Shampoos for general use
Family shampoos are required to foam and cleanse the hair well, without excessive detergency, and to provide easy untangling and hair shine while being cost-effective, with an image of softness.

Mild shampoos for frequent use
The development of personal hygiene, practicing sport or exercise, living in a highly polluted city, or humid ambient air result in increasingly frequent shampooing. Regardless of the issue, be it excessive sweating, greasy hair, density of airborne pollutant particles, or coating related to leave-on hair care or dressing products, the need for detergency is not as high when shampooing every second day or less, but high enough for cleansing hair likely more exposed or prone to collect more soil. This type of shampoo is based upon the combination of anionic and amphoteric surfactants selected for suitable mildness and tolerance. Another requirement is fine tuning its conditioning potency (i.e., favoring ease of combing and yielding a beautiful head of hair but without causing any buildup of polymer film deposit and its resulting effect of weighing hair down).

Conditioning shampoos
These shampoos are tailor-made for achieving the dual function of a shampoo and a conditioner. Targeting increasingly high expectations in terms of beautifully changing hair appearance, condition, and touch, they must yield closer to the performance of two separately applied products with distinct functions and abundant water rinsing in between a single operation using a multifunctional product. In addition to cleansing and foaming properties, conditioning shampoos (Figure 19.6) must hold the capacity of correcting fairly efficiently the flaws inherent to some types of hair. The formula of such products is highly sophisticated, requiring subtle adjustment of detergent and conditioning actions to ensure during shampooing both clear soil extraction/dispersion and sequential microdeposit of cationic/silicone polymer softening film along each hair.

Conditioning shampoos for fine hair are designed to provide body, spring, and bounce, whereas dry hairs need easy disentangling, reduced friction, lubrication, and shine. Cationic polymers or PDMS may have a negative impact on the rate of regreasing of greasy hairs post shampooing. Therefore, dedicated shampoos must impart volume and lightness, and delay weighing down by sebum uptake. When targeting dyed or lightened hairs, conditioning shampoos should bring suppleness, control, and easy combing and brushing, and also enhance vividness of the coloring.

Styling shampoos
These aim at helping to impart and sustain a hairstyle post shampooing. Anionic, amphoteric, and nonionic polymers are combined with conditioning high-molecular-weight cationic polymers according to a carefully adjusted measuring out depending on type of hair. PCs with weak ionic charge are favored to avoid excessive bonding to hair and risk of hair being weighed down.

Specific shampoos for scalp condition
Intended for dandruff or greasy scalp, such shampoos aim at clearing scalp conditions and mitigating associated unaesthetical aspects. When developing a shampoo

Ingredient	Amount w/w %
Sodium lauryl ether sulfate	15
Cocoamidopropyl betaine	3
Fatty acid ethanolamide	2
Ethyleneglycol distearate	2
Cationic polymer	0.2
Polydimethylsiloxane	1
Fragrance	0.5
Preservative qsp	
Water	qsp 100
pH adjusted at 7	

Figure 19.6 **Basic formula of a conditioning shampoo. Cleansing base includes anionic and amphoteric surfactants. A thickener and a pearlescent agent are added for foaming consistency, appearance, and quality in use. (Adapted from Tan Tai Ho L; Ho Tan Tai ed. *Formulating Detergents and Personal Care Products: A [Complete] Guide to Product Development*. Urbana, IL: AOCS Press; 2000.)**

for greasy scalp and hair, the prime focus is on defining the most suitable blend of surfactants (i.e., the cleansing base).

Dandruff is a most common scalp disorder, shared by about 45% of the human population, irrespective of gender and ethnicity,[8] mainly in large urban cities, where psychological stress is prevalent. The central inducer of this scaly disorder is the resident yeast *Malassezia* sp., the proliferation of which accounts for 75% of scalp microflora in dandruff conditions, initiating a micro-inflammatory process. The latter causes persistent itching, increased epidermal turnover, and impaired keratinocyte maturation, as reflected by scale production (33.2 mg/2 days vs. 8.1 on nondandruff scalp) and an elevated parakeratotic index (18.4 vs. 3.9)—that is, the percentage of corneocytes which retain a nucleus.[9] The inducing yeast colonizes the stratum disjunctum releasing lipase and lipoxygenase that degrade sebum components, used as nutrients.

Efficient and safe antifungal agents are available, mainly zinc pyrithione (ZPT), piroctone olamine, selenium sulfide, climbazole, and ketoconazole, used at 0.5–1.5 g% in anti-dandruff shampoos. Regular application (i.e., twice a week) of such active ingredients within a mild cleansing base significantly eliminates the symptoms and improves scalp condition.

