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Cleansing without compromise: the impact of cleansers on the skin barrier and the technology of mild cleansing

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ABSTRACT: Cleanser technology has come a long way from merely cleansing to providing mildness and moisturizing benefits as well. It is known that harsh surfactants in cleansers can cause damage to skin proteins and lipids, leading to after-wash tightness, dryness, barrier damage, irritation, and even itch. In order for cleansers to provide skin-care benefits, they first must minimize surfactant damage to skin proteins and lipids. Secondly, they must deposit and deliver beneficial agents such as occlusives, skin lipids, and humectants under wash conditions to improve skin hydration, as well as mechanical and visual properties. While all surfactants tend to interact to some degree with lipids, their interaction with proteins can vary significantly, depending upon the nature of their functional head group. *In vitro*, *ex vivo*, and *in vivo* studies have shown that surfactants that cause significant skin irritation interact strongly with skin proteins. Based on this understanding, several surfactants and surfactant mixtures have been identified as "less irritating" mild surfactants because of their diminished interactions with skin proteins. Surfactants that interact minimally with both skin lipids and proteins are especially mild. Another factor that can aggravate surfactant-induced dryness and irritation is the pH of the cleanser. The present authors' recent studies demonstrate that high pH (pH 10) solutions, even in the absence of surfactants, can increase stratum corneum (SC) swelling and alter lipid rigidity, thereby suggesting that cleansers with neutral or acidic pH, close to SC-normal pH 5.5, may be potentially less damaging to the skin. Mildness enhancers and moisturizing agents such as lipids, occlusives, and humectants minimize damaging interactions between surfactants, and skin proteins and lipids, and thereby, reduce skin damage. In addition, these agents play an ameliorative role, replenishing the skin lipids lost during the wash period. The present review discusses the benefits of such agents and their respective roles in improving the overall health of the skin barrier.

KEYWORDS: amphoteric surfactants, anionic surfactants, dry skin, non-ionic surfactants, skin barrier damage, stratum corneum, syndet, surfactants, after-wash tightness.

Introduction

Cleansers are designed to remove dirt, sweat, sebum, and oils from the skin. This is achieved through the use of surfactants that aid in the uplifting of dirt and solubilization of oily soils. In addition to removing unwanted materials from the skin, the cleansing process helps to promote normal exfoliation, and thereby rejuvenates the skin.

However, the interaction of cleanser surfactants with stratum corneum (SC) proteins and lipids can be deleterious to skin (1–7). For example, cleanser surfactants can cause immediate after-wash tightness (AWT) (8), as well as dryness (5),

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barrier damage, erythema, irritation, and itch (3). The extent to which surfactants cause such damage is dependent upon the nature of the surfactants as well as the cleansing conditions. Minimizing damage caused by cleansers is the first step toward cleansing without compromise. The second step compensates for the level of damage caused by cleansers by providing moisturizing benefits during wash. Moisturizing the skin maintains an optimal level of hydration and plasticization that allows the skin to retain its normal viscoelasticity (9). This ensures adequate extensibility and flexibility for skin movement. On the other hand, absence of moisturization is a state that can manifest in a variety of ways, including a sensation of AWT, lack of flexibility/extensibility, visible dryness (skin ashing), skin roughness, scaling, cracking, and ultimately, irritation in the form of visible erythema and itching.

Mild moisturizing cleansers are expected to provide cleansing benefits without negatively altering the hydration and viscoelastic properties of skin. This expectation may go beyond the simple absence of negatives to providing moisturizing benefits to dry skin. Current technologies that compensate for cleanser damage and provide benefits include those that deposit oils, lipids, and humectants during wash.

Surfactants and their damaging effects on skin

Commonly used surfactants in cleansing

Because of their excellent foam and lather characteristics, anionic surfactants are typically used as primary surfactants in cleansers. Liquid cleansers often have a combination of anionic and amphoteric surfactants, while non-ionic surfactants are used less often. Amino-acid-based surfactants are also beginning to be used in cleanser systems.

Typical anionic surfactants used in cleansers include soaps (salts of fatty acids) and synthetic surfactants such as alkyl ether sulfate, alkyl acyl isethionates, alkyl phosphates, alkyl sulfosuccinates, and alkyl sulfonates. Commonly used zwitterionic surfactants include cocoamido propyl betaine, cocoamphoacetate, and cocoamphodiacetate. Alkyl polyglucoside is one of the non-ionic surfactants found in some cleansers. Amino-acid-based surfactants such as alkyl glutamates, sarcosinates, and glycinates are also being increasingly used in cleansers. The structure of the relevant surfactants is shown in Fig. 1.

