Chapter 10

Shampoos, Conditioners, and Styling Aids

Key Terms

Amphoteric surfactants
Anionic surfactants
Cationic surfactants
Chlorofluorocarbons
Detergent
Emulsions
Fatty alcohols
Fatty materials
Hydrogen bonding
Hydrophilic
Hydrophobic
Inverse micelles
Lipophilic
Lipophobic
micelle
Nonionic surfactants
Oil-in-water emulsions
SD (alcohol)
Silicones
Soaps
Surface tension
Surfactant
Volatile alcohols
Volatile organic compounds
Water-in-oil emulstions

Learning Objectives

After completing this chapter, you should be able to:

- Understand and explain the chemistry of shampoo.
- Describe the relationship among soaps, detergents, and surfactants.
- Explain how wetting improves product performance and chemical services.
- List the basic types of surfactants.
- Define ions.
- Understand folklore chemicals and why they are used.
- Describe the purpose for each ingredient in shampoos and conditioners.
- Understand hydrogen bonding and surface tension.

INTRODUCTION

Shampoos, conditioners and styling aids are emulsions. **Emulsions** (ee-MUL-shuns) are mixtures of two immiscible liquids (usually oil and water) dispersed by an emulsifying agent. The term *emulsify* means "to form an emulsion," which is a mixture of one liquid dispersed in another (Chapter 8, General Chemistry). Since water is the major ingredient in most of the emulsions a hairstylist uses, let's begin our study of emulsions by examining the properties of water that are essential to understanding emulsions.

WATER IS POLAR

The earth is *polar,* which means it has both a north and a south pole with opposite magnetic charges. Water is also polar, which means it has opposite electrical charges at opposite ends of its molecule (Figs. 10-1 and 10-2). The hydrogen end

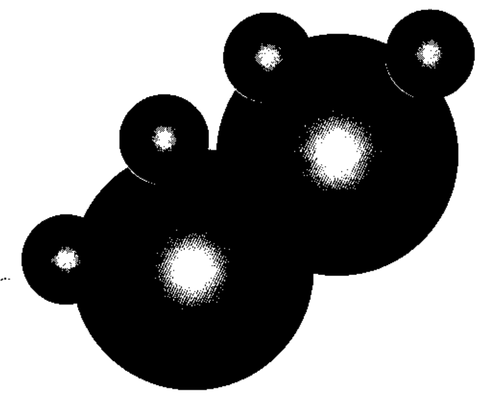

Figure 10-1 *Three dimensional representation of water molecules.*
(Reprinted with permission of Padi Americas)

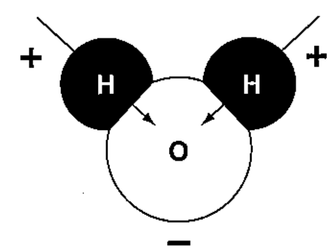

Figure 10-2 *Water molecule showing a positive charge on the hydrogen end and a negative charge on the oxygen end.*
(Reprinted with permission of Padi Americas)

of a water molecule has a slight positive charge and the oxygen end of a water molecule has a slight negative charge.

Hydrogen Bonding and Surface Tension

Since opposites attract, the positive (hydrogen) end of one water molecule is attracted to the negative (oxygen) end of another water molecule. This attraction between water molecules is a special type of ionic bonding called **hydrogen bonding** (Figure 10-3). Hydrogen bonding is like "sticky glue" that holds water molecules together. This attraction between water molecules is called **surface tension**. Surface tension tends to minimize the surface area and acts like a flexible skin on the surface of water. Surface tension permits insects to "walk" on the surface of water and causes water to be shaped in a spherical drop (Figure 10-4).

Water has the ability to dissolve many polar substances because of its polar nature. Since "like dissolves like," water acts as a solvent for most other ionic substances, as well as those that have the ability to hydrogen bond. Substances that dissolve in water are **hydrophilic** (hy-droh-FIL-ik), which means water loving, from "hydro" (water) and "philic" (love).

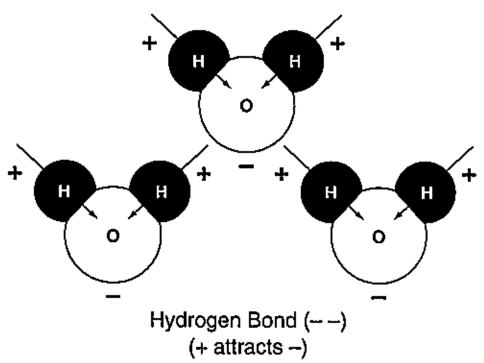

Figure 10-3 *Water molecules showing hydrogen bonding due to opposite electrical charges on the water molecules.*
(Reprinted with permission of Padi Americas)

Figure 10-4 *Drops of water showing the effects of surface tension and the lack of "wetting".*
(Courtesy: Unilever Ltd.)

OILS ARE NONPOLAR

Oils are nonpolar, have no electric charge and do not hydrogen bond. Oils mix with oils, but do not mix with water. Oils are **lipophilic** (lip-oh-**FIL**-ik), which means oil loving, from "lipid" (oil) and "philic" (love). Although water is called the universal solvent, it can't dissolve oils. You have probably heard the saying, "oil and water don't mix."

Not only do oil and water not mix, water actually repels oil because of hydrogen bonding and surface tension. So in addition to water being hydrophilic (water loving), water is also **lipophobic** (lip-oh-**FOH**-bik), which means oil hating, from "lipid" (oil) and "phobic" (hating). Conversely, oil is lipophilic (oil loving) and is also **hydrophobic** (hy-droh-**FOH**-bik), which means water hating, from "hydro" (water) and "phobic" (hating).

SURFACTANTS

Now that we know why oil and water don't mix, let's see how surfactants overcome those obstacles to form an emulsion. The name **surfactant** (sur-**FAK**-tant) is a contraction for surface active agent (**surf**ace **act**ive age**nt**). Surfactants are able to wet the hair and disperse oil in water by reducing surface tension. A surfactant molecule has two distinct parts that make the emulsification of oil and water possible (Fig. 10-5). One end of the surfactant molecule is hydrophilic (water loving) and the other end is lipophilic (oil loving). Since "like dissolves like," the hydrophilic end dissolves in water and the lipophilic end dissolves in oil. So, a surfactant molecule dissolves in both oil and water and joins them together.