Improved hair density or thickness was reported following daily use of antidandruff shampoo in men with alopecia.[10]

Shampoos for babies and children

The purpose here is to ensure an optimal mildness and comfort to skin and eyes. The composition is therefore based upon nonionic surfactants (about 10%) such as fatty acid esters of highly ethoxylated glycerol or sorbitan (e.g., copra monoglycerides with 30 ethoxy groups, palm glycerides with 200 ethoxy groups, sorbitan [20 ethoxy groups] monolaurate) (Figure 19.7). These surfactants favor the formation of large micelles that hardly adsorb onto proteins, and in particular onto the surface of mucous lachrymal membrane, thus avoiding any eye tingling, watering, or dislike.

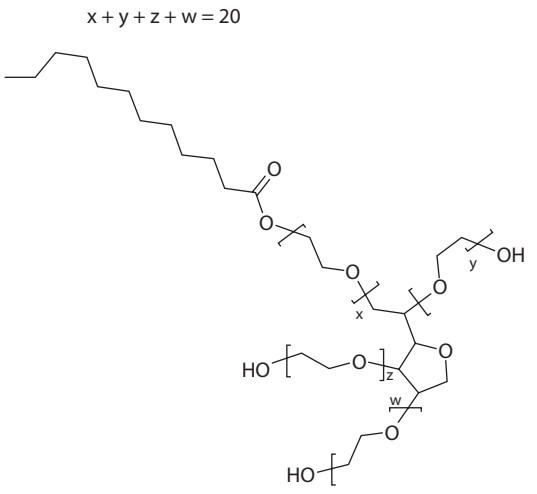

Figure 19.7 **Sorbitan monolaurate (20 OE).**

HAIR CONDITIONERS

The prime target of hair care products is correcting deterioration of the hair surface and protecting it from weathering or any further external assault.

The hair surface is the outer part of the cuticle, a thick sheath that tightly wraps the core of the hair, or cortex which is the key mechanical structure and strength of the fiber. The hair cuticle is made up of superimposed layers (7–10 at the proximal end, decreasing toward the distal end and in short cycling hairs) of flat inert cells/scales covering each other like roof tiles. Hair structure is composed of keratin proteins characterized by a high overall sulfur content. Among the 18 amino acids included in the keratin polypeptide sequence, one of them, cystine, has a disulfide linkage and amounts to 20%–30% of the proteinaceous material in the outermost layer of the cuticle.[11] Natural hair is covered by a long lipid chain, mainly 18-methyl eicosanoic acid (MEA) covalently bound by a thioester linkage.[12]

The hair surface undergoes multiple physical and chemical stresses depending upon hair routines and exposures. Frequent and daily mechanical handling such as brushing and combing erodes and uplifts cuticle scales and breaks cell edges producing a jagged surface. Frequent, hot blow drying combined with brushing makes hair dry and brittle. Environmental factors, primarily sun exposure, change the chemical balance of the hair surface through cleaving intra- and interkeratin chain disulfide linkages and thus giving rise to numerous strong sulfonic acid groups by the photo-oxidation process (Figure 19.8). The highly cystine-rich surface of hair takes on a strong anionic character, dramatically changing interactions, hair/hair included. Lipid MEA coating also vanishes, leaving hair rough and poorly lubricated.

Upon contact with such damaged hair, cationics become strongly attracted. An electrochemical bond is created between the positive (cationic) group and a negative (anionic) site/group of the hair surface. In the presence of a cationic surfactant (Figure 19.9a), which is composed of a cationic hydrophilic group at the end of a lipophilic (hydrocarbon) chain, the electrostatic bonding of the cationic group to the hair surface anionic site/group leads to the deposit of a monomolecular layer of surfactant fatty chain onto hair (Figure 19.9b). As a consequence, hair touch and surface properties are drastically altered. The extremely thin lipid chain coating lubricates the damaged area. The friction coefficient is considerably decreased. Following application of cationic surfactant, hair roughness vanishes, as does

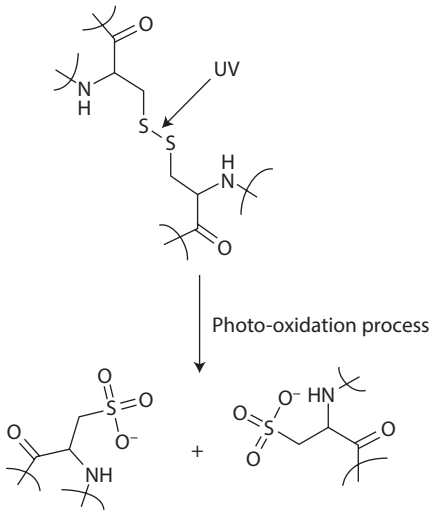

Figure 19.8 **Cystine linkage between two keratin polypeptide chains. UV-induced radical cleavage of disulfide bond and photo-oxidative conversion into sulfionic groups.**

flyaway behavior, as a result of charge neutralization. Hairs, then, gain a soft feel.

