SURFACTANTS

Say Goodbye to Traditional Cleansing Surfactants

Why biosurfactant technology is replacing these problematic ingredients

By Dr. Lee Speight *

Introduction

The world's habits have been forever changed from the events over the past year, especially in regards to cleansing and disinfecting. While March marks the one year anniversary of a global shutdown, the 16th of March this year has another significance: the 155th anniversary of Joseph Lister's discovery that hand washing before surgery prevented infections (Onthisday.com 2021). While hand washing and sanitizing at regular intervals is undoubtably good for personal and public health, as it dramatically curtails the spread of opportunistic pathogens, it does enact a heavy toll on individual's skin (Pope and Ousley 2020), leading to a search for safer, milder cleansing ingredients.

Finding the "Cracks" in Current Hand-Washing Products

Hand washing in public is predominately accomplished by hand sanitizing products. While effective at killing microbes, hand sanitizers are ineffective at removing visible dirt (CDC 2020) (Pickering, Davis and Boehm 2011). Typical hand sanitizers are composed primarily of ethyl or isopropyl alcohol and do not contain soaps or cleansers. While powerful disinfecting agents, these alcohols are hygroscopic and pull water away from the skin as they evaporate and dry. This leads to irritated and cracked skin upon regular usage of alcohol-based hand sanitizers. Some hand sanitizing products add moisturizers such as aloe vera to mitigate the drying effect of the alcohols, however this is not entirely effective (Rundle, et al. 2020). Further, as hand sanitization simply kills most germs and does not remove them or any debris, hand washing is necessary at regular intervals to ensure proper hygiene (CDC 2020). Yet hand washing, despite not containing skin-drying alcohols, is more irritative to the skin on the hands (World Health Organization 2009). Why?

To adequately wash one's hands, it is recommended that the hands be scrubbed continuously for twenty (20) seconds (UC Davis Health 2020). This time is needed to generate sufficient friction to adequately dislodge dirt and germs from folds on the skin. Interestingly, it is this friction and mechanical removal of germs that gives hand washing its cleaning power (CDC 2020). Studies in the early 2000s showed that there was no benefit for the addition of antimicrobial ingredients, such as triclosan, to hand soaps as both antimicrobial and traditional hand soap provided the same disinfecting effect (CDC 2020). However, the mechanical force of this friction, combined with the strong surfactancy of traditional hand soaps, leaves users' hands dry, irritated, and raw. Frequent hand washing, typical of those in the healthcare industry and now commonplace due to COVID-19 hygiene programs, greatly exacerbates hand skin irritation (World Health Organization 2009).

To mitigate the irritation caused by frequent hand washing, experts recommend to pat dry hands instead of rubbing dry (UC Davis Health 2020). Many hand soap manufacturers offer "moisturizing" formulations containing emollients or skin-soothing agents to make their products milder on the skin. In addition, experts recommend post-hand washing moisturization with lotions without fragrances or anti-aging actives to mitigate irritation due to hand washing (UC Davis Health 2020). However, these mitigations beg the question: why is moisturization particularly needed after hand washing? Why is hand washing more drying and irritative to the skin than alcohol-based hand sanitizers (Rundle, et al. 2020)?

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The Problem Ingredient: Surfactants

The answer is surfactants. Traditional surfactants for hand soaps like sodium alkyl sulfates and sodium alkyl ether sulfates are powerful grease cutters capable of removing all of the oils from a surface, leaving it clean and bare. This performance makes these sulfate surfactants effective in dish cleaning and laundry applications where the goal is to completely remove grease and soil deposits from a surface. Yet when this surfactant chemistry is used on hands, the performance is similar – all oleochemical material and soils are removed from the surface of the hands (The Derm Review 2020). While this sounds positive from a sanitization perspective, it is troubling from the perspective of skin health.

Human skin, including that on hands, has a delicate water balance that it must maintain, despite being exposed constantly to the environment. Barrier lipids on the exterior of skin cells act as a seal to protect cells from overhydration in humid environments and dehydration in dry environments (Visscher 2009). Both alcohol-based hand sanitizers and the surfactants in hand soaps remove these barrier lipids. Hand sanitizing products do cause some removal of the barrier lipids (Rundle, et al. 2020). The active ingredients of hand sanitizers, short-chain alcohols, are not ideal degreasers and typically do not completely remove the barrier lipids.

Traditional surfactants in hand soaps remove barrier lipids from the skin during an effective twenty-second hand washing session. Sulfates specifically have been an ingredient of concern for many in the personal care space due to their prevalence in cleanser products and degreasing ability (The Derm Review 2020). Sulfates were found to be the most drying of all tested anionic traditional surfactants in multiple clinical studies (Branco, et al. 2005) (Gloor, et al. 2004). This is not surprising – sulfate surfactants are workhorse surfactants in degreasing products such as manual dish wash. Not exactly the type of chemistry that one would desire to translate to their hands.