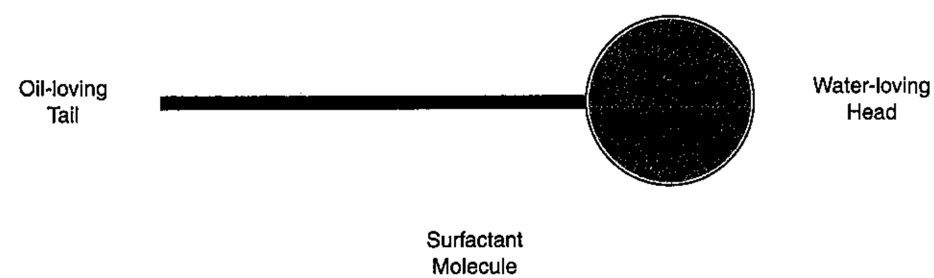

Figure 10-5 *Surfactant molecule showing an oil-loving tail and a water-loving head.*

SHAMPOO

Shampoo sinks aren't the most glamorous spot in the salon, but that's where a lot of the action is. The success or failure of many chemical services depends on using the proper shampoo.

Proper shampooing and conditioning are among the most important services performed in the salon. Too often clients are passed quickly through this essential process. Proper cleansing of the hair is vital and should not be underestimated.

Imagine allowing three or four minutes to cleanse and thoroughly rinse 100,000 individual hair fibers with over 40 square feet of hair on the average head.

Thanks to surfactants, a marvel of modern chemistry, the hair and scalp can be gently and safely cleansed.

SHAMPOO CHEMISTRY

Oils, such as sebum, are insoluble in water. Sebum combines with dead cells from the scalp, dust, pollen, smoke, and other environmental contaminants to form a sticky, oily coating on the hair and scalp. It is difficult to remove oils or other water-insoluble substances from the hair. It is much like trying to rinse Vaseline from a cashmere sweater (Figs. 10-6–10-8).

Figure 10-6 *Normal clean hair, magnified 5,000 times.*
(Courtesy: *Gillette Company Research Institute,* Rockville, Maryland)

Figure 10-7 *Normal hair with accumulated sebum and debis, magnified 7,500 times.*
(Courtesy: *Gillette Company Research Institute,* Rockville, Maryland)

Figure 10-8 *Normal hair with dandruff flakes adhering to fiber, magnified 1,200 times.*
(Courtesy: *Gillette Company Research Institute,* Rockville, Maryland)

Soaps

Detergent is a Latin word for a "wiping-off substance." **Soaps** are the most common types of detergents. Records of their use date back 5,000 years to the ancient Babylonians. Soaps are made by mixing plant oils or animal fat with strong alkaline (basic) substances. Typically, coconut oil, palm oil, castor oil, and/or olive oil are used in soaps.

Soaps have several disadvantages. They combine with hard water to form stubborn, insoluble films. These films coat and dull the hair. Also, the high alkalinity of soap has a negative effect on hair and skin. Small amounts of soap are still used in modern shampoos but only as thickeners or to give a pearlescent look.

Surfactants

These unique molecules prove that "natural" is not always better. In fact, chemistry often provides great improvements upon nature. Surfactants are designed to be mild and easily rinsed from the hair.

Surfactants work by getting between the surface of the oil and water. Surfactants are happiest when they are at the oil and water interface (the boundary where oil meets water). They flood into the interface and concentrate there (Figs. 10-9–10-12).

The "water-loving," hydrophilic head penetrates into the water portion of the interface. At the same time, the "oil-loving," lipophilic tail pokes in the oily substances on the hair. The result is that the oil makes a bead and floats off the hair shaft (Figs. 10-13–10-17).

This bead of oil is completely surrounded by surfactant molecules that form a sphere called a **micelle** (**MY**-cell) (Figure 10-20). Thanks to the surfactant, this

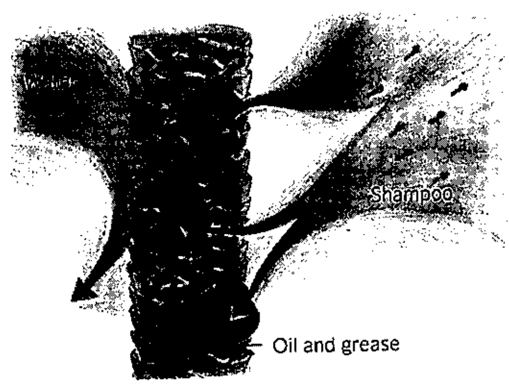

Figure 10-9 *Tail of shampoo molecules is attracted to hair, grease, and dirt.*

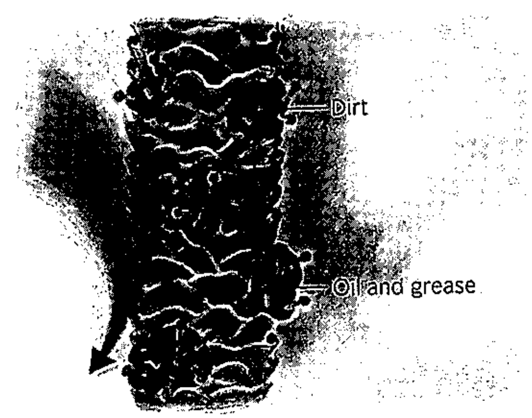

Figure 10-10 *Surfactant molecules collect at the oil/water interface, causing the oil to form a bead.*