Fixing the cationic surfactant takes place where an anionic (sulfonic) group is present. The more altered the hair surface, the more numerous are the anionic groups and the more cationic surfactant molecules are bound to the hair surface. As a result, an even hair surface is regained, every damaged site being neutralized and smoothed over. Rinsing with water removes unneeded cationic surfactant, leaving hair with appropriate care where needed. It is worth emphasizing that cationic surfactants used for hair care and beauty are devoid of detergent properties. They compose hydrocarbon (fatty) chains clearly longer than those of anionic, amphoteric, and nonionic surfactants used for hair cleansing (i.e., 17–20 carbon atoms instead of 12–14). They are consequently endowed with radically different properties.

Being most suitable for hairs with surfaces that exhibit behavior and interactions altered by acquired anionic character, conditioning cationic surfactants allow damaged areas to be protected (negatively charged) site by site, leveling out the surface. Rid of rough patches, the latter becomes amazingly easy to comb through. These cationic surfactants that show potent conditioners, however, cannot improve hair consistency, and most are incompatible with anionic surfactants used in shampoos and various hair products. When mixed, they form complexes that abolish their respective properties, and hence, the tremendous step forward brought by another category of ingredients mentioned in the previous sections (i.e., cationic polymers).

In the structure of a cationic polymer, the functional groups prone to bind to the hair surface are not at the end of a lipophilic chain but instead are grafted to or located along a macromolecular chain (Figure 19.10). As a result, while being attracted by anionic groups and readily taken up by an anionic hair surface, they stretch over the hair a continuous film with multiple binding sites, whereby surface properties are transformed. In addition to covering and smoothing hair, cationic polymer imparts texture and body without weighing hair down. The hair surface becomes even, soft, protected all along from external assaults, while hair is easy to disentangle and dress.

Most frailty hairs are fine, or very curly hairs at twisting points where the cortex, which endows hair with outstanding mechanical properties and resilience, is highly reduced. The finer the hair, the lower is the mass that most composes the cuticle. Surface alterations consequently affect the whole hair. Flyaways and lack of control are major issues for fine hair, lacking body and firmness. More porous, such hair easily breaks, and the friction coefficient is high. Cationic polymers substantially benefit his type of hair.

Cationic polymers for hair conditioning are polysaccharides derived from cellulose, guar, starch, chitosan, or a variety of vinyl, allyl, acrylate, and methacrylate copolymers.

Another major hair condition contributor, as highlighted in the paragraph dedicated to shampoos, is the

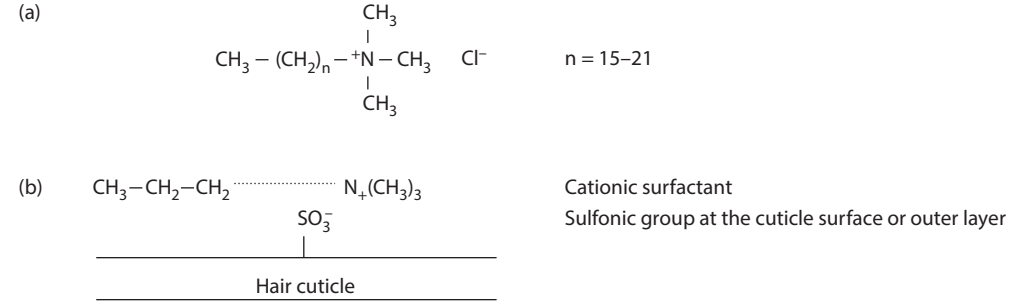

Figure 19.9 **(a) Cationic surfactant (e.g., cetyltrimethylammonium chloride, *n* = 15). (b) Electrostatic bonds between cationic surfactant and anionic group at the hair surface.**