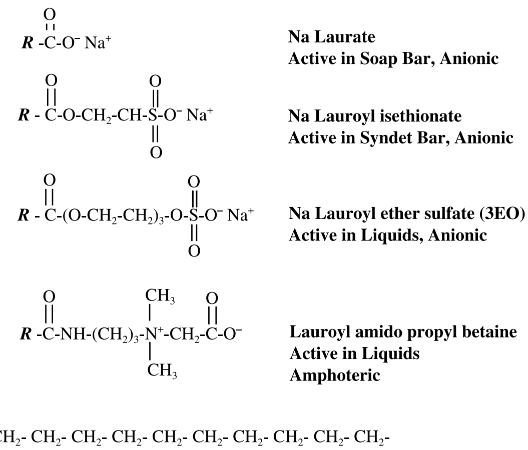

Fig. 1. Structure of typical surfactants in cleansers.

Table 1. Typical composition of syndet and soap bars

Syndet bar	
Sodium cocoyl isethionate	Coconut fatty acid
Stearic acid	Natural oils
Sodium stearate	Salts
Cocamido propyl betaine	Sequestrant
Polyethylene glycol (PEG)	Titanium dioxide
Sodium isethionate	
Soap bar (ordinary)	
Sodium tallowate	
Sodium cocoate	
Soap bar (superfatted)	
Sodium tallowate	Glycerin
Sodium cocoate	Sorbitol
Palm kernelate Types	Sodium chloride
Sodium palmitate	Pentasodium pentetate
Water	Tetrasodium etidronate
PEG-6 methyl ether	Butyl hydroxy toluene (BHT)
Palm acid or tallow acid	Titanium dioxide
Fragrance	

Adapted from Baranda L, Gonzalez-Amaro R, Torres-Alvarez B, Alvarez C, Ramirez V. Correlation between pH and irritant effect of cleansers marketed for dry skin. International Journal of Dermatology 2002: **41**: 494–499, courtesy of Blackwell Publishing, Inc.

Cleansers with non-soap-based surfactants are often referred to as “syndets” (synthetic detergent-based bars or liquids). The typical compositions of soap and syndet bars are shown in Table 1. Soap-based cleansers often are alkaline in nature (pH 10), whereas syndets are mostly neutral or acidic (pH 7 or less). Such pH differences have important implications for cleanser-induced damage (10).

Surfactant interaction with stratum corneum proteins

Cleanser surfactants can bind to SC proteins, leading to transient swelling and hyper-hydration under wash conditions. This then is usually followed by de-swelling while the water evaporates, leading to drying stresses (1–3). Swelling can also facilitate the penetration of surfactants, as well as other cleanser ingredients, into deeper layers, possibly leading to a biochemical response such as irritation and itch. Since the surfactant binding reduces the ability of skin proteins to bind and hold water, skin often returns to a state of lower hydration after wash (3,4). In addition, cleansers can lead to a reduction in the level of natural moisturizing factor (NMF) in skin (7). Factors that reduce the water content of skin can lead to changes in the skin's viscoelasticity, which can manifest as AWT of the skin within minutes after wash (8). Continued use of such cleansers can lead to dry skin, barrier damage, erythema, and itch. Thus, cleanser interaction with skin proteins can negatively affect skin hydration and viscoelasticity.

Interactions of cleanser surfactants with SC proteins and model proteins have been studied extensively (11,12). The present authors' recent studies have shown that the tendency of surfactants to cause protein denaturation/damage is related to the charge density of protein-bound, micelle-like surfactant aggregates (13). This explains the following well-known order for the irritation potential of surfactants, namely, anionic surfactants > amphoteric surfactants > non-ionic surfactants. Among anionic surfactants, the tendency to bind to proteins varies as follows: sodium lauryl sulfate (SLS), or sodium laurate > monoalkyl phosphate > sodium cocoyl isethionate (12). In general, for a surfactant with a given chain length, the larger the head-group size, the lower its tendency to cause protein swelling. Thus, ethoxylated alkyl sulfates tend to bind less to keratin (the major SC protein) than do the corresponding alkyl sulfates (14).

Common approaches to lowering the tendency of anionic surfactants to damage proteins include increasing the size of the head/polar group of the surfactant (14,15), and using a combination of anionic surfactants with amphoteric or non-ionic surfactants (16). Thus, sodium lauroyl isethionate (SLI)—a commonly used mild surfactant with a larger head group and a lower critical micelle concentration (CMC) that is used in syndet bars—shows only about one-fifth as much binding in one hour as sodium laurate and sodium dodecyl sulfate (SDS) under the same conditions (0.1 mg mg^{-1} of corneum for SLI versus 0.5 mg mg^{-1} for SDS) (17). Modulating the irritation potential of sodium laureth sulfate (SLES), which is often used in liquid cleansers, typically involves the addition of an amphoteric surfactant, cocamidopropylbetaine (CAPB). Figure 2 shows the protein swelling/denaturation tendency of some of the key cleanser surfactants, measured in terms of their collagen-swelling potential, an approximate measure of its irritation potential (18).