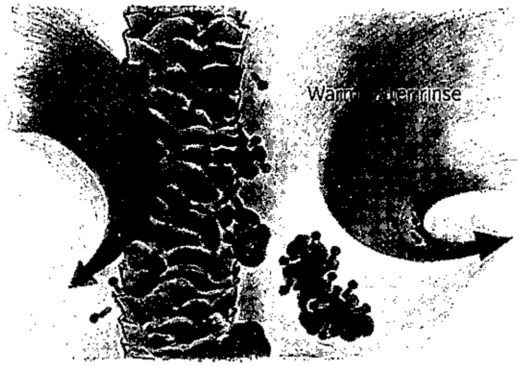

Figure 10-11 *Rinsing with water dislodges the beads of oil and debris from the hair shaft.*

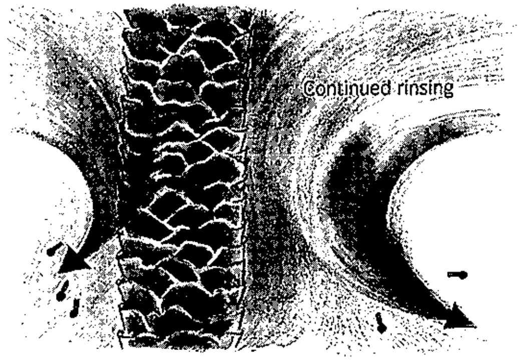

Figure 10-12 *Continued rinsing is necessary to remove remaining surfactant molecules.*

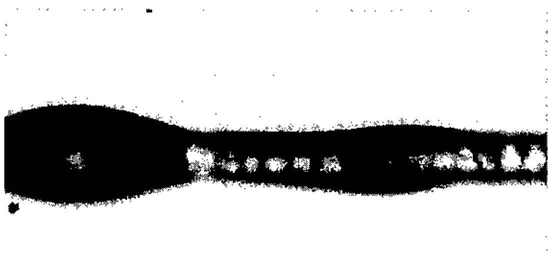

Figure 10-13 *Oil coated hair.*
(*Courtesy: British Launderers Research Association*)

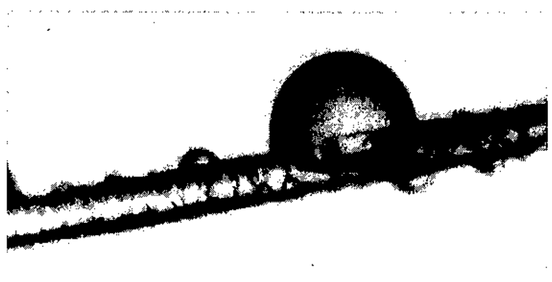

Figure 10-14 *Oil bead is starting to form.*
(*Courtesy: Dr. J A. Kichener, Royal College of Science*)

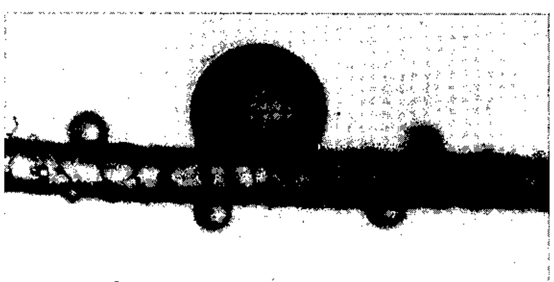

Figure 10-15 *Bead has less contact with the surface of the hair shaft.*

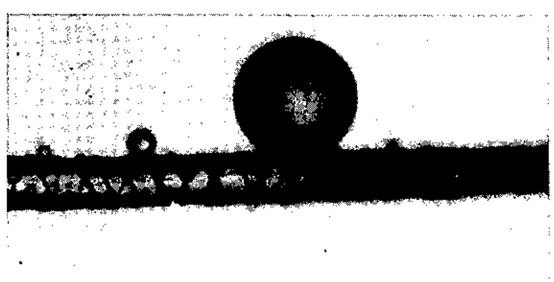

Figure 10-16 *Oil bead is barely touching the hair shaft.*

Figure 10-17 *Oil floats away, leaving hair clean.*

droplet of oil is now emulsified (dispersed) in water, within the micelle, until more water can rinse it away. When the hair is rinsed, the emulsified oil and dirt that are bound to the water are carried away with it.

Gentle massaging of the scalp and hair is important. Massaging helps the surfactant remove the oily emulsions. This process, along with the proper wetting techniques, allow the product to penetrate the hair shaft and work more efficiently (Fig. 10-18).

We have all seen shampoo advertisements showing happy, beautiful people taking showers with their heads heaped high with mounds of lather. These images have taught the public to associate lather with cleansing ability. The truth is, lots of foamy lather only means too much shampoo is used. Excess foam equals waste!

Sebum and other oils quickly destroy foam. Ideally, the head should have just enough lather to lubricate the scalp and hair. This will help your fingers massage the shampoo more effectively into the hair.

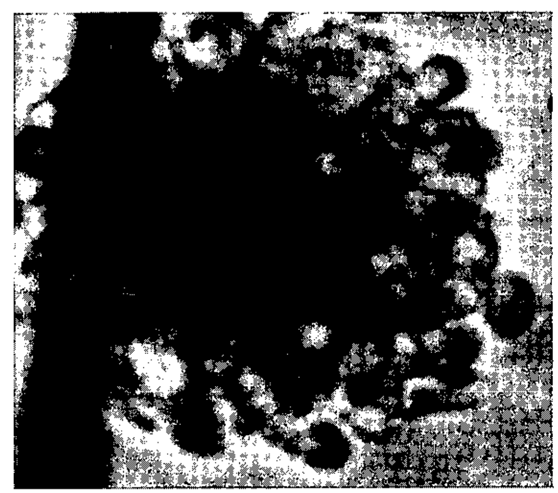

Figure 10-18 *The action of a shampoo on dirt particles attached to a fiber. The surfactant molecules surround the dirt and help to lever it off with the aid of proper rinsing.*
(Courtesy: British Launderers Research Association)

LATHER UP!

People expect a lot from shampoos. Unfortunately, it isn't always easy to tell a good shampoo from a poor one. Cost, fragrance, and lots of foam is what most people look for in shampoo.

Lather or foam is of little importance, but it often gets the most attention. Foaming occurs when surfactant molecules gather around air instead of oil. The result is millions of tiny bubbles. Obviously, the air bubbles are using the surfactants that should be removing dirt and oil (Figure 10–19).

