SYNETH™

LONZA SPECIALTY ESTERS

SYNETH™ C15 K RSPO MB

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Plant-derived and cold-processable, non-ionic surfactant exhibiting exemplary mildness, flash foaming, and oil pick-up properties, ideal for gentle cleansing applications in skin and hair care.

Key features and benefits

- Naturally derived from plant origin
- Multi-functional, non-ionic surfactant/emulsifier balancing cleansing performance with mildness on skin and eyes
- Cold-processable and highly compatible with other surfactants and polar emollients
- Low surface tension and good surfactant dynamics for effective cleansing and oil pick-up
- Non-PEG, EO/PO free, 1,4-dioxane free
- COSMOS, Non-GMO, RSPO MB, Halal, Kosher, Vegan

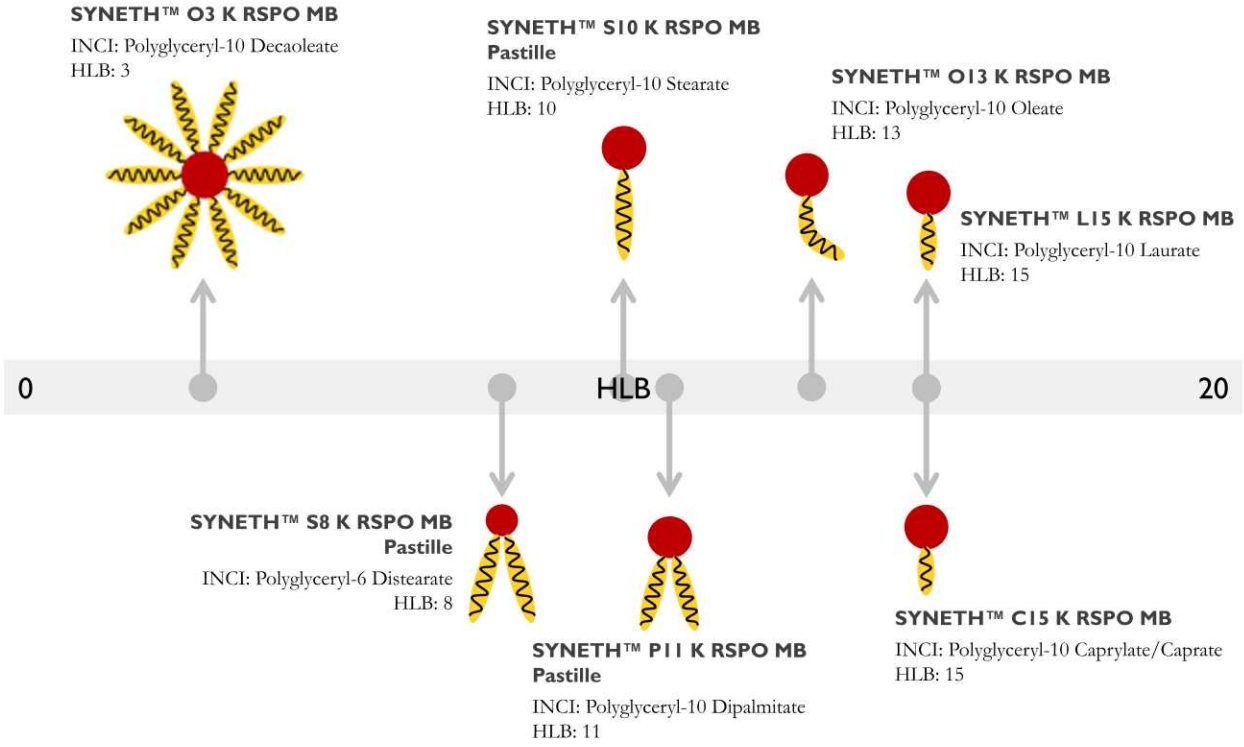
Properties

- INCI: Polyglyceryl-10 Caprylate/Caprate
- Average molecular weight: 644 g/mol
- Appearance: Amber syrup
- HLB: 15
- Active level: 100%

