

Prevalence of Surfactant in the Contact Allergen Management Program

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Background: Surfactants are common ingredients in topical products, which can cause both irritant and allergic contact dermatitis.

Objective: The aim of this study was to determine the prevalence of 12 common groups of surfactants and 12 common individual surfactants among products in each category in the American Contact Dermatitis Society Contact Allergen Management Program (CAMP).

Methods: The American Contact Dermatitis Society CAMP was queried for the 12 surfactant groups and the 12 individual surfactants.

Results: The laureth/pareth sulfate group was the most prevalent surfactant group in CAMP products (17.9%). Laureth/pareth sulfates were the most common surfactant group in all product categories, except household and eye care products. The betaine/sultaine group (13.5%) and glucosides (10.0%) were also found in a significant proportion of CAMP products. Oleamidopropyl dimethylamine has the highest positive reaction rate (3.5%) but was tied for the lowest prevalence (0.20%) of the 12 individual surfactants studied. In contrast, cocamidopropyl betaine has a lower positive reaction rate (1.6%) with a higher prevalence (10.4%).

Conclusions: Surfactants were commonly found across all product types in CAMP. This study provides important information on allergen and irritant exposures in care products.

Surfactants are versatile molecules used for a variety of purposes in topical products. Their primary attribute is the ability to be miscible with both hydrophobic and hydrophilic molecules, which allows them to be used as cleansing agents, or to allow 2 or more otherwise incompatible chemicals to be used in topical products.¹ Their amphipathic structure allows them to interact with proteins and lipids of the stratum corneum, which can cause damage to the skin barrier.²

Surfactants have the ability to cause both irritant and allergic contact dermatitis. Many older formulations used anionic lauryl sulfate surfactants, most commonly sodium lauryl sulfate (SLS), because of their ability to provide rich suds and to cleanse effectively. However, SLS is one of the most irritating detergents, which led to the development of much milder formulations including other anionic surfactants (eg, glutamates, sarcosinates/sarcosines, lactylates, isethionates, sulfonates, sulfosuccinates),

as well as cationic (eg, betaines/sultaines), amphoteric (eg, acyl/dialkyl ethanolamines), and nonionic (eg, glucosides) surfactants. Other important groups of surfactants include dimethylamines (used not only “as is” in topical products but also as raw materials from which betaines are formulated) and quaternary ammonium surfactants (a moderately irritating class of surfactants with antimicrobial effects).¹

Unfortunately, over time, some of the milder surfactants have been found to cause allergic contact dermatitis. Seven surfactants are currently on the American Contact Dermatitis Society (ACDS) core testing series of 80 contact allergens, including cocamidopropyl betaine (CAPB), oleamidopropyl dimethylamine (OAPDMA), amidoamine (AA), stearamidopropyl dimethylamine, dimethylaminopropylamine (DMAPA), cocamide diethanolamine, decyl glucoside (DG), and benzalkonium chloride (BAC). Other surfactants that have been reported to cause contact allergy include lauryl glucoside, triethanolamine (TEA), and rarely benzethonium chloride.^{3–6}

This study was designed to explore the relative prevalence of various surfactants in the ACDS Contact Allergen Management Program (CAMP) database, including their relative prevalence within different product categories. The surfactants studied included 12 broad surfactant groups and 12 common individual surfactants, 10 of which are known to be potential contact allergens (listed in the previous paragraph), as well as SLS and sodium laureth sulfate. The relative prevalence of each surfactant was

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analyzed in comparison with allergic contact dermatitis rates in previous studies to identify pertinent allergenic surfactants.

METHODS

The ACDS CAMP database was queried for 12 broad surfactant groups and 12 specific surfactants. The CAMP data were extracted and collated in Microsoft Excel (version 14.5.1, 2011; Microsoft Corporation, Redmond, Washington). Raw data for the 8 CAMP product categories were also mapped, and all results were exported as a Microsoft Excel worksheet for further sorting and analysis.

RESULTS

A total of 4519 products were present in CAMP at the time of query. The relative prevalence of the 12 individual selected surfactants in CAMP is shown in Table 1, and the relative prevalence of the 12 surfactant groups is shown in Table 2.

Laureth/Pareth Sulfates

Laureth/pareth sulfates were the most prevalent surfactant group of the 12 groups studied. They were found in 811 (17.9%) of 4519 products in CAMP. This was the most common group found in skin care products (301/1578 [19.0%]), hair care products (311/789 [39.4%]), medications (63/794 [7.9%]), makeup (59/672 [8.8%]), nail care products (3/87 [3.4%]), and eye care products (4/83 [4.8%]). Laureth/pareth sulfates were found in 55 (87.3%) of 63 hair dye kits, 209 (81%) of 258 shampoos, 3 (50%) of 6 seborrhea medications, 39 (47.6%) of 82 laundry detergents, 4 (40%) of 10 depigmenting agents, 154 (39.5%) of 390 soaps/cleansers, 16 (34%) of 47 dishwashing products, and 60 (31.7%) of 189 antiaging/antiwrinkle/skin-firming products.