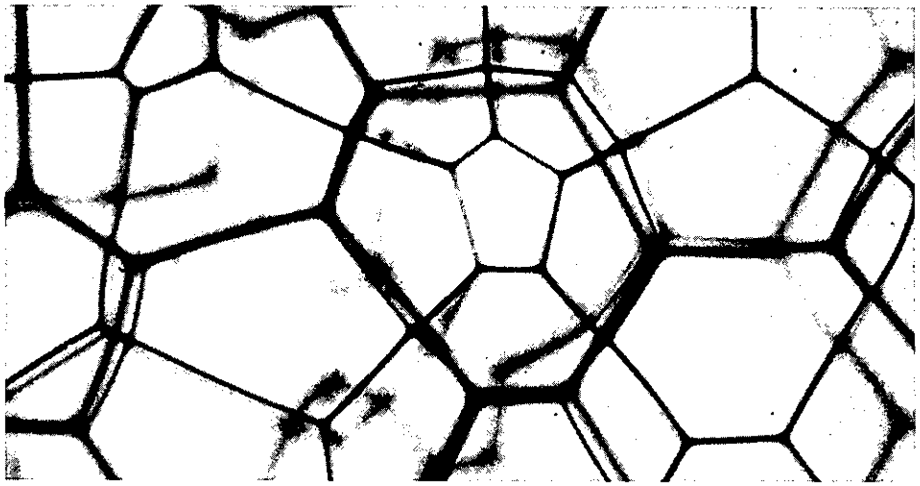

Figure 10-19 *A magnified view of foam bubbles.*
(Courtesy: Dr. J. A. Kichener, Royal College of Science)

Fragrances and foaming qualities are not good ways to evaluate shampoos. Examine the hair condition after several uses. Is it flyaway, is it hard to comb, does it seem limp, do the colors fade, is the hair dry or the scalp itchy?

Carefully choose the shampoo to use and recommend. The quality of your services and the success of your repeat business may depend on the decision of product choice.

All surfactants aren't detergents. Many surfactants do not clean well enough to be used as a detergent but are still essential to the formation of emulsions. Different surfactants perform different functions and serve many purposes. Surfactants are used as detergents, wetting agents, emulsifiers, stabilizers, foam builders, conditioners, thickeners, and pearling agents. All soaps and detergents are surfactants, but all surfactants aren't soaps or detergents.

Emulsions

An **emulsion** is a mixture of one liquid dispersed in another. One of the liquids is usually oil and the other is usually water. These two immiscible liquids form two distinct phases. The two most common types of emulsions are oil-in-water (O/W) and water-in-oil (W/O).

Oil-in-Water (O/W) Emulsions

In **oil-in-water emulsions**, droplets of oil are dispersed in water. The droplets of oil (micelles) are surrounded by surfactants with their "tails" (lipophilic ends) pointing in and their "heads" (hydrophilic ends) pointing out, which keeps the oil dispersed in water (Fig. 10-21). In O/W emulsions, the water is the continuous or external phase and the oil is discontinuous or internal phase (Figure 10-

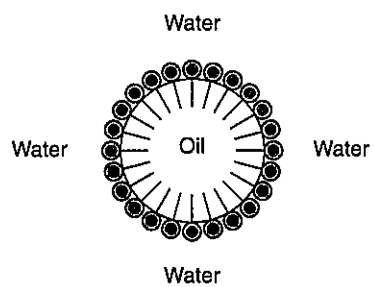

Figure 10-20 *This representatation of a micelle shows a drop of oil surrounded by water.*

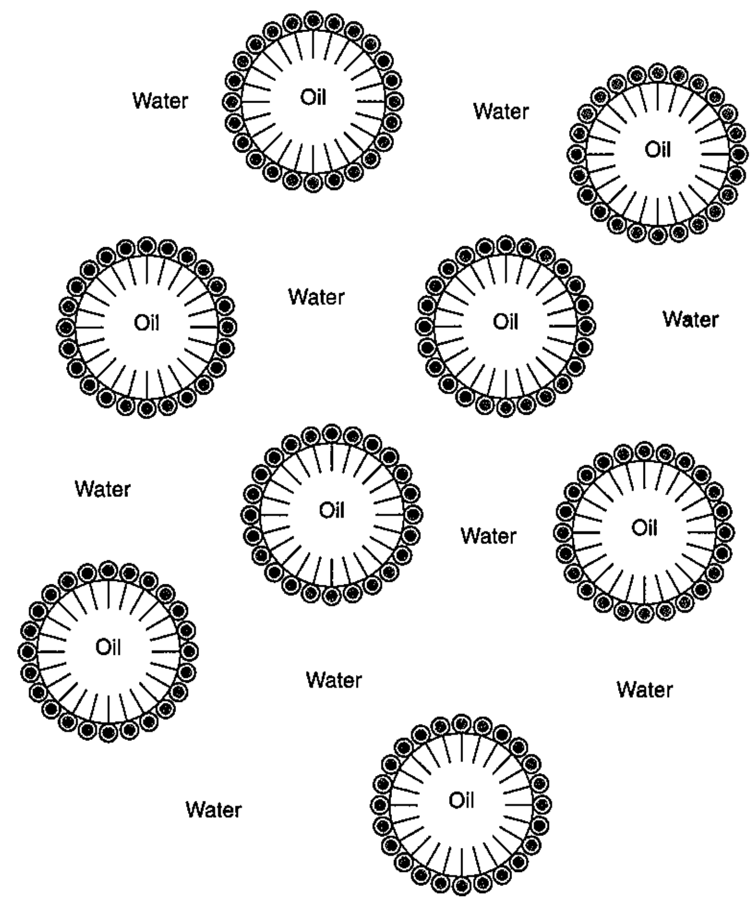

Figure 10-21 *Many micelles form an oil-in-water emulsion with droplets of oil suspended in water. Oil is the internal phase and water is the external phase.*

21). Oil-in-water emulsions usually contain a small amount of oil and a greater amount of water. Most of the emulsions used in a salon are oil-in-water.