Introducing SYNETH™ Polyglycerol esters

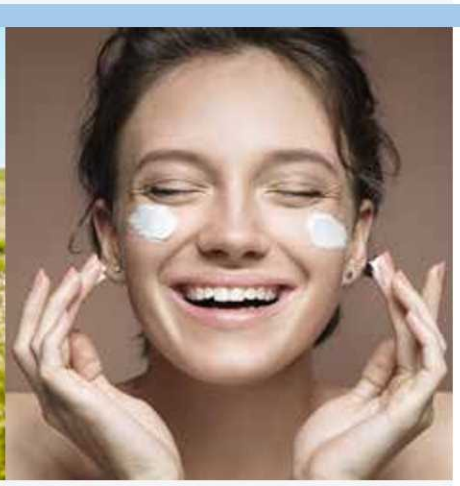
Lonza's SYNETH™ range of polyglycerol esters was designed with two goals in mind. The first is to provide a range of surfactants and emulsifiers for Personal Care that strike the best possible balance between functionality and performance, product aesthetics and texture, mildness, and a positive environmental profile. The second goal is to offer formulators the possibility of achieving an unprecedented range of product forms and textures across any category within Personal Care and Beauty, all based on the same customizable chemistry.

Produced by etherification of glycerol to polyglycerol followed by esterification of polyglycerol with a fatty acid, the SYNETH™ chemistry is customizable in the sense that the size of the polyglycerol head group and the nature and number of aliphatic side chains can be controlled by varying the reactants and reaction conditions. This allows us to offer a wide range of HLB values based on a single class of chemistry:



SYNETH™ polyglycerol esters are extremely mild to the skin and many have been shown to provide active moisturization. Moreover, being naturally derived from plant origin they meet the increasing demand for "green chemistry." Complying with a number of key standards and certifications, including Kosher, Halal, Vegan, RSPO MB, Non-GMO, and COSMOS allows them to be used in products that appeal to the widest range of consumers.



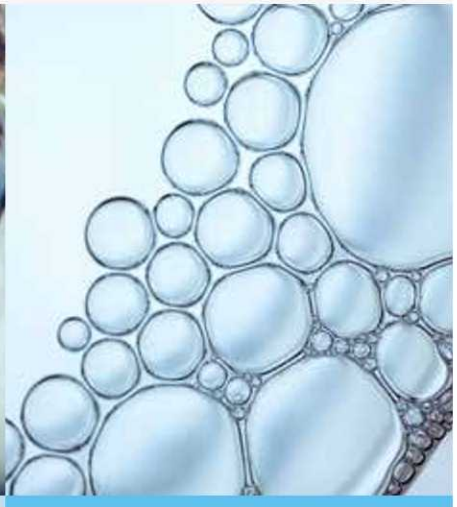


With applications ranging from foaming and cleansing to emulsification to pigment wetting, product forms from heavy creams to light lotions to gentle cleansers, across categories from skin and hair care to color cosmetics, the SYNETH™ range is unprecedented in its versatility. In today's world where consumers are highly informed and concerned about the effect of cosmetic ingredients on their health and that of the environment, yet are unwilling to compromise on product functionality and aesthetics, SYNETH™ is the perfect solution for formulators who are looking to offer the best product performance and most innovative textures without having to rely on ethoxylated ingredients or sulfate and silicone based chemistries. At the same time, by being able to rely on a single, well characterized range of surfactants and emulsifiers that are either cold or low temperature processable, formulators can achieve superior speed to market and meet demands for faster and greater innovation.

We call it...

Formulating without compromise





SYNETH™ C15 Structure and properties

SYNETH™ C15 K RSPO MB ("SYNETH™ C15") is part of Lonza's SYNETH™ range of naturally derived polyglycerol esters, which offer excellent mildness on skin and superb performance and versatility in a wide range of personal care applications.