Sodium laureth sulfate had the second highest overall relative prevalence of the 12 individual surfactants in the study. It was found in 399 (8.8%) of 4519 products in CAMP. Sodium laureth sulfate

TABLE 1. Prevalence of Individual Surfactants in CAMP Database Products

Surfactant	Total Products (N = 4519)	Percent of Total Products
CAPB	469	10.4
SLS	399	8.8
TEA	325	7.2
SLS	298	6.6
DG	123	2.7
BAC	105	2.3
Amidoamine	102	2.3
Lauryl glucoside	70	1.5
Benzethonium chloride	33	0.7
Cocamide + lauramide DEA	30	0.7
DMAPA	8	0.2
OAPDMA	8	0.2

DEA indicates diethanolamine.

TABLE 2. Prevalence of Surfactant Groups in CAMP Database Products

Surfactant Group	Total Products (N = 4519)	Percent of Total Products
Laureth/pareth sulfates	811	17.9
Betaine/sultaines	609	13.5
Glucosides	451	10.0
Lauryl sulfates	329	7.3
Sulfonates	264	5.8
Amphoteric surfactants	147	3.3
Dimethylamines	144	3.2
Glutamates	118	2.6
Sarcosinate/sarcosines	98	2.2
Isethionates	94	2.1
Sulfosuccinates	81	1.8
Lactylates	69	1.5

was found in 168 (65.1%) of 258 shampoos, 2 (33.3%) of 6 seborrhea medications, 129 (33.1%) of 390 soaps/cleansers, 18 (28.6%) of 63 hair dye kits, and 11 (23.4%) of 47 dishwashing products.

Betaines and Sultaines

Betaines/sultaines were the second most prevalent surfactant group, found in 609 (13.5%) of 4519 products in CAMP. It was the most common group in oral care products (24/249 [9.6%]) and the second most common in skin care (245/1578 [15.5%]) and hair care products (251/786 [31.9%]).

Cocamidopropyl betaine was the most prevalent individual surfactant and was found in 469 (10.4%) of 4519 products in CAMP. It was the most prevalent individual surfactant in hair care products (217/789 [27.5%]), second in skin care products (165/1567 [10.5%]), and third in oral care products (23/249 [9.2%]). Cocamidopropyl betaine was present in 162 (62.8%) of 258 shampoos, 33 (52.4%) of 63 hair dye kits, 3 (50%) of 6 seborrhea medications, 143 (36.7%) of 390 soaps/cleaners, and 21 (27.6%) of 76 toothpastes/gels. Dimethylamines, such as DMAPA, AA, and OAPDMA, are closely related to betaines but showed lower prevalence in CAMP. Oleamidopropyl dimethylamine and AA were tied for the least common individual surfactants and were found in only 8 (0.2%) of 4519 total products. Dimethylaminopropylamine was found in only 102 (2.3%) of 4519 total products.

Glucosides

Glucosides were the third most prevalent surfactant group, found in 451 (10.0%) of 4519 products in CAMP. They were found in 101 (37.8%) of 267 household products and 221 (14%) of 1578 skin care products. Of the individual surfactants, DG was the fifth most prevalent, and lauryl glucoside was the eighth most prevalent; DG was present in 123 (2.7%) of 4519 products, and lauryl glucoside was in 70 (1.5%) of 4519 products. Decyl glucoside was the most common surfactant found in odor and stain remover products

(5/17 [29.4%]) and hair dye kits (12/63 [28.6%]). Lauryl glucoside was most commonly found in odor and stain remover products (3/7 [42.9%]).

Lauryl Sulfates

Lauryl sulfates were the fourth most prevalent surfactant group. They were found in 329 (7.3%) of 4519 products in CAMP. Sodium lauryl sulfate was the fourth most prevalent individual surfactant and was found in 298 (6.6%) of 4519 products in CAMP. It was found in 55 (72.4%) of 76 oral toothpastes/gels, 21 (44.7%) of 47 dishwashing household products, 3 (33.3%) of 10 depigmenting agents, 83 (32.2%) of 258 shampoos, 3 (25%) of 12 over the counter (OTC) corticosteroids, and 15 (23.8%) of 63 hair dye kits.