Water-in-Oil (W/O) Emulsions

In a **water-in-oil emulsion**, droplets of water are dispersed in oil. The droplets of water (**inverse micelles**) are surrounded by surfactants with their "heads" (hydrophilic ends) pointing in and their "tails" (lipophilic ends) pointing out. (Fig. 10-22). In W/O emulsions, the oil is the continuous or external phase and the water is discontinuous, or internal phase (Figure 10.23). Water-in-oil emulsions usually contain a smaller amount of water and a greater amount of oil. Cold creams are water-in-oil emulsions.

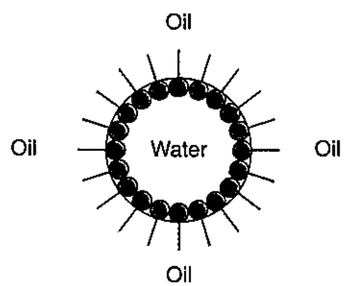

Figure 10-22 *This representation of an inverse micelle shows a droplet of water surrounded by oil.*

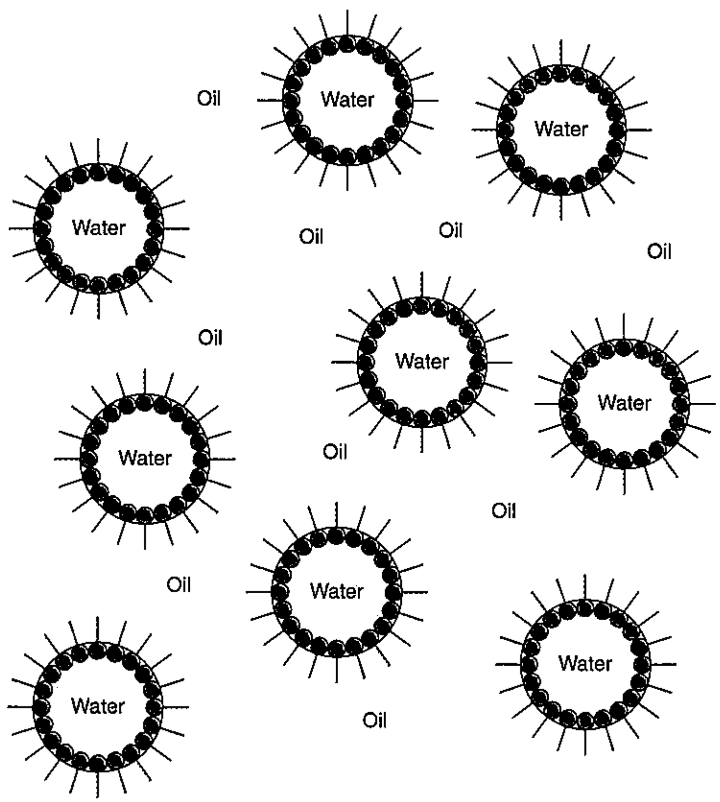

Figure 10-23 *Many inverse micelles from a water-in-oil emulsion with droplets of water suspended in oil. Water is the internal phase and oil is the external phase.*

Multiple Phase (W/O/W) Emulsions

Multiple phase emulsions have more than two phases. In a water-in-oil-in-water (W/O/W) emulsion, a two-phase W/O emulsion is dispersed in water. Multiple phase emulsions are able to encapsulate active ingredients to reduce skin irritation and provide longer shelf life. On dilution during rinsing, encapsulated particles break apart and deposit active ingredients on the hair and skin.

Microemulsions

Microemulsions have a small micelle size. Standard emulsions, without adding coloring, are usually white because of the refraction of light by the micelles, but microemulsions are transparent because their micelles are too small to be "seen" by light. The white, titanium dioxide sunblock usually worn by lifeguards, can now be completely transparent because of the technology of microemulsions.

Liposomes

Liposomes (**LYE**-poh-sohmes) are water compartments (vesicles) enclosed by a lipid bilayer (two-layer micelles). These two single layers have their hydrophobic "tails" facing each other and their hydrophilic "heads" facing the water. This structure is similar to the cell membrane that encloses all the cells of the body. Like microemulsions, liposomes have the ability to separate active ingredients, which keeps them stable and aids in the delivery of active ingredients.

The major types of surfactants are:

Anionic (an-eye-**ON**-ick)

Cationic (kat-eye-**ON**-ick)

Nonionic (non-eye-**ON**-ick)

Amphoteric (am-fo-**TERR**-ick)

Anionic Surfactants (Negatively Charged)

Anionic surfactants are the most widely used detergents in the cosmetology profession. They are inexpensive, simple to prepare, and excellent cleaners. They also rinse easily from the hair. A major disadvantage is that they can be harsh and irritating to the scalp. Frequently, other surfactants and ingredients are added to reduce skin irritation.

Cationic Surfactants (Positively Charged)

Cationic surfactants are rarely used in high concentrations in the cosmetology profession. Many types are dangerous to the eyes, but are safe and useful in low amounts. Until recently, their positive charges prevented them from being mixed with negatively charged anionic surfactants. Newer types, however, eliminate this incompatibility.

Cationic surfactants are antibacterial. Because of their positive charge, they form ionic bonds (salt bonds) with the negatively charged surface of the hair. (Hair has a multitude of ionic bonds. The negative ions outnumber the positive; therefore, the surface of the hair carries a negative charge.) The result is better wet combing, softness, and gloss. The most important cationic surfactants are quaternary ammonium compounds, referred to as "quats." Quats are substantive (resist being rinsed away) because of their positive charge that attracts and bonds them to negatively charged hair. Quats are excellent conditioners that improve wet combing, reduce static electricity, and improve flyaway hair.

Nonionic Surfactants (No Charge)

Nonionic surfactants have neither a positive nor a negative charge. Once again, the name tells you something about the nature of these chemicals. By themselves, they are not useful as cleansing agents, but nonionic surfactants are found in

SAPONINS—NATURE'S SURFACTANTS

Saponins (**SAP**-uh-nins) are an unusual set of nonionic surfactants. Saponins are called natural surfactants because they are the only ones found in nature. Plants like soapbark, soapwort, sarsaparilla, and ivy contain large amounts of this chemical.