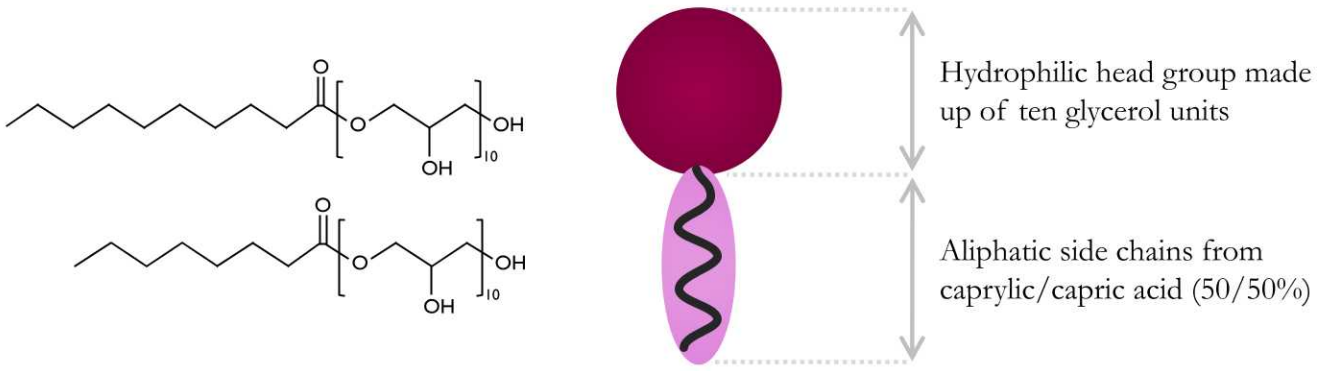


Fig. 1 Schematic of SYNETH™ C15 monomer structure.

Characteristic features of SYNETH™ C15 are the large hydrophilic head group, comprising ten glycerol units, as well as the short-chain, linear $C_{8/10}$ hydrophobic tail, resulting in an overall hydrophilic and highly water-soluble surfactant. The decaglyceryl, non-ionic head group is fundamental to the moisturization and mildness benefits of SYNETH™ C15. The $C_{8/10}$ mixed chain, derived from caprylic acid (50%) and capric acid (50%) allows for excellent mobility and compact packing at interfaces, resulting in low surface tension. The distinctive chemistry of SYNETH™ C15 translates into excellent surfactant dynamics, wetting, flash foaming, and cleansing performance, atypical for non-ionic surfactants. These properties make it an unparalleled formulation option for mild moisturizing cleansers and high foaming, low viscosity applications.

Surface tension and critical micelle concentration

Figure 2 displays the surface tension of aqueous solutions of SYNETH™ C15 plotted against the SYNETH™ C15 concentration. From Fig. 2 we deduce that SYNETH™ C15 has both a characteristically low equilibrated surface tension of 25 mN/m and a characteristically low critical micelle concentration (CMC) of 9 mg/l. SYNETH™ C15's physico-chemical properties calculated from the surface tension plot are listed in Table 1.

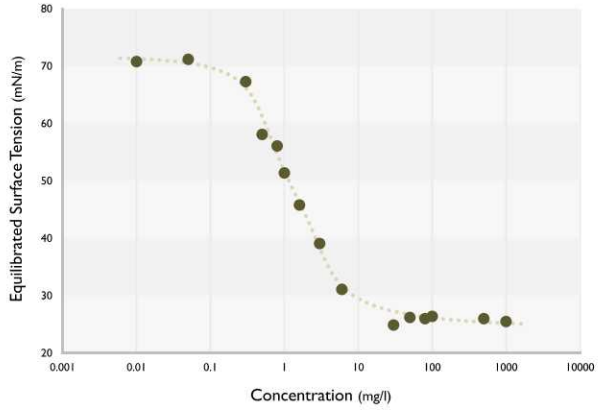


Fig. 2 Equilibrated surface tension vs. concentration for SYNETH™ C15. The equilibrated surface tension was measured at room temperature (25.0 ± 0.1°C) with a stabilization time of 20 minutes using a KRUSS K100 Surface Tensiometer and De Noüy (platinum) ring methodology.

Table 1 Physico-chemical properties of SYNETH™ C15 as determined from the surface tension measurements of Fig. 2.