The Search for Alternative Options

How does a formulator make a milder, yet equally effective hand washing formulation? Betaines, a type of amphoteric surfactant, can be used as a secondary surfactant to moderate the harshness of sulfates. Yet betaines are synthetic chemicals and can contain skin sensitizing impurities, such as dimethylaminopropylamine and lauramidopropyldimethylamine, so the viability of this solution is ambiguous. Formulators can also choose to remove sulfates entirely and replace them with sarcosinates; however, part of the mildness offered by sarcosinates is due to their lower efficacy relative to sulfates.

While encouraging, both of these means of mitigating the harshness of sodium alkyl sulfate surfactants share a common downside – a reliance on salt thickening. Salt thickening is a means of using a combination of anionic surfactants and sodium chloride (salt) to create the gel-like viscosity and rheology that consumers expect from liquid personal cleansing products. Both sarcosinates and betaines are designed to work in salt thickened formulations. These types of formulations require high loadings of both salt and surfactants to achieve effective thickening, potentially worsening the risk of skin irritation due to barrier lipid removal and exposure to salt.

A New Solution: Biosurfactants

Sophorolipids, a type of glycolipid biosurfactant, are a viable alternative that provide equal or improved cleansing performance without the skin irritation associated with sulfate surfactants. First isolated from the honey of Canadian honeybees, these natural sophorolipids are effective biosurfactants with many additional benefits (Gorin, Spencer and Tulloch 1961). Relevant to hand skin health, sophorolipids have shown success as additives to wound healing formulations, promoting the renewal of skin with minimal scarring (More, et al. 2019) (Sen, et al. 2020) (Lydon, et al. 2017). The combination of strong surfactant activity along with impressive biocompatibility makes sophorolipids ideal for use in skin cleansing applications.

Sophorolipids, while of interest to formulators for decades, have only recently become commercially available due to previous manufacturing and cost limitations. Driving the emergence of these high-performing, natural ingredients is Locus Performance Ingredients (Locus PI), which uses an innovation production method to customize and scale them at the cost and dosage rates needed for widespread adoption. The company's Ferma™ S sophorolipids, which were launched in August 2020 and have been designed for optimal functionality in personal care and cosmetic formulations. Ferma™ SH is a high HLB, linear sophorolipid, designed for foaming, cleansing, and detergent applications. Ferma™ SL is a low HLB, predominately lactonic sophorolipid,

Ferma™ S sophorolipids have been designed by Locus Performance Ingredients for optimal functionality in personal care and cosmetic formulations.

with excellent emulsification and degreasing performance. Both of these sophorolipid products have been designed to be perfectly blendable to achieve maximum performance for any HLB requirement.

Biosurfactant Cleansing Formulations

Ferma™ S biosurfactants have strong efficacy of sophorolipids and are capable of acting as the primary surfactants in skin cleansing formulations. Locus Performance Ingredients has developed several formulations utilizing the Ferma™ S biosurfactants to demonstrate their high efficacy and performance. These formulations are designed to be minimalistic and provide for effective cleansing without irritative surfactants such sodium alkyl sulfates.

1.) Foaming Hand Soap

The first formulation utilizing sophorolipids as the primary surfactant is a foaming hand soap concentrate. This hand soap is designed to be supplied as a concentrate to consumers along with a foaming dispenser. At a 1:10 concentrate:water dilution, this formulation is an effective foaming cleanser that leaves hands feeling refreshed. As it is designed to be used in a foaming dispenser, no rheology or viscosity modification was necessary.

Material	Weight %
Phase A	**95.79**
Water	31.68
Ferma™ SL (60% Active)	5.13
Ferma™ SH (60% Active)	42.74
Sodium Lauroyl Sarcosinate (30% Active)	13.68
EDTA	0.34
NaCl	1.71
Citric Acid	0.51
Phase B	**1.71**
Cocamide MEA	1.71
Phase C	**2.50**
Fragrance (optional)	1.00
Lincoserve SSB	1.50
Totals	**100.00**

Table 1: Locus Performance Ingredients Hand Cleanser Concentrate Formulation – Designed to be diluted 5x with water and dispensed in a foaming dispenser

2.) Gelled Hand Soap

Locus Performance Ingredients' next Ferma S-based formulation is a gelled hand soap. This gelled hand soap is similar to the foaming hand soap, but designed to closely resemble common gelled hand soaps. Utilizing a natural cellulosic thickening agent, this formulation is extremely gentle on skin as it has much less sodium chloride than analogous formulations. This alternative formulation provides an equivalent sensory experience to consumers, including flow, pumpability and foam. After washing, this formulation makes hands feel hydrated and supple rather than dry.

In both hand cleansing formulations, Locus Performance Ingredients was able to create effective cleansers at much lower surfactant loading than traditional hand soaps, with 3.3 % active surfactants in the diluted foaming formulation and 6.6 % in the gelled hand cleanser formulation. These are much lower amounts than traditional formulations, which can contain 20 – 30 % active surfactants. The lower surfactant loading is possible due to the strong efficacy of sophorolipids. This lower loading, combined with the gentle nature of sophorolipids, makes for a more pleasant hand washing experience, especially when used repeatedly.