Sound pretty wonderful, don't they? The interesting thing about saponins is that they are terrible surfactants. Saponins proved to be such poor cleansing and conditioning agents, they were not used for many years. Even though these natural surfactants are useless, the craze for natural ingredients has caused some manufacturers to include them in shampoo products.

This is just one example of a *folklore ingredient.* Many shampoos contain folklore ingredients. Folklore is defined as traditions or beliefs passed on by word of mouth. These beliefs are not based on scientific fact. Sometimes, science can verify the belief, but usually, they are proven untrue.

Many natural ingredients used in shampoos and conditioners are folklore chemicals. Generally, there is no scientific evidence to back up the claims made for these ingredients.

For example, the ancients believed that rosemary oil strengthened the memory and kept lovers faithful. Modern wisdom says that it enhances the highlights and stimulates hair growth. The truth is rosemary oil is a toxic skin and eye irritant.

The public incorrectly assumes anything "natural" must be good. Names like cucumber juice, nettle, or goldenrod extract dupe a consumer into paying more for insignificant amounts of fancy-sounding herbs or botanical extracts.

Don't buy a product just because it has exotic-sounding ingredients. Buy a product because it works better.

nearly all shampoo formulations. Usually, they are added to make anionic surfactants milder and less irritating.

Amphoteric Surfactants (Positively or Negatively Charged)

The charge on an **amphoteric surfactant** depends entirely upon the shampoo's pH level. At low pHs (less than 5 or 6), they are positively charged, like cationic surfactants. At higher pHs, they become negatively charged, like anionic surfactants. In between the high and low pH value, they have no charge, like nonionic surfactants.

This versatility makes amphoteric surfactants extremely useful. They have the conditioning properties of cationic surfactants but have a lower skin sensitivity and eye irritation. These surfactants are often found in nonstinging or baby shampoos. They are more costly than anionic surfactants and don't cleanse as well, but they make excellent additions to high-quality shampoos.

Ethoxylated Surfactants

Ethoxylates are formed by the addition of ethylene oxide to a fatty material. **Ethoxylated surfactants** decrease skin and eye irritation and increases solubility. Sodium laureth sulfate is an ethoxylated version of sodium lauryl sulfate. Other common ethoxylates are octoxynol-40, nonoxynol-10 and polysorbate 80.

Typical Shampoo Formulations

Water

Shampoos in gel, cream, or liquid states need large amounts of water to keep all of the ingredients dissolved. Water is the solvent in shampoo. Typically, between 45 and 75 percent of the content is water.

Surfactants

Surfactants make up between 30 and 40 percent of a shampoo's content. As mentioned previously, it is common to use blends of three or four different surfactants.

Foam Builders and Stabilizers

The purpose for adding foam builders and stabilizers is to create large amounts of thick, creamy-feeling bubbles. Although the effect is only cosmetic, small amounts of foam do help a person spread the shampoo through the hair.

Antistatic Detanglers

Detanglers are usually low concentrations of cationic surfactants that coat the hair shaft and improve wet combing. They also reduce static and flyaway hair.

Thickeners

Thickeners help control the final thickness of the shampoo. With so much water content, shampoos would be thin without thickeners. The major types of thickeners used are plant gums and synthetic polymers. Thickeners are also used to make gels. These additives prevent ingredients from settling to the bottom of the bottle.

Conditioners

Conditioners are the ingredients that add shine, gloss, and emollience to the hair. Some also act as moisturizers.

Chelators (Sequestrants)

Chelate (KEE-late) means "claw" in Latin. The chemical structure of chelators have clawlike branches. The claw grabs and holds the calcium or magnesium ions found in water. These ions are the reason for hard water. The more of these ions found in the water, the harder the water. Calcium and magnesium ions cause soap film (the deposits on shower walls and bath tubs). Chelators prevent films from depositing on the hair shaft.

Opacifiers and Pearling Agents

The disadvantage of clear shampoos is that many useful additives can't be used. They would cloud the product or make it look unattractive. Cremes and opaque products offer the widest range of possibilities. Formulators are less restricted and can add an extensive variety of ingredients. *Opacifiers* cover up cloudiness or unattractive colors. *Pearling agents* give a "pearlescent" texture to shampoos.

Preservatives

Many shampoo and conditioner ingredients provide a source of food for mold or bacteria. *Preservatives* inhibit their growth and improve the shampoo's shelf life. Without preservatives, shampoos would not be as safe. For example, certain types of bacteria produce toxins that damage the eyes or can cause blindness.

Some individuals develop allergic sensitivities to preservatives, but the advantages of preservatives far outweigh any occasional problems. Thanks to preservatives and the care taken by manufacturers, shampoos and conditioners are some of the safest cosmetic products available. If reactions or other problems occur, consult the shampoo Material Safety Data Sheet (MSDS) and refer to a dermatologist.

Fragrances and Coloring

Fragrance and coloring make up less than one percent of the shampoo formula but are responsible for over 90 percent of shampoo sales. Neither ingredient is necessary or useful beyond improving appearance and odor. Never choose a shampoo simply because it smells good or has a pretty color.

Common Shampoo Ingredients

Shampoos are oil-in-water emulsions designed to clean hair and skin with minimum damage and irritation. Some of the more common ingredients are listed in the table below along with their function. Many ingredients have dozens of minor variations, far too many to list here. Sodium sulfate/ammonium sulfate, lauryl sulfate/laureth sulfate, and cocamide MEA/cocamide DEA are examples of similar ingredients with similar names.

The only way to learn about the products you use is to read the back of the bottle. Although at first it may seem impossible, it doesn't take long to learn to recognize the most common ingredients. Once you can identify the top ten, you will be amazed at how similar many of the products you use really are. Shampoos, liquid hand soaps, and bubble baths all clean hair and skin and contain many of the same ingredients. Lists of product ingredients can be found in Appendix F.