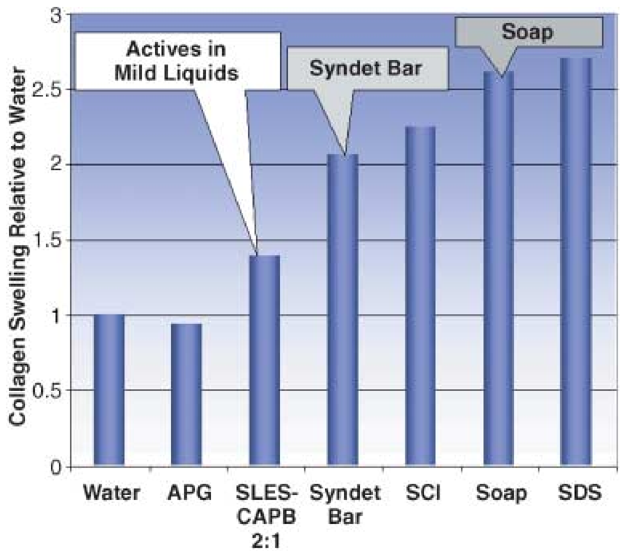

Fig. 2. Collagen (protein) swelling potential of different cleanser surfactants: (APG) alkyl polyglucoside; (SLES) sodium lauryl ether sulfate; (CAPB) cocamidopropyl betaine; (SCI) sodium cocoyl isethionate; and (SDS) sodium dodecyl(lauryl) sulfate.

Surfactant interaction with lipids

As is the case with proteins, surfactant interactions with skin lipids have been studied extensively (4,11,12,19). Still, the mechanisms by which surfactants interact with lipids and cause skin damage have yet to be fully established (11,12,19). It has been suggested that surfactants above their CMC solubilize lipids in surfactant micelles and thereby cause SC delipidation (12). Lipid damage is also caused by the adsorption and intercalation of surfactants—especially charged surfactants—into SC lipid bilayers, resulting in its increased permeability and even bi-layer destabilization (6,20,21). Biological damage may also be caused by alterations in the lipid biosynthetic processes, leading to changes in the relative levels of various lipids (11). For instance, Rawlings and colleagues (19) have observed that the progressive drop in ceramide levels relative to the severity of the

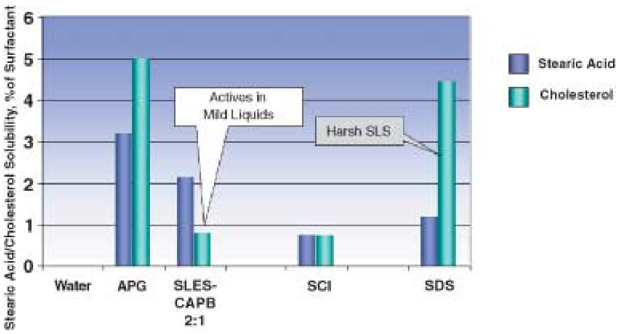

Fig. 3. Lipid dissolution tendency of various surfactants, as indicated by their ability to dissolve stearic acid and cholesterol: (APG) alkyl polyglucoside; (CAPB) cocamidopropyl betaine; (SCI) sodium cocoyl isethionate; and (SDS) sodium dodecyl(lauryl) sulfate. Reprinted from Ananthapadmanabhan KP, Subramanyan K, Rattinger GB. Moisturizing Cleansers. In: Leyden JJ, Rawlings AV, eds. Skin Moisturization. Cosmetic Science and Technology Series, Vol. 25, p. 412. Courtesy of Marcel Dekker, Inc.