Material	Weight %
Phase A	**99.16**
Water	85.54
Ferma™ SL (60% Active)	1.03
Ferma™ SH (60% Active)	8.55
Sodium Lauroyl Sarcosinate (30% Active)	2.74
EDTA	0.07
Xantham gum	0.80
NaCl	.034
Citric Acid	0.10
Phase B	**0.34**
Cocamide MEA	0.34
Phase C	**0.50**
Fragrance (optional)	0.20
Lincoserve SSB	0.30
Totals	**100.00**

Table 2: Locus Performance Ingredients Gelled Hand Cleanser Formulation

3.) Body Wash

While hands are under intense cleansing regimes due to COVID-19, all of the skin on one's body deserves gentle yet effective cleansers. Traditional body washes contain 15 – 25 % active surfactant and equally large amounts of salt and citric acid to achieve a good flow rheology. Using Ferma™ S products along with a sarcosinate co-surfactant, experts at Locus PI were able to achieve a refreshing body wash with 9.72 % active surfactants. Only 1 % of an acrylate polymer in this formulation was required to achieve good flow rheology, allowing the exclusion of both salt and citric acid. This formulation provides a luxurious sensory experience where the body wash is dispensed with the feel of a lotion, but with strong foaming and cleansing performance.

Material	Weight %
Phase A	**70.78**
Water	69.18
Acrylates/C10-30 Alkyl Acrylate Crosspolymer	1.35
Hydroxyethyl Celluose	0.25
Phase B	**18.77**
Ferma™ SH (60% Active)	7.40
Ferma™ SL (60% Active)	6.25
Sodium Lauryol Sarcosinate (30 % Active)	5.12
Phase C	**9.60**
Petrolatum	6.90
Glyceryl Oleate	0.15
Mineral Oil	0.50
Soybean Oil	1.00
Shea Butter	1.00
Eucalyptus Oil	0.05
Phase D	**0.85**
Preservative	0.05
Fragrance	0.80
Totals	**100.00**

Table 3: Locus Performance Ingredients Body Wash Cleanser Formulation

4.) Shampoos and Conditioners

An often-neglected part of human skin is the scalp. However, the human scalp is susceptible to damage from disruption of its own barrier lipids. Recent research has shown that disruption of the oleochemical balance on the scalp can lead to irritation, flaking, and discomfort. Traditional hair cleansing products contain 20–30 % active surfactants which can strip the scalp entirely of its protecting barrier lipids.

Ferma™ S products can also be utilized to create gentle shampoos and conditioners. In a combination shampoo and conditioner product, Locus was able to use 16.3 % active surfactants and 4 % salt to create a product formulation with a comparable sensory in-use experience to traditional formulations. Containing lower total active surfactant content than traditional formulations, our combination hair cleanser contains no sulfates as well as no ethoxylated ingredients while still producing a luxurious foam.

Material	Weight %
Phase A	**67.26**
Water	62.00
Hydroxylethyl Cellulose	5.03
Sodium Hydroxide	0.23
Phase B	**6.30**
Ceraphyl 70	1.46
Aloe Vera Juice 10X Concentrate	1.59
Honey Extract in Glycerin	1.73
Panthenol	0.29
Cetrimonium Chloride	1.23
Phase C	**1.78**
Glycol Distearate	1.78
Phase D	**22.64**
Ferma™ SL (60% Active)	11.57
Ferma™ SH (60% Active)	11.07
Phase E	**2.02**
Preservative	0.92
Fragrance	1.10
Totals	**100.00**

Table 4:
2-in-1 Shampoo/ Conditioner Formulation

All four of these formulations utilize Locus Performance Ingredient's Ferma™ S biosurfactants as the primary surfactants, completely replacing irritative sulfate surfactants. Further, as Ferma™ S products are intrinsically mild, amphoteric co-surfactants such as betaines were not necessary. Ferma™ S products have a high degree of synergy with cellulosic additives, such a xantham gum, to produce viscosity and rheologies similar to traditional salt thickened formulations.

Formulation has changed a lot in the last 155 years, but hand washing is still more important than ever to promoting positive public health. Fortunately, technology has improved dramatically in this time allowing for the creation of mild skin cleansers to make routine hand washing more pleasant. Ferma™ S sophorolipid products from Locus Performance Ingredients allow personal care formulators to create sulfate-free cleansing products with minimal amounts of active surfactant without sacrificing performance.

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Dr. Lee Speight is a science and ingredient expert with extensive experience developing and introducing new consumer products. He has a passion for discovering environmentally friendly innovations and has successfully executed multiple validation programs to drive growth of commodity biochemicals. Lee is currently responsible for the product, business and technical development of biosurfactant solutions at Locus Performance Ingredients. Previously, he led the nationwide launch of consumer products formulated with bio-based products in partnerships with Clorox and other major CPGs. He has a PhD in Chemistry from the University of Pennsylvania, an MBA from Quantic School of Business and Technology and a BSc in Chemistry from the College of William & Mary.