Function	Ingredient
Diluent	Water
Primary Surfactants (Detergents)	Sodium Lauryl Sulfate, Ammonium Laureth Sulfate TEA Sulfate
Secondary Surfactants	Cocamidopropyl Betaine, Lauryl Polyglucose, Sulfosuccinate, Isethionate, Hydroxysultaine
Foam Stabilizers	Cocamide DEA, Lauramide DEA
Viscosity Builders	Sodium Chloride, Ammonium Chloride
Pearling Agents/ Opacifiers	Glycol Distearate,
Thickener/Stabilizer	Hydroxyethyl Cellulose, Gum Arabic, Acacia, Sodium Algenate, Carrageenan, Chitin, Guar, Xanthan, Vegum, Carbomer 940, Silicates, PEG
Preservative	Methylparaben, Propylparaben, Methylisothiazolinone,
Sequestrant/Chelator	EDTA, Sodium Citrate, Trisodium Phosphate
Anti-Dandruff	Zinc Pyrithione, Salicylic Acid, Sulfur, Coal Tar, Menthol

CONDITIONER CHEMISTRY

Surfactants are better than soap but still aren't perfect. They can't remove only the dirty oil and leave the oils essential for healthy hair. Since daily shampooing may cause excessively dry hair, regular conditioning will help the hair regain much of its lost shine and body.

Other factors influence the condition of the hair and scalp. Chemical damage results from permanent wave lotion, excessive bleaching, peroxide, color, blow dryers, medicated shampoos, and exposure to weather. Air pollutants, wind, sea, and chlorinated pool water also can cause damage to the hair shaft.

Sunlight is very damaging and causes significant damage to the hair, even to virgin hair. Damaged hair looks lifeless and dull. It breaks more easily, is more porous, and dries more slowly.

It is optimistic to believe that any conditioner will repair damaged hair. The best we can hope for is to restore hair's natural appearance and feel. The hard keratin surface of hair is a tight mesh of cuticles. The outer layers are very *hydrophobic*, especially on virgin hair. This prevents most conditioning agents from deeply penetrating the hair shaft. In most cases, a conditioning agent merely coats and lubricates the outer hair shaft. This causes consumers to believe the hair is healthier, when actually it only has a slippery-feeling texture.

Little can be done to truly improve the condition of virgin hair. However, damaged hair is more porous and absorbs larger amounts of conditioning chemicals.

This does not mean that conditioners are unnecessary or useless. They can significantly improve the appearance and manageability of hair. A well-formulated conditioner can improve the hair's life, volume, spring, sheen, softness, and manageability, and reduce static flyaway. However, it is important to realize that these improvements do not mean the hair has been restored to its original health.

Conditioning shampoos have some value but are limited in performance. Adding heavy or deep conditioning agents to shampoo interferes with the action of the shampoo and actually traps debris on the hair shaft (Fig. 10-24).

Dry-formula shampoos contain moisture-attracting chemicals that increase the water content of damaged hair. Fine/limp hair shampoos frequently depend on polymers or other materials that coat the hair with a thin film. These films add body and bounce, however, they may build up with repeated use.

Since we've already learned so much about shampoo ingredients, learning about conditioners will be easy. Hair conditioners can really be thought of as

Figure 10-24 *Hair soiled with excess hair cream, which must be removed by shampoo.*

inverted shampoos. Most shampoos contain a large amount of surfactant and a small amount of fatty material (conditioner). On the other hand, most hair conditioners contain a large amount of fatty material (conditioner) and a small amount of surfactant. Yes, conditioners contain surfactants, often the same ones used in shampoos. Without surfactants, conditioners wouldn't lather and couldn't be rinsed from the hair.

In addition to the surfactants already discussed in shampoos, a well-designed conditioner contains the following types of ingredients:

Protein and Protein Derivatives

Since proteins are long chains containing hundreds of amino acids, it is nearly impossible for them to penetrate the hair shaft. There is some chance that damaged, porous hair will absorb useful amounts of protein, but damaged hair cannot be reconstructed from additives. Some studies indicate that small proteins help seal split ends and prevent them from getting worse. In general, the smaller the protein and the greater hair damage, the more absorption.

Concentrated protein conditioners are used to increase the tensile strength of the hair and to temporarily close split ends. These conditioners use hydrolized protein (small fragments) and are designed to pass through the cuticle, penetrate into the cortex, and replace the keratin that has been lost from the hair. They improve texture, equalize porosity, and increase elasticity.

Fatty Materials

Hair conditioners improve wet combing and make hair feel soft by depositing **fatty materials** on the hair. Fatty materials are the backbone of many conditioners. Most conditioners contain large amounts of several different types of fatty materials.

Figure 10-25 *Hair with attached dirt particles, dandruff scales, sebum coating.*

Figure 10-26 *Same hair after cleaning with a mildly acid soapless shampoo.*

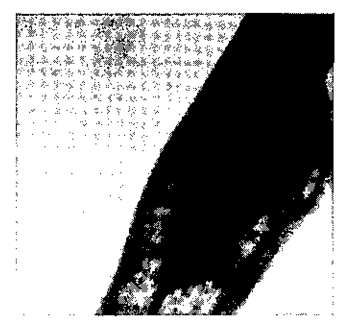

Figure 10-27 *Hair after continued washing with highly alkaline soap.* Note *swelling and severe damage to shaft.*

Fatty Alcohols

When most consumers think of alcohol, they think only of small, light-weight, volatile alcohols like methyl alcohol (wood alcohol), isopropyl alcohol (rubbing alcohol), and ethyl alcohol (alcoholic beverages). But those aren't the only kinds of alcohols. **Fatty alcohols** are large, non-volatile oils, fats or waxes, which contain an alcohol group, and are used as conditioners. Cetyl alcohol, cetearyl alcohol, stearyl alcohol, and myristyl alcohol are some of the most common fatty alcohols.