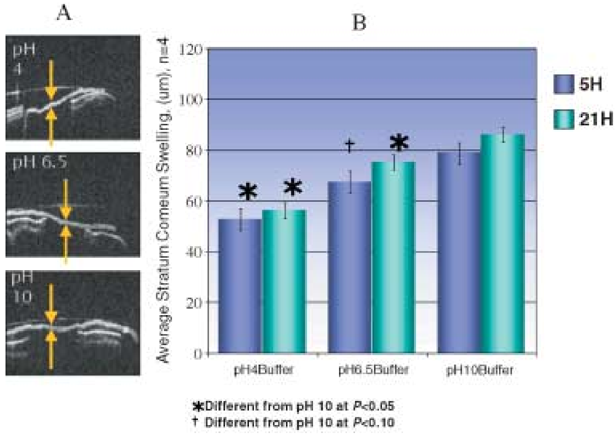

Fig. 4. (a) Optical coherence tomography images of the stratum corneum (SC). The arrows show the position and thickness of the corneum. (b) pH dependence of swelling of the SC in buffered solutions at 5 and 21 h. The buffer strength = 0.006 M: (*) significant at the *P* < 0.05 level compared to pH 10 values; and (†) significant at the *P* < 0.1 level compared to pH 10. Adapted from Ananthapadmanabhan KP, Lips A, Vincent C, et al. pH-induced alterations in stratum corneum properties. Int J Cosmet Sci 2003: 25: 103–112.

xerosis in soap-induced winter xerotic dry skin may have a biochemical origin.

The present authors' laboratory has shown that washing skin with a liquid cleanser base (anionic–amphoteric surfactant mix without any moisturizing ingredients) can reduce levels of fatty acids and cholesterol in skin even after a single wash (22). Importantly, the selective removal of cholesterol and/or fatty acids can impair the maintenance of a healthy SC. The relative tendencies of SDS, SLES, CAPB, and a sugar-based non-ionic surfactant, alkyl polyglucoside (APG), to solubilize stearic acid and cholesterol under controlled conditions are shown in Fig. 3. Clearly, non-ionic surfactants have a greater tendency to dissolve stearic acid than do anionic surfactants, which may translate into greater skin de-fatting if cleansers with excessive levels of non-ionic surfactants are used. This hypothesis is consistent with transmission electron microscopic studies that show that non-ionic-surfactant-based cleansers alter the lipid region to a greater extent than do mild cleansing bars with sodium cocoyl isethionate as the surfactant (23,24).

Role of pH

Another factor that may contribute to SC damage is the cleanser's pH. Soap-based cleansers are alkaline in nature, while the pH of most syndets (synthetic surfactant-based cleansers) is close to neutral or slightly acidic. It is well known that soap-based cleansers (alkyl carboxylates) have a higher potential to irritate skin than cleansers with synthetic surfactants (syndets) such as sodium alkyl isethionate or alkyl ether sulfates (25–30). In principle, variations in irritation potential among alkaline soaps and neutral pH syndets can arise from inherent structural and charge-density differences, direct effects of pH on the SC, and/or indirect effects of pH on the solution chemistry of charged head groups. Past work has failed to differentiate or clarify the direct and indirect roles of pH on surfactant-induced skin irritation.

The present authors' recent work has shown that SC swelling and lipid rigidity is a function of pH in the absence of cleanser surfactants (31). In one study, SC swelling and lipid rigidity were greater at pH 10 than at pH 6.5. Optical coherence tomography images of the SC at various pH values, and the extent of SC swelling, can be seen in Fig. 4. The study also demonstrated an additional concentration-dependent effect of surfactants on both protein swelling and lipid organization. These results suggest that the higher pH of soap bars may be a contributing factor in the higher irritation potential of soap bars compared with syndet bars.

The important role of pH in maintaining SC structure and function was further demonstrated by Fluhr and colleagues (32), who demonstrated that small and sustained pH increases, like those caused by daily soap-based cleansers, for example, adversely influence the barrier repair mechanism.

Clinical manifestations of surfactant damage

In addition to cleanser surfactants, other factors such as age, heredity, nutrition, and weather can influence the condition of the skin and induce damage. The use of harsh cleansers can aggravate the situation even further.

After-wash tightness

Unlike mild syndet surfactant-based cleansers, harsh cleansers such as soaps induce perceivable skin tightness (30), a sensation that manifests about 5–10 min after washing with a cleanser. The tightness is linked to stresses created in skin by the rapid evaporation of water from surface layers. As mentioned previously, treatment with harsh surfactants can actually lead to hyper-hydration immediately after washing, followed by rapid evaporation of water to equilibrium values that are below the pre-surfactant-treatment levels (2,3). This hyper-hydration coupled with lower equilibrium hydration levels creates a higher than normal rate of evaporation, and thus, a differential stress in the upper layers of skin, leading to AWT. Results reported in the literature seem to indicate that the tendency to cause skin tightness parallels both lipid removal as well as protein binding (12).