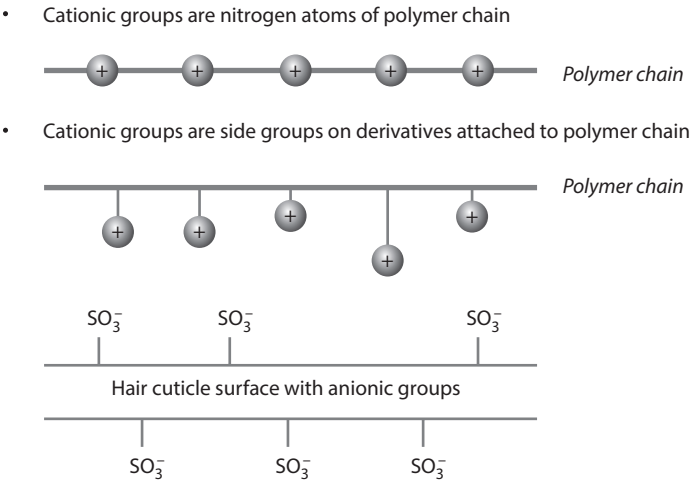

Figure 19.10 **Cationic polymers.**

field of silicone polymers. First used for their nongreasiness and light feel, these have met with outstanding diversity of applications and cosmetic development on account of low surface tension, despite viscosity that may be high, hydrophobic behavior, weak cohesive forces, and being chemically inert. Whereas PCs are most suitable for hairs prone to interact following oxidative damage to epicuticle layers, PDMS provide optimal benefi s to natural, undamaged, or physically impaired hairs, yielding a smooth feel from root to tip and lightweight, nimbled hairs. These silicone polymers spread a thin, uniform, hydrophobic deposit on the hair, smoothing out the whole hair shaft, split end included (Figure 19.11a), enhancing sheen and gloss, and steadily protecting it when combing.

To prevent buildup and undesired hair-appearance possibly resulting from repeated applications, hair conditioners require a meticulous, thorough development taking into account type of hair, targeted effects and benefi s, frequency of use, and hair routines (waving, coloring, lightening, straightening, relaxing). Hair conditioning agents must be blended with the most adequate vehicles able to boost, extend, and magnify their effects and favor pleasantness in use, comprehensive distribution within the head of hair, and the whole range of care and beauty contributions with added benefi s. Hence, among the palette of ingredients that are used to improve hair condition, the following can be mentioned:

- Fatty materials such as fatty alcohols, natural oils (e.g., olive, almond, avocado, karite, monoi, corn), or waxes (e.g., jojoba, beeswax) that have been traditionally used in all civilizations for lubricating, nourishing hair, and providing sheen; fatty acids (e.g., oleic, linoleic, linolenic, behenic); ethoxylated derivatives; ceramides such as *N*-oleoyl sphinganine, shown to restore damaged hair cuticles through strengthening interscale junction and protecting the hair shaft from brushing and sun-induced damage.[13]
- Protein hydrolysates (e.g., silk, wool, collagen, soybean, oat, wheat).

Hair conditioners include a large variety of products to suitably meet the changing and diverse needs or demands according to the type, abundance, and condition of hair, preferred texture, intended frequency of application, and level of expected performance.

Most are rinsed off after being left on the hair for some time, generally a few minutes, or longer in the case of deep conditioners. Practically, they are presented as:

- *Conditioning creams or emulsions*: Of common use, applied after shampooing, these are of varying viscosity (i.e., fluid lotions, gel emulsions, or creams such as untangling balms). They usually contain cationic surfactant and fatty alcohols, readily spread onto the head of hair where they are left 1 or 2 minutes, then rinsed off. They are intended for

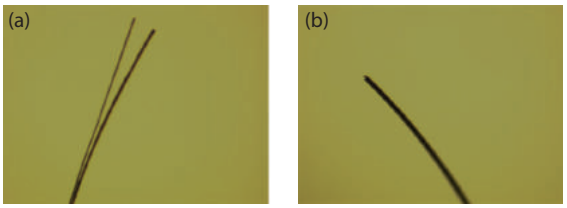

Figure 19.11 **Hair split end (a) before (b) after applying a conditioning serum based upon silicone derivatives.**

normal, dry, or very dry hair to which they provide manageability, suppleness, ease of combing, and shine.