Quaternary Ammonium Surfactants

There is a very large number of quaternary ammonium surfactants used for a variety of purposes in topical and household products. In this study, the overall prevalence of this diverse group of surfactants was not studied. However, the prevalence of 2 important quaternary ammonium surfactants was examined. Benzalkonium chloride was found in 105 (2.3%) of 4519 products in CAMP. It was the most prevalent individual surfactant in eye care products (23/83 [27.7%]). It was present in 8 (50%) of 16 ophthalmic prescription medications and 22 (35.5%) of 62 topical eye care products. It was also found in 3 (33.3%) of 9 OTC antimicrobial/antiseptic medications and 21 (21.2%) of 99 OTC acne/rosacea medications. As an individual surfactant, benzethonium chloride was found in 33 (0.70%) of 4519 products. It was present in 6 (40%) of 15 skin care powders and 4 (25%) of 16 perianal medications.

Amphoteric Surfactants

Triethanolamine, an amphoteric surfactant, was found in 325 (7.2%) of 4519 products in total. It was the most prevalent surfactant in the makeup category (58/672 [8.6%]), nail product category (2/87 [2.3%]), and skin care (178/1578 [11.3%]). It was present in 37 (56.9%) of 65 shaving products, 3 (50%) of 6 keratolytic medications, and 43 (36.1%) of 119 mascaras, 3 (33.3%) of 10 depigmenting agents, and 19 (30.6%) of 62 OTC anesthetic/pain relief/first aid medications.

Other Mild Surfactant Groups

The overall relative prevalence values of other mild anionic surfactant groups in CAMP were sulfonates (264/4519 [5.8%]), glutamates (118/4519 [2.6%]), sarcosinates/sarcosines (98/4519 [2.2%]), lactylates (69/4519 [1.5%]), isethionates (95/4519 [2.1%]), and sulfosuccinates (81/4519 [1.8%]).

DISCUSSION

Laureth/pareth sulfates were the most common surfactant group, and lauryl sulfates were the fourth most prevalent surfactant group

found in the CAMP database products. Our data highlight that both groups are commonly found in shampoos, hair care products, dish soaps, and laundry detergents. These surfactants are found in many types of products where it is desirable to have abundant suds, despite the tendency of these ingredients to be more irritating.¹ Laureth/pareth sulfates still retain the high production of suds seen with lauryl sulfates and are somewhat less irritating, but still have significant irritation potential on sensitive skin.¹ Although both groups are common causes of irritant dermatitis, they are not known to cause allergic contact dermatitis.

The second most common surfactant group, betaine/sultaine, was introduced into products to decrease irritancy. However, some have been found to be potential contact allergens. In our study, CAPB was the most prevalent individual surfactant and was most commonly found in hair care products, such as shampoo and hair dye kits. From 1995 to 2001, CAPB was ranked 29th among the top 50 most common allergens detected in patch tests, with reported sensitization rates between 3.0% and 7.2%, and was ultimately named the contact allergen of the year in 2004.^{7–12} The 2015–2016 North American Contact Dermatitis Group (NACDG) cycle data reported a lower positive reaction rate of 1.6%.¹³ Figure 1 shows that CAPB is the most prevalent surfactant of those studied in the CAMP database but has a lower rate of positive reactions than many of the other individual surfactants in this study.¹³ There is a debate that the real sensitizers may be contaminant chemicals (DMAPA and AA), rather than CAPB itself.^{9,14–16} In our study, AA and DMAPA were both uncommonly listed as ingredients in products, with AA present in only 2.3% of products and DMAPA found in only 0.2%. The NACDG reports a positive reaction rate of 2.3% for DMAPA and 1.3% for AA.¹³

Oleamidopropyl dimethylamine, which is also a dimethylamine, such as AA and DMAPA, was tied for the least common of the 12 studied surfactants. However, there has been a significant increase in positive patch test reaction rates for OAPDMA from 2.3% in 2011–2012 to 3.5% in 2015–2016.^{13,17} The allergen has been reported to cause eyelid dermatitis.^{18,19} Figure 1 illustrates the high positive reaction rate but low prevalence for OAPDMA. Notably, there are several studies that highlight the increased rate of positive reactions to DMAPA and CAPB in patients who are sensitized to OAPDMA. This commonality of allergy to the 3 surfactants might not be due to cross-reaction but rather to the fact that OAPDMA and CAPB share DMAPA as a starting material, and DMAPA remains in the finished product as an impurity at variable levels.^{16,19,20}