Skin dryness, scaling, and roughness

Harsh cleansers such as soaps can induce dryness, leading to scaly, rough skin. However, it should be noted that irritation is not a prerequisite for skin dryness (25). In fact, some of the lipid solvents such as alcohols, acetone (33), and even certain non-ionic surfactants that cause minimal or no irritation can cause significant dryness. Thus, there appears to be a link between lipid removal and dry skin. These effects may be much more acute during winter months, when the air is cold and dry. Changes in skin elasticity at temperatures below the transition temperature of skin lipids make the SC more vulnerable to chapping/cracking, leading to barrier breakdown. Similarly, the glass transition temperature of skin lipids increases markedly under low humidity conditions, conferring greater susceptibility to cracking as well. Thus, the combination of harsh cleanser use, cold temperatures, and low humidity make the conditions ideal for dry skin.

Visible skin dryness has been found to correlate positively with lack of surface hydration, but not necessarily with an increase in transepidermal water loss (TEWL). This suggests that significant barrier breakdown is not a requirement for skin dryness. However, a continued increase in dryness to values above a certain level may lead to cracking and chapping, barrier breakdown, and eventually, to irritation.

Skin irritation

Erythema and itching are inflammatory responses to penetration of the skin by a foreign substance such as a surfactant. It is not necessary for the surfactant to penetrate into dermal layers to elicit a response. Communication via the production of cytokines can also elicit a response from the dermis (12). Harsh soaps and soap-based liquid cleansers—because of the harsh surfactants they contain—may damage the barrier, and thus, potentially cause skin irritation, erythema, and itching. By contrast, most of the currently available syndet surfactant-based cleansers are formulated to be significantly milder than soap, and indeed, do cause considerably less irritation and itch.

Irrespective of the exact mechanisms involved in AWT, skin dryness/roughness, and irritation, a moisturizing cleanser would be expected to prevent or ameliorate these effects. Thus a moisturizing cleanser would deliver benefits beyond a traditional, single-purpose cleanser.

Current mild cleanser technology

As shown in Fig. 5, skin cleansing technology has evolved from basic soap to syndet bars and shower gels with moisturizing lipids, emollients, occlusives, and humectants that offer other skin care benefits beyond cleansing. All these products,

Fig. 5. Schematic of the evolution of personal cleansing technology. Reprinted from Ananthapadmanabhan KP, Subramanyan K, Rattinger GB. Moisturizing Cleansers. In: Leyden JJ, Rawlings AV, eds. Skin Moisturization. Cosmetic Science and Technology Series, Vol. 25, p. 406. Courtesy of Marcel Dekker, Inc.

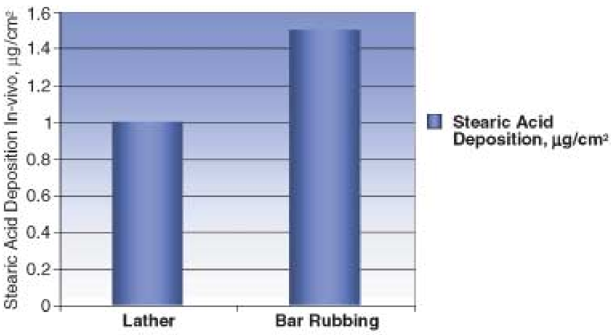

Fig. 6. ***In vivo*** **deposition of stearic acid determined using deuterated stearic acid from a syndet bar containing moisturizing lipids. Lather refers to the generation of lather on the hand and applying it on the skin. Bar rubbing involved directly rubbing the bar on the skin.**

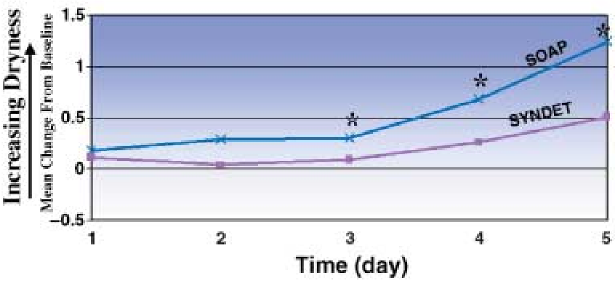

Fig. 7. Changes in dryness caused by soap and syndet bars in a 5-day controlled forearm application wash test. The soap used was Ivory® and the syndet used was Dove®.

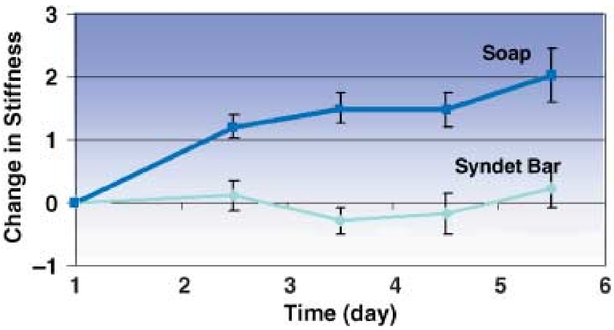

Fig. 8. Linear skin rheometer measurements of changes in skin stiffness after multiple washes with soap and syndet bar. The soap used was Ivory and the syndet used was Dove.

which range in mildness and moisturizing efficacy, are now on the market. The potential damage to the skin has been minimized with the use of mild surfactants, and the incorporation of beneficial agents.