- *Deep conditioners*: These are thick creams for intensive care of damaged or very dry hair with high friction coefficient. For less frequent use (e.g., once a week), they contain more conditioning agents and are left on the hair for a prolonged time (10–15 minutes). Silicone polymers and cationic surfactants are often combined to obtain synergetic repairing effects, help to recover tightly adhesive scales, smooth over the hair shaft, and impart lightness.
- *Lotions or fluid gels*: Of light texture, clear or opaque, without fatty ingredients, they are aqueous solutions of cationic surfactant and/or PC intended for normal or fine hair or hair with a greasy tendency. The target is to afford lightness, volume, control, and sheen with no perception of deposit that could detract from the look of the hair.
- *Oils*: Plant oils have long been used as nutrients to protect, beautify, lubricate, and give shine to hair. Clear, translucent emulsions are now available where oils are combined with cationics and silicones, can impregnate the outer layers of cuticle and resist removal by shampoos.[14]

Leave-on conditioners

Other hair care and beauty products are designed to be kept in the hair after application. They aim at facilitating combing (combing aids) and affording sheen and smoothness to hair. They contain cationic surfactants or polymers in a lower amount than products to be rinsed post application. Various silicones are also widely used, such as cationic amodimethicones or ethoxylated silicones. They are presented as aerosol foams or creams and gel emulsions of various viscosities.

Oils and serums

Originally and essentially water-free products containing oils and/or silicone derivatives, they are used for nourishing and protecting very dry hair exposed to sun, air conditioning, salt water, drying wind, or climate. Silicone derivatives, less oily and of widely varying texture, are used in a variety of serums for smoothing hairs or repairing damaged areas such as split ends (Figure 19.11b). Aqueous serums containing cationic and/or silicone derivatives are also proposed.

Hairstyling products

The basic ingredient in hairstyling and hair-dressing products is anionic film-forming polymer that gives hold to hair shape through sheathing the hair shaft.[15] A thin, fluid coating maintains the hairstyle in an inconspicuous way, looking natural. It also helps the hairstyle keep its shape in a humid atmosphere. The deposited film must be hard and resistant enough when passing the brush through, for example. Depending on the expected effect, a given polymer or a combination of polymers is chosen, together with additives to increase film hardness or give some flexibility or favor hair sticking together to yield stranded effects. Water-soluble polymers are preferred for easy removal by shampooing. Anionic polymer can be combined with cationic polymer, taking advantage of the affinity of the latter toward hair and conditioning properties, providing a soft feel and possibly synergetic hold. Silicone derivatives are often added to improve hair shaft condition, reduce friction, make brushing easier, and contribute to smoother hair. Lubricants such as ceramide may also be introduced, and polyols (e.g., glycerol) as well to reduce dry feel.[16]

Spreadability is a critical point. The texture of the product is a decisive factor. Most commonly, aqueous or aqueous alcoholic lotions are applied to the hair using a spray, or are thickened with gelling agents such as guar gum derivatives.

EVALUATION OF HAIR SURFACE CONDITION AND CARE-INDUCED CHANGES

A variety of techniques have been studied and developed for assessing the condition of the hair surface and most closely reflecting the sensory and visual appreciation of the consumers following hair-conditioning product applications.[17] Confocal laser scanning microscopy was used to generate high-resolution three-dimensional (3D) images of polymer deposits on hair before and after shampooing.[18,19] The availability of atomic force microscopes was a further significant advance in providing hair surface images of very high spatial resolution, down to the nanometer, and allowing friction or viscoelastic properties to be measured.[20,21] The effects produced by hair-conditioning or styling products or shampoos can be thoroughly explored, as well as the interactions and friction forces at the nano level.[22–24]

Other devices measure the wet and dry combing forces[25,26] or hair brittleness[27] on hair swatches or hair in vivo in real-life conditions before and after hair product applications. Electrostatic charges (flyaway) developed during combing, and the antistatic effect of hair conditioners, can be recorded by automated or manual tensile combs.[28,29] Other techniques for characterizing the hair surface properties include potent analytical methods, such as secondary ion mass spectroscopy (SIMS),[13,30,31] x-ray photoelectron microscopy,[32,33] and dynamic electronic and permeability analysis.[34,35]

A video method addressing the difficult issue of dynamic properties of hairs in relation to visual perception of the head of hair moving in real-life conditions was recently published.[36]

Appraising shine or luster, a key attribute of hair visual appearance and beauty perception, has been another major challenge. Many authors have used a goniophotometer, recording the multiangular distribution of reflected

light when hair is illuminated with white light or a laser beam at a 30° angle. Reflected light includes specular, internal, and diffuse reflections. Various formulas have been proposed for calculating shine from data obtained from a single hair or tresses of aligned hairs.[37–40] A new approach involves taking images of hair using a fast video camera with high polarization contrast, called SAMBA, and analyzing these with a specific algorithm to calculate luster.[41,42] Results were shown to be in agreement with the subjective evaluation of consumers.[41,43]

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MEDICINE/DERMATOLOGY

THE ALOPECIAS

DIAGNOSIS AND TREATMENTS

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Disorders of hair growth are among the most common problems confronted in the practice of dermatology.

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