Glucosides were the third most common surfactant group and were most commonly found in household products. They are found in both rinse-off products and leave-on products, such as moisturizers, deodorants, and sunscreens.⁵ In our study, DG (2.7%) was slightly more prevalent than lauryl glucoside (1.5%), and both were most commonly found in odor and stain remover products. Positive reaction rates to DG have increased from 1.6% in 2013–2014 to 2.1% in 2015–2016.^{13,21} Because of their increasing prevalence, alkyl glucosides were ranked the ACDS Contact Allergen of the Year for 2017.²² Decyl glucoside, lauryl glucoside, cetearyl glucoside, and

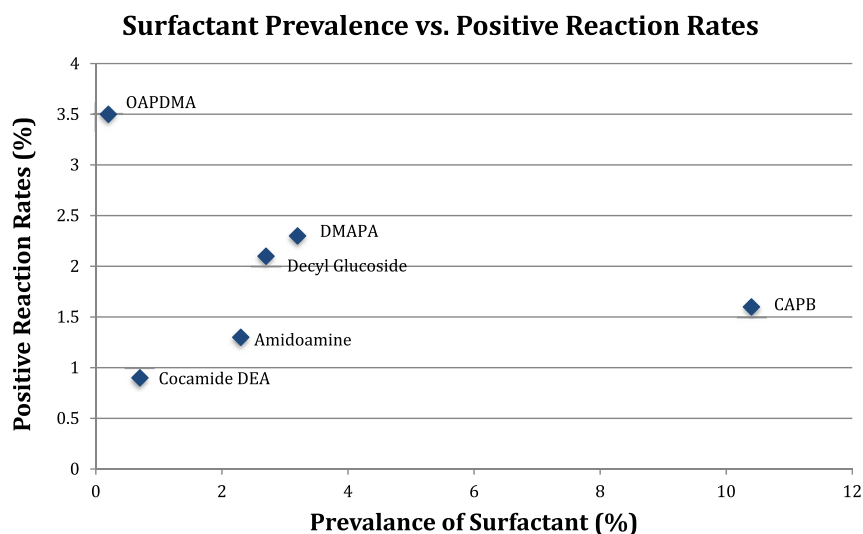


Figure 1. Prevalence of surfactant in CAMP database products versus rate of positive reactions from the 2015–2016 NACDG patch test series data.¹³

coco glucoside are responsible for most cases of contact dermatitis.⁵ Importantly, many articles demonstrate that most patients simultaneously tested to several glucosides had multiple positive reactions, and thus, the authors suggest that patch testers include various glucosides in their cosmetic series.^{5,23}

Benzalkonium chloride is a cationic quaternary ammonium compound often used in products for its antimicrobial effects.¹ This study shows that it was the most common surfactant found in eye care products. There are reports of BAC's ability to cause eyelid contact dermatitis in addition to cases of conjunctivitis, cheilitis, stomatitis, and hand dermatitis from occupational exposures.¹⁸ Benzalkonium chloride is a known irritant that could lead to false-positive patch test reactions, and thus, there are inconsistent data regarding its ability to cause allergic contact dermatitis.^{6,24,25} Benzethonium chloride is newer to the marketplace, and thus, there are fewer data regarding its irritancy and sensitizing potential. Coreactivity between the 2 surfactants may exist; there are only a few case reports of irritant dermatitis to benzethonium chloride and 2 cases of allergic dermatitis.²⁵

Triethanolamine belongs to the short-chain alkanolamines group. It was the third most prevalent individual surfactant and was most commonly found in the makeup category. Lessman et al²⁶ analyzed patch test data of 85,098 patients who had been tested with TEA 2.5% petrolatum and ultimately determined that the risk of sensitization to TEA seems to be low (0.3%).

Limitations

The CAMP database does not include all commercial products currently available for use. Although the CAMP database contains approximately 5000 common products and strives to be a good representation of the overall marketplace, it is possible that the database may not perfectly represent the marketplace as a whole. In addition, companies may change the product ingredient composition, which could affect data collected from CAMP.

CONCLUSIONS

Laureth and pareth sulfates were the most prevalent surfactant group in the ACDS CAMP database. Betaines, sultaines, and glucosides were also found in a significant portion of CAMP products. The laureth/pareth sulfate group was the most common surfactant group in all product categories, except household and eye care products. Regarding allergenic potential, OAPDMA has the highest positive reaction rate but the lowest prevalence in care products. In contrast, CAPB has the highest prevalence with a lower positive reaction rate. The prevalence of less irritating surfactant groups that rarely cause contact allergy (sultaines, glutamates, sarcosinates/sarcosines, lactylates, isethionates, sulfonates, sulfosuccinates, and amphoteric) is also reported. Further data on the risk of contact allergy to these groups of surfactants are needed. The data in this study are valuable to both physicians and product manufacturers.

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