Early attempts to minimize the damage potential of soaps involved the incorporation of glycerol in soap bars and the production of transparent glycerin bars. However, since glycerol could not be delivered effectively under wash conditions, the benefits of glycerol were never fully realized.

The first breakthrough in mild cleansing occurred in the 1950s with the introduction of syndet bars, with mild alkyl isethionate as the synthetic surfactant. Incorporation of a long-chain fatty acid lipid cocktail, often referred to as a “moisturizing cream”, has enhanced the mildness and moisturizing properties of syndet bars. Other beneficial agents such as petrolatum, triglycerides, and sterols have become more common with the introduction of liquid cleansers and moisturizing body wash/shower gel technologies. Occlusives and oils deposited on skin during cleansing can reduce the visible signs of dryness, as well as provide a barrier that helps reduce the skin’s water loss.

In addition to replenishing the fatty acids and sterols lost during the wash process, emollients function as “sacrificial lipids” within surfactant micelles, minimizing the surfactant-mediated depletion of skin lipids. These two mechanisms have yet to be elucidated. However, it has been shown that mild syndet bars with fatty acids do deposit about 1–2 $\mu g\,cm^{-2}$ of fatty acid during wash conditions (Fig. 6). Interestingly, similar levels of fatty acids are removed by the cleanser after a single wash (22). In the case of liquids, the present authors’ laboratory has shown that the triglyceride deposits from a typical moisturizing body wash can be as great as 10–15 $\mu g\,cm^{-2}$ under cleansing conditions (34).

Skin benefits from mild syndet bars with “moisturizing cream”. The current mild bar technology based on syndet surfactants and fatty acids acting as skin-benefiting lipids is well documented as producing a significantly milder bar than common soaps, as discussed in pp. 35–42 of this supplement (25–30). Soaps cause significantly higher levels of skin dryness than do syndets, as demonstrated by the standard arm-wash protocol, or forearm controlled application test (Fig. 7) (28). In a similar test, skin mechanical properties were measured using a linear skin rheometer (35). As shown in Fig. 8, the syndet bar did not induce any stiffness, whereas soap did and the extent of stiffness appeared to increase with increased soap usage (36).

This observed increase in SC dryness and stiffness caused by soap is consistent with its ability to remove natural moisturizing factor (NMF) and lipids, as shown in Fig. 9. Clearly, soap is found to remove more NMF and cholesterol than the

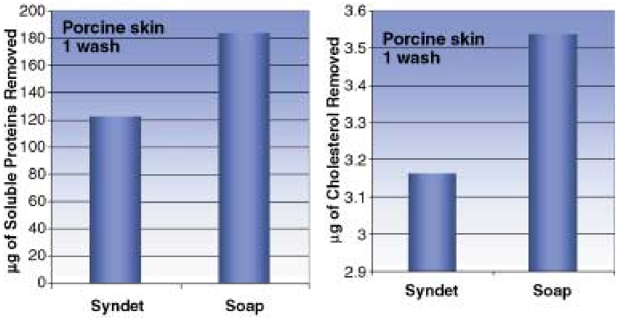

Fig. 9. Removal of soluble proteins and lipids (cholesterol) from the skin after a single wash with soap and syndet bar. The soap used was Ivory and the syndet used was Dove.

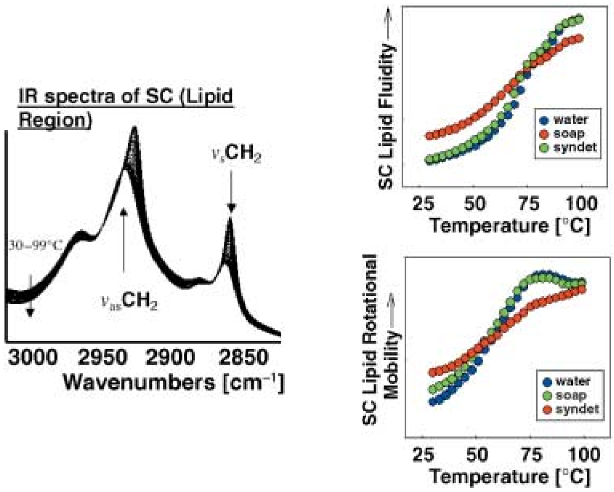

Fig. 10. The infrared (IR) spectral region I (left) shows the Carbon-Hydrogen (C-H) stretching vibrations of lipids within intact stratum corneum (SC) collected from 30 to 99 °C. The SC samples were treated with five brief washes at 40 °C in water (control), a 20% syndet bar slurry, and a 20% soap bar slurry. Both the symmetric ($\nu_s CH_2$) and antisymmetric ($\nu_{as} CH_2$) vibrations are sensitive to membrane lipid order and provide a direct measure of changes in SC lipid physical properties. The peak position of the CH_2 bands is sensitive to lipid intramolecular order (fluidity), whereas the peak width is sensitive to lipid chain rotational freedom.