Silicones

Silicones (SIL-ih-kohnz) are oils that contain a repeating silicon-oxygen chain. Silicones belong to a family of chemicals called polysiloxanes. Silicones are superior to their plain oil counterparts because they are less greasy and form a "breathable" film that is non-comedogenic. Amodimethicone, cyclomethicone and dimethicone are examples of silicon conditioners.

Humectants

Unique chemicals called *humectants* absorb water and hold it tightly. Humectants are used to keep many products from drying out. They are also used in skin and hair care products, i.e., damaged or dry hair shampoos. Humectants act like microscopic sponges, attracting moisture to the skin and hair. Common humectants such as sodium PCA, sodium lactate, and glycerin, are found in conditioners.

Moisturizers

The term *moisturizer* is applied freely to many ingredients. Since only water can moisturize, it is a misleading name for substances other than water. Frequently, moisturizers refer to oily substances (not water soluble) that coat the hair (or skin), preventing water loss by evaporation. Lanolin, mineral oil, and cholesterol are examples of water-trapping additives found in many conditioners and other types of cosmetic products.

Naturals, Botanicals and Vitamins

Many consumers believe that botanical ingredients are healthier, more natural and more effective, even though there is no scientific evidence to support those claims. There is no formal definition of the term "natural." And natural does not always mean better or safer. Poison ivy is natural, but I wouldn't want it in my shampoo. Natural gas is a colorless, odorless, toxic gas. The pungent odor associated with natural gas is added as a warning, so that its presence can be detected. Even chemicals that have no smell may not be safe.

Essence of chamomile, rose hips, and yarrow may sound great, but in reality these are solutions of mostly water. There is no scientific evidence to indicate that botanical ingredients are any more effective than chemicals from other sources. Botanicals are processed and preserved and contain solvents, diluents, and other unknown ingredients that may not even be listed on the product label.

According to Donald A. Davis, the editor of *Drug and Cosmetic Industry Magazine*, "By their very nature, cosmetics have to build upon the expectations, dreams and wish fulfillment of those who buy and use them. The gap between what is promised and what is really attainable unduly abuses credibility. They throw into disrepute some serious technological advances now being made in an industry that was too long noted for the shallowness of its scientific curiosity about the workings of the skin and hair."

Styling Aids

The two main types of styling aids are setting lotions (gels) and hairsprays. Both setting lotions and hairsprays hold hair in place by depositing a flexible film of polymeric resins. Setting lotions are usually applied to wet hair and then dried, while hairsprays are usually applied to dry hair after styling.

A good styling lotion should increase body and volume and improve hold. It should also comb easily, not be sticky, be quick drying, and not flake when brushed. Since most modern styling lotions are emulsions, many of the ingredients are the same ones found in shampoos and conditioners. The main ingredients in setting lotions are polymeric resins, thickeners, nonionic surfactants, fragrances, preservatives and sometimes alcohol.

Conditioning gels and leave-in conditioners have the same basic formula, but the polymeric resin is usually replaced with a cationic conditioning polymer. Protein derivatives and quats may also be added as conditioning agents.

Polymeric Resins

The most important ingredient in any setting lotion is the *polymeric resin* that provides the hold. The amount of resin used affects the degree of holding power. A higher concentration of resin forms a harder film and firmer hold. The main hair fixative polymers commonly used in setting lotions are: Polyvinylpyrrolidone (PVP), Polyquaternium, PVM/MA Copolymer, and Octylacrylamide/Acrylates.

Nonionic Surfactants

Most setting lotions are emulsions and nonionic surfactants used as emulsifiers. Nonionic surfactants may also soften the resin and provide some conditioning. Examples include Laureth-23, Oleth-20, and Steareth-20.

Alcohols

Although fatty alcohols may be used in some styling lotions for conditioning, **volatile alcohols** are often added to shorten the drying time and increase hold.

Many hairstylists apply hairspray to a roller set to speed-up drying. SD Alcohol is by far the most common volatile alcohol used in setting lotions.

SD (specially denatured) alcohol is ethyl alcohol or ethanol and is the same alcohol found in alcoholic beverages. SD stands for specially denatured. Denaturants are added to ethyl alcohol to make it unsuitable for human consumption. Denaturants have an intensely bitter taste that renders the alcohol unpalatable. Denatured alcohol is not subject to the consumption tax that must be paid if ethyl alcohol is used as a beverage. Although alcohol-free setting lotions are thought to be less drying to the hair, that's not necessarily true. Any dryness caused by alcohol is reversed as soon as the hair is wet.

Hairsprays

Setting lotions are usually applied to wet hair and then dried, while hairsprays are usually applied to dry hair, either as the style is being finished or after the styling has been completed. Setting lotions are mostly water and need not contain any volatile organic compounds. Hairsprays, on the other hand, must contain a majority of volatile organic compounds and a minimum of water, as too much water would wet the hair and ruin the finished hairstyle.

Although there are some variations, the resins used in hairsprays and setting lotions are much the same. The major difference between setting lotions and hairsprays is the amount of water that is used. Hairsprays rely on the use of volatile organic compounds (VOCs) with little water.

Volatile Organic Compounds (VOCs)

The name **volatile organic compounds** (VOCs) describe exactly what these chemicals are. VOCs are two or more elements combined chemically (compounds) that contain carbon (organic) and evaporate quickly (volatile).

Although smog is not a problem in sparsely populated areas, it has become a large problem in cities like Los Angeles. Even though automobile exhaust is the major cause of photochemical smog, VOCs also contribute. In the early '90s, the Environmental Protection Agency (EPA) required the reduction of all VOCs in hairsprays to be less than 80 percent. It should come as no surprise that California regulations are more restrictive. The California Air Resource Board (CARB) now restricts the VOCs in hairsprays to be less than 55 percent. Many manufactures now make the same hairspray in two different formulas, one for California (55 percent) and another (80 percent) for the rest of the United States.

Pump and Aerosol Hairsprays

The most common VOC used in pump hairsprays is SD Alcohol. In addition to SD alcohol, aerosol hairsprays also use other VOCs as propellants. The primary purpose of the propellant is to provide pressure to the gas phase in the can, so that the product can be dispensed simply by pressing the valve. The most common