	30.5
Anhydrous ethyl alcohol	56.5
"Polawax"	3.0
Freon® 12/Freon® 114 (40/60) Propellant	10.0

*"Polawax" is an ethoxylated fatty alcohol marketed by Croda, Inc.

The proportions of water, alcohol and propellant are adjusted so that the components are mutually soluble and form a clear solution. The aerosol product, therefore, is not an emulsion and does not need to be shaken immediately before use. Another advantage of the aqueous alcohol foam system is that it contains over 50% ethyl alcohol which has made possible the development of a number of new foam products. Some of these are listed in Table IV.

Table IV
Some Commercial Aqueous Alcohol Foam Products

1. After-Shaves
2. Colognes
3. Hair Dressings
4. Insect Repellents
5. Skin Moisturizers
6. Sunscreens

The aqueous ethyl alcohol foam system can be varied to give either fairly stable foams or quick-breaking foams. This is achieved by changing the water/alcohol ratio or the concentration and type of surface-active agent. Different propellants can also affect foam properties, as can the active ingredients that are added.

The stability of the aqueous alcohol foams depends upon the presence of solid particles of the surface-active agent between the gas bubbles which prevents coalescence of the bubbles. This situation can occur only if the surface-active agent is essentially insoluble in the aqueous alcohol concentrate. The solubility of the surface-active agent in the concentrate, therefore, is one of the main factors that governs the stability of the aqueous alcohol foams. Increasing the concentration of alcohol beyond a certain point or increasing the temperature will destroy the foaming properties of the aqueous alcohol system. The reason for this is that the surface-active agent becomes soluble in the aqueous alcohol concentrate under these conditions.

One of the unfortunate properties of the aqueous ethyl alcohol system formulated with "Polawax" as the surface-active agent is that although the system may be crystal clear at room temperature, the "Polawax" will separate from solution if the product is cooled slightly below room temperature. This results in an unattractive package, and for this reason most aqueous alcohol foam products are packaged in opaque glass bottles.

Nonaqueous Foams

Thus far, there have been essentially no products on the market based upon the nonaqueous foam systems. To a considerable extent this is because these foams are relatively new. However, these foams have quite unique properties and the future should see a whole series of cosmetic and pharmaceutical products based upon the nonaqueous foam systems. Since these foams do not contain water, they are particularly useful for active ingredients that are sensitive to moisture. The nonaqueous foams can be formulated either with glycols or mineral oil as the continuous phase.[14,15]

The composition of a simple, nonaqueous foam based upon propylene glycol is given in Table V.

Table V
Nonaqueous Propylene Glycol Foam

	wt. %
Propylene Glycol	87.0
"Polawax"	3.0
Freon® 12/Freon® (40/60) Propellant	10.0

Propylene glycol and the propellant are not miscible and, therefore, the system consists of an emulsion of propellant droplets dispersed in propylene glycol. Propylene glycol foams are stable for weeks, partially because propylene glycol has a low rate of evaporation. The propylene glycol foams are very dense and creamy.

The properties of the glycol foams are determined by the type of glycol, surface-active agent and propellant that are used. Propylene glycol is particularly desirable as a base because it is low in toxicity and gives excellent, stable foams. Many other glycols give good foams. Surfactants other than "Polawax" can also be used. One of the requirements for a surface-active agent to be effective is that it must be insoluble in the

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glycol that is used. The product will not foam if the surface-active agent is soluble in the glycol.

The second nonaqueous foam system is formulated with mineral oil as the base. Mineral oil is used in many nonaerosol cosmetic and pharmaceutical products, and the nonaqueous mineral oil foams should be useful for these types of products.

Mineral oil is miscible with the propellants and the mineral oil foam system, therefore, differs from the propylene glycol system in this respect since the latter is an emulsion system.

The composition of a typical mineral oil foam is given in Table VI.

Table VI
Composition of a Mineral Oil Foam

	wt. %
Mineral Oil	81.0
Cetyl Alcohol	2.0
Stearyl Alcohol	2.0
Freon® 12 Propellant	15.0

The mineral oil foams are comparatively thin and unstable compared to the glycol foams. The properties of the foams depend upon the mineral oil, surface-active agent, and propellant that are used. High viscosity mineral oils generally produce more stable foams than the lower viscosity oils. A variety of surface-active agents can be used including the polyoxyethylene fatty ethers. Although it is not necessary for the surface-active agent to be insoluble in the solution of mineral oil and propellant, the surface-active agent must be insoluble in the mineral oil alone in order to produce a foam. Since the mineral oils are miscible with the propellants, they serve as vapor pressure depressants. Therefore, 10-15% of Freon®. 12 alone is used as the propellant in order to provide sufficient pressure.

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