syndet bar, even after a single wash. Stratum corneum lipid rigidity, as measured by Fourier-transform infrared spectroscopy (37,38), also shows significant perturbation of the lipid layer by soap compared to that by syndet bar. Figure 10 shows that neither lipid chain fluidity nor rotational freedom is significantly different between water and syndet-treated SC. However, SC washed with soap slurry displays differences in both the slope and cooperativity of both SC lipid parameters, indicating significant alteration in lipid organization relative to the water control. Such changes can be a result of alterations in SC lipid composition, either through the removal of endogenous lipid species or the intercalation of surfactant molecules into the SC. It is interesting to note that the infrared spectra also indicate that protein structure is also more affected by soap (data not shown) (39).

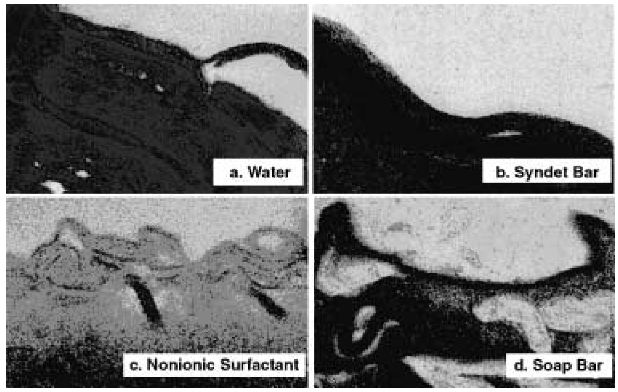

Fig. 11. Lipids display normal lamellar morphology, comprising electron-dense and electron-lucent bands for (a) water and (b) synthetic detergent. (c) Non-ionic-surfactant-treated samples displayed disordered lipids: no intracellular damage was present. (d) In contrast, soap-bar-treated tissue displayed a significant loss of lipids, and intracellular damage as well. Adapted from Misra M, Ananthapadmanabhan KP, Hoyberg K, Gursky RP, Prowell S, Aronson MP. Correlation between surfactant-induced ultrastructural changes in epidermis and transepidermal water loss. J Soc Cosmet Chem 1997: 48: 219–234.

Skin ultrastructural changes induced by soap versus mild syndet bars. Ultrastructural changes to the SC upon treatment with cleansers can provide valuable information on the extent of surfactant damage to proteins and lipids (23,24). An *ex vivo* arm-wash methodology—in combination with TEWL measurements, environmental scanning electron microscopy, and transmission electron microscopy—clearly demonstrates changes to the ultrastructure of full-thickness human skin after multiple washes with a soap bar and a syndet bar. Transmission electron microscopy revealed significant damage to both lipid and protein regions after the soap wash (Fig. 11). In contrast, under the same conditions, the syndet-washed skin showed well-preserved lipid and protein regions. The study also demonstrated a good correlation between

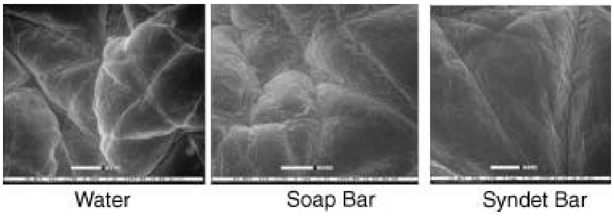

Fig. 12. Environmental scanning electron microscopy of the stratum corneum of cadaver skin that has been washed 15 times: (a) water; (b) soap; and (c) syndet bar. The soap-washed sample shows the onset of uplifting and scale formation. Adapted from Misra M, Ananthapadmanabhan KP, Hoyberg K, Gursky RP, Prowell S, Aronson MP. Correlation between surfactant-induced ultrastructural changes in epidermis and transepidermal water loss. J Soc Cosmet Chem 1997: 48: 219–234.