SYNETH™ C15™ Physico-chemical properties	
Critical micelle concentration (CMC)	9 mg/ml
Equilibrated surface tension above CMC	25 mN/m
Surface area per molecule	44 Å²
Surface excess	3.8E-10 mol/cm²

The very low surface tension of SYNETH™ C15 signals high surface activity and interfacial packing, vital for cleansing performance, efficient emulsification, effective surface wetting, and delivery of actives to a surface. The high surface activity of SYNETH™ C15 is particularly atypical for high molecular weight, non-ionic surfactants. As such, SYNETH™ C15 is unique in that it combines the desirable properties of ionic surfactants, such as cleansing performance and foaming ability, with the superior mildness to skin of non-ionics.

The low CMC signals effective micelle formation at low concentrations and high micelle density at higher concentrations, providing further support for the multi-functional benefits of SYNETH™ C15 in foaming, wetting, and oil solubilization. Since it is the interaction of free surfactant monomers with the skin, rather than micelles, that is commonly considered the cause of skin irritation, the low CMC also contributes to the mildness of SYNETH™ C15.

Surface dynamics

In order to determine its surface dynamics and mobility, the surface tension of aqueous solutions of SYNETH™ C15 was measured both as a function of SYNETH™ C15 concentration and as a function of the surface age, as displayed in Fig. 3.

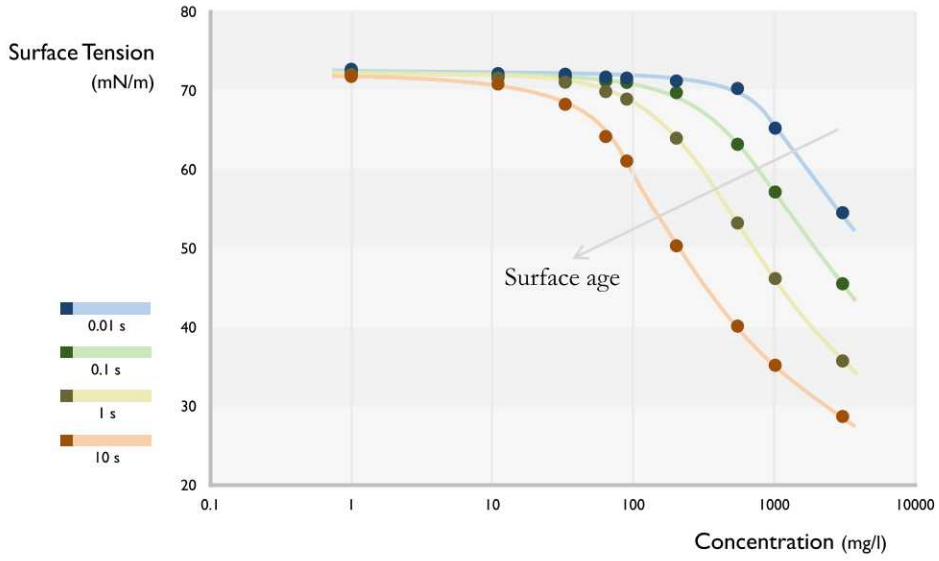


Fig. 3 Dynamic surface tension vs. concentration for SYNETH™ C15 measured at different surface ages. Measurement were conducted at room temperature (25.0 ± 0.1°C) using a KRUSS BP100 Bubble Pressure Tensiometer.

SYNETH™ C15's ability to significantly lower the interfacial tension on a fast time scale is in sharp contrast to alternative mild, non-ionic surfactants, such as alkyl glucosides and polysorbate chemistries, which tend to exhibit poor dynamics. This observation points to a highly mobile surfactant monomer for SYNETH™ C15. The ability of SYNETH™ C15 monomers to navigate to a surface and significantly influence the interfacial tension on a ms time scale are of particular importance for foaming applications, where foam volume, density, and stability rely on how quickly surfactant monomers can migrate to and stabilize a new surface to form a bubble. High density, small bubble size flash foam can only be produced by an abundance of highly dynamic monomers in solution. The same dynamic properties also contribute to good cleansing and wetting properties.

Flash foaming properties

The foaming ability of a surfactant-based product is a critical property that drives consumer perception of its cleansing performance. SYNETH™ C15 exhibits excellent foaming characteristics sure to delight the most discerning consumers.

To compare the flash foaming properties of SYNETH™ C15 to benchmark chemistries with comparable mildness on skin, PEG-80 Sorbitan Laurate ("PEG-80") and Decyl Glucoside, the time evolution of foam volume was studied in a simple face wash formulation chassis containing 5% surfactant (formula compositions listed in Table 2). Fig. 4 displays the results of this study.

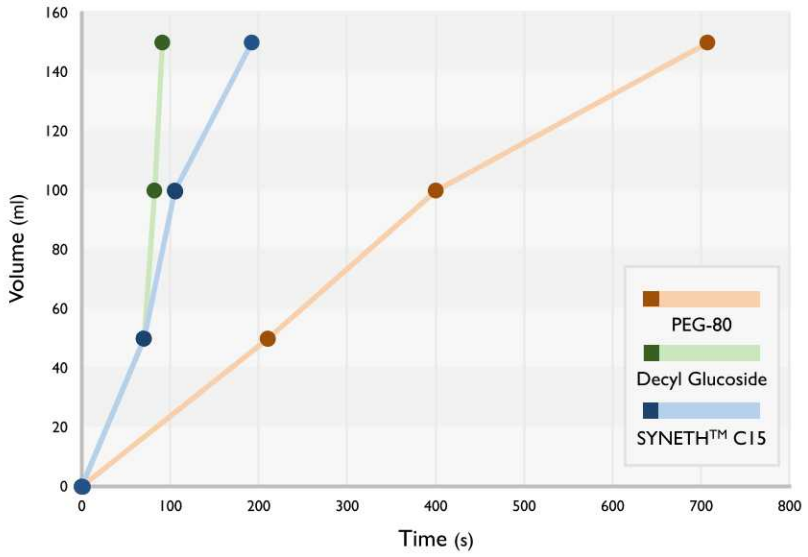


Fig 4 Foam volume vs. time for the different formulas listed in Table 2. Foams were generated by stirring at a constant rotation speed of 1000 rpm and monitored using a TECLIS Foam Analyzer. The solution was diluted tenfold to 0.1 g/ml in distilled water and foaming was observed until 150 ml of foam was generated. Foam volume and foam stability were determined by conductivity measurements, while bubble evolution was monitored by a CCD camera, which photographed the sample every five seconds.

Ingredient	Formula 1	Formula 2	Formula 3
Water	66.50	66.50	66.50
Acrylates/C_{10-30} Alkyl Acrylate Crosspolymer	0.75	0.75	0.75
Glycerin	2.00	2.00	2.00
Sodium Cocoyl Glutamate	10.00	10.00	10.00
Cocamidopropyl Betaine	15.00	15.00	15.00
SYNETH™ C15	**5.00**	-	-
PEG-80 Sorbitan Laurate	-	**5.00**	-
Decyl Glucoside	-	-	**5.00**
Mikrokill® COS	0.75	0.75	0.75
TOTAL	100.00	100.00	100.00

Table 2 Face wash formulation chassis with SYNETH™ C15, PEG-80 Sorbitan Laurate, and Decyl Glucoside.

SYNETH™ C15 generated significantly better flash foam than PEG-80, taking approximately three times less to achieve the same foam volume. SYNETH™ C15 showed similar flash foaming properties to Decyl Glucoside in terms of the rate of foam volume generation. However, where the two surfactants differ significantly is in liquid pick-up. With SYNETH™ C15, almost all of the liquid was converted into foam, while for Decyl Glucoside over 25% of the liquid remained. These observations suggest superior foaming efficiency of SYNETH™ C15, likely due to higher monomer mobility. Good liquid pick-up is instrumental for generating creamy, luxurious foams of smaller bubble size and higher density. Such foam characteristics are much more desirable in personal care applications than the dry, rigid foams formed by Decyl Glucoside. Table 3 displays the quantitative parameters obtained from the foaming study.

Table 3 Quantitative foaming parameters for SYNETH™ C15, PEG-80 Sorbitan Laurate, and Decyl Glucoside in a face wash formulation chassis.

	SYNETH™ C15	Decyl Glucoside	PEG-80 Sorbitan Laurate
Initial liquid volume (ml)	150	150	150
Time required to reach 150 ml of foam (s)	192	91	707
Foam volume at 50 s during stirring (ml)	49.4	59.4	9.0
Liquid volume remaining in the column after stirring stops (ml)	0.8	43.9	5.2
Time required to reach half of liquid volume entrapped at air-foam interface (s)	9	6	51

To try to achieve the same amount of flash foam as the SYNETH™ C15 system in the same amount of time, a formulator would need to include more PEG-80 or Decyl Glucoside (approx. 7.5 to 10%) in the system or include a secondary foaming surfactant, potentially increasing the formulation cost. In addition, without SYNETH™ C15 the end user would need to use greater energy, i.e. rub more vigorously, to generate the same desired foam structure and volume.

Figure 5a shows the time evolution (post-sparging) of the foam structure for 5% of SYNETH™ C15 in water, providing a full picture of its intrinsic foaming properties. The measured initial average bubble radius is 55 µm with a bubble count density of 103.7 mm^{-1}, which corresponds to a rich foam with a luxurious, velvety feel, uncharacteristic of high HLB surfactants. The time required for the measured bubble count to half is 237 s consistent with a long-lasting flash foamer, ideal for cleansing applications. Figure 5a further shows that the foam maintains its basic structure with a modest increase in bubble size over the course of ten minutes.

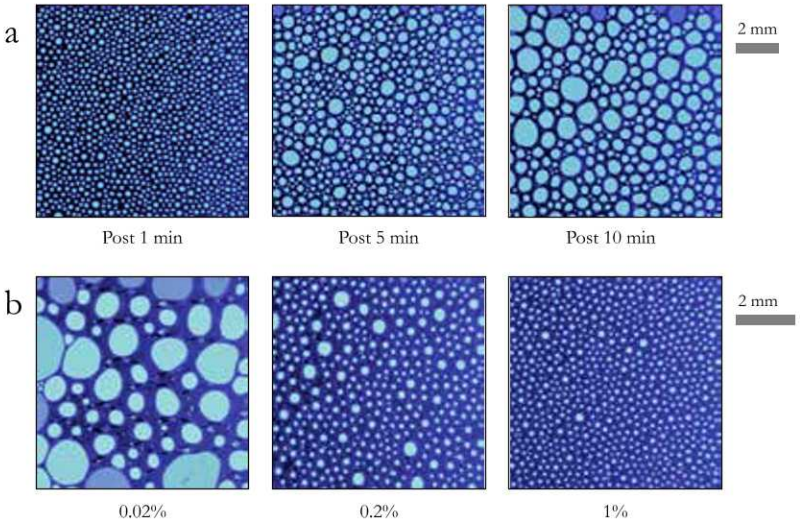


Fig 5 a) Evolution of foam structure for 5% SYNETH™ C15 in water; b) Foam structure of aqueous solutions of SYNETH™ C15 at different concentrations 20 seconds after sparging was completed. Images were obtained using a KRUSS DFA100 Dynamic Foam Analyzer with a Foam Structure Analyzer Module. Foam was generated by sparging air into the solution at 0.2 l/min for 10 seconds. Measurements were carried out at room temperature (25.0 ± 0.1°C). Scale is 2mm.

Figure 5b shows the dependence of the structure of foam produced from aqueous solutions of SYNETH™ C15 measured at 20 seconds after the completion of sparging on SYNETH™ C15 concentration. Quantitative foam parameters obtained from the images in Fig. 5b are listed in Table 4. As the concentration is increased from 0.02 to 1% SYNETH™ C15 forms increasingly dense foams with smaller bubbles and a more uniform size distribution. Even at low concentrations the SYNETH™ C15 foam maintains its structure (bubble size and density), unperturbed by external forces even when the majority of foam has drained after 10 minutes. The trend of decreasing bubble size with increasing concentration reflects an increase in the ability of surfactant monomers to migrate to the surface and stabilize the foam.

Table 4 Foaming parameters for SYNETH™ C15 measured at 0.02%, 0.2% and 1% in water.

Foaming parameters/concentration	0.02%	0.2%	1.0%
Maximum foam volume (ml)	39.2	51.1	73.2
Initial bubble count (mm^{-1})	1.3	26.5	67.8
Initial average bubble radius (μm)	433	103	67
Final average bubble radius post 10 min (μm)	403	144	119

In summary, the foaming data presented herein highlight the excellent flash foaming properties of SYNETH™ C15, particularly when compared to typical non-ionic surfactants/emulsifiers, and provides strong support for its use in cleansing applications in both skin and hair care.

Mildness to skin and eyes

SYNETH™ C15, along with a number of surfactant benchmarks, was evaluated in an *in vitro* MatTek Epiderm™ Skin Irritation Test and an an *in vitro* MatTek EpiOcular™ Eye Irritation Test with results listed in Table 5. SYNETH™ C15 did not show any significant decrease in mean skin tissue viability, as did PEG-80 and the negative control (saline). In the same study, both Decyl Glucoside (17% viability) and Cocamidopropyl Betaine (33% viability) performed significantly worse with both qualifying as a skin irritant (viability less than 50%).

Product	Mean skin tissue viability (%)	Irritancy classification (Skin)	Time to reach 50% EpiOcularTM tissue viability (min)	Irritancy classification (Eye)
SYNETH™ C15	105	Non-irritant	32.3	Mild
PEG-80 Sorbitan Laurate	99	Non-irritant	>256.0	Minimal
Decyl Glucoside	17	Irritant	<16.0	Moderate to severe
Cocamidopropyl Betaine	33	Irritant	<1.0	Severe
Phosphate Buffered Saline (negative control)	100	Non-irritant	-	-
5% Sodium Dodecyl Sulfate (positive control)	3.1	Irritant	-	-

Table 5 Results from an *in vitro* MatTek™ Irritation Study and *in vitro* MatTek EpiOcular™ Eye Irritation Test comparing SYNETH™ C15 with different benchmark surfactants. A sample with a mean skin tissue viability percentage of 50% or more is considered non-irritant, while a sample with a mean tissue viability percentage of 50% or less is considered irritant. EpiOcular™ tissue viability was determined via methyl thiazole tetrazolium (MTT) uptake and reduction. The mean percent viability is measured as a function of time to calculate an ET50, which represents the time at which the EpiOcular™ tissue viability was reduced by 50% compared to control tissue treated with 100 µl of tissue culture water.

The skin mildness of SYNETH™ C15 can be attributed to the non-ionic and polyglyceryl nature of its head group and its low CMC. Polyhydroxy compounds are well known for their skin humectant benefits and skin barrier enhancing properties. The non-ionic nature of SYNETH™ C15 minimizes any binding of surfactant monomers to the skin, while the low CMC ensures that only a low concentration of monomers can interact with the skin by binding to proteins or dissolving lipids. Collectively, these properties all contribute to the low skin irritation potential of SYNETH™ C15.

A common issue with surfactants is irritation of the eyes. Surfactants disrupt the balance of water on the surface of the eye itself and can cause severe irritation in the form of sting, dryness, itchiness, and redness. The eye irritation test results, listed in Table 5, show SYNETH™ C15 is classified as a mild eye irritating surfactant, making it suitable for use in formulations that come in close contact to eyes such as face washes and baby shampoos.

Mitigation of SDS skin penetration

The irritancy of surfactants to skin is the result of penetration of surfactant monomers into the skin's upper layers, which can result in denaturation of functional proteins and disruption of lipid bilayers, and ultimately to a compromised barrier function. Here, we show that SYNETH™ C15 can mitigate the penetration of Sodium Dodecyl Sulfate (SDS, a well-known skin irritant), suggesting that SYNETH™ C15 can help mitigate the irritation potential of formulas containing SDS.

Figure 6 compares the penetration of SDS into *ex vivo* surgical human abdominal skin treated with a solution of 1.25% SDS and treated with a mixture of SDS and SYNETH™ C15 (1.25% and 0.625%, respectively) as determined using Confocal Raman Spectroscopy.