Fig. 13. Emollient body wash was milder (less barrier damage) and more moisturizing compared to a regular body wash: (emollient body wash) Dove Deep Moisture Body Wash; and (regular body wash) Softsoap® moisturizing body wash.

high TEWL and damage to SC ultrastructure. Interestingly, a non-ionic surfactant-based cleanser wash resulted in a disrupted lipid region with much less damage to proteins (23). Corresponding changes in the surface morphology of skin were observed using environmental scanning electron microscopy (Fig. 12). Furthermore, the soap-washed samples demonstrated significant uplifting of cells and surface roughness; by contrast, syndet-washed samples showed no signs of uplifting of cells. While these represent exaggerated conditions, they clearly demonstrate the potential for damage from soap systems. These results are consistent with the well-accepted mildness of syndet bars versus soap bars.

Skin benefits from moisturizing body wash technologies. The introduction of liquid cleansers in the 1990s offered new opportunities for milder formulations than those used for bars. Since the processing of liquid systems is straightforward, when compared to bars, it is now possible to select milder surfactants and surfactant mixtures from a much wider array of surfactants. Thus, most of the syndet-based liquid cleansers use a combination of anionic and amphoteric surfactant mixtures to enhance mildness. Liquids technology also allows more efficient deposition and delivery of beneficial agents onto skin from a wash-off system. Thus, borrowing technology from shampoo systems that allowed the deposition of conditioning materials such as silicone oils onto hair, the deposition and delivery of emollients and occlusives from wash-off systems using polymeric deposition aids is now possible. Some of the leading liquid cleansers currently available contain vegetable oils such as sunflower or soybean, occlusives such as petrolatum, and humectants such as glycerol that have beneficial effects on the skin. The market is continuing to explode with wash-off systems offering novel combinations of ingredients and leading to a range of novel skin-care claims.

Liquid cleansers can be designed to deposit beneficial lipids such as cholesterol and fatty acids during wash. Recently, Subramanyan and colleagues (22), using deuterium-labeled body wash lipids to aid identification, demonstrated that liquid cleansers, with the beneficial actives stearic acid and lanolin alcohol, replaced about 50–60% of the cholesterol and stearic acid removed from the SC during cleansing.

Moisturizing body wash containing about 20% triglyceride oils and 0.5% sterol (oils as small droplet emulsions, a cationic deposition aid) has been shown in *in vivo* studies to deposit about 10 $\mu g\ cm^{-2}$ of triglycerides and 0.6 $\mu g\ cm^{-2}$ of cholesterol onto skin during wash (40). Clearly, the triglyceride deposition from this system is significantly higher than that of stearic acid from bars, indicating that liquid cleanser technology allows for the deposition of materials at much higher levels than bars.

The clinical benefits of oil deposition on skin have been determined using *in vivo* dryness relief clinical studies, as discussed in pp. 26–34 of this supplement. Performance of a traditional body wash (TBW; i.e., SLES, CAPB, thickener, fragrance, and water) without any moisturizing agents is compared to a moisturizing body wash (MBW; i.e., sunflower oil/petrolatum, SLES, CAPB, glycerin, thickener, fragrance, and water) that deposits occlusives or oils on the skin under wash conditions (28). It has been clearly demonstrated that incorporation of high levels of emollients into liquid cleansers improves the mildness and moisturization of these cleansers. Results from a 5-day controlled application leg wash test are included in Fig. 13, which shows that an emollient body wash is milder and more moisturizing compared to a regular body wash.

Progress in liquid cleanser technology will continue in the coming years. The success of the technology will depend upon how effectively the deposition and delivery of benefit agents can be balanced against the ability of the cleanser to provide freshness and cleanliness with the desired in-use sensory and lather properties.

Conclusions

Cleansers have come a long way from serving only as cleaning agents for the removal of oils, soil, dirt, and bacteria from skin to also providing mildness and moisturizing benefits. Soap-based cleansers tend to interact with skin proteins and lipids, leading to dry skin and irritation. For washoff systems to provide skin-care benefits other than cleanliness, their potential to damage skin must first be minimized. Opportunities to deliver other benefits from cleansers can then be examined. The introduction of syndet bars about half a century ago was a major breakthrough in cleanser technology, given their significantly reduced potential for damaging skin. Developing cleansers that effectively deliver moisturizing benefits is a technical challenge: It requires depositing skin-care agents, which are normally removed by skin cleansers, under wash-off conditions. Emollients minimize barrier damage in two fundamental ways: first, by reducing the interactions between the cleanser surfactants, and the skin proteins and lipids; and secondly, by restoring those that are inevitably lost during a wash period. New product forms such as liquid cleansers introduced in the 1990s and non-woven technology introduced more recently offer exciting opportunities for delivering moisturizing benefits from wash-off systems. Skin cleansing products that contain emollients, occlusives, humectants, and skin nutrients are already on the market. Wash-off systems that provide additional skin-care benefits will continue to be an area of active research, resulting in novel technologies and product forms in the coming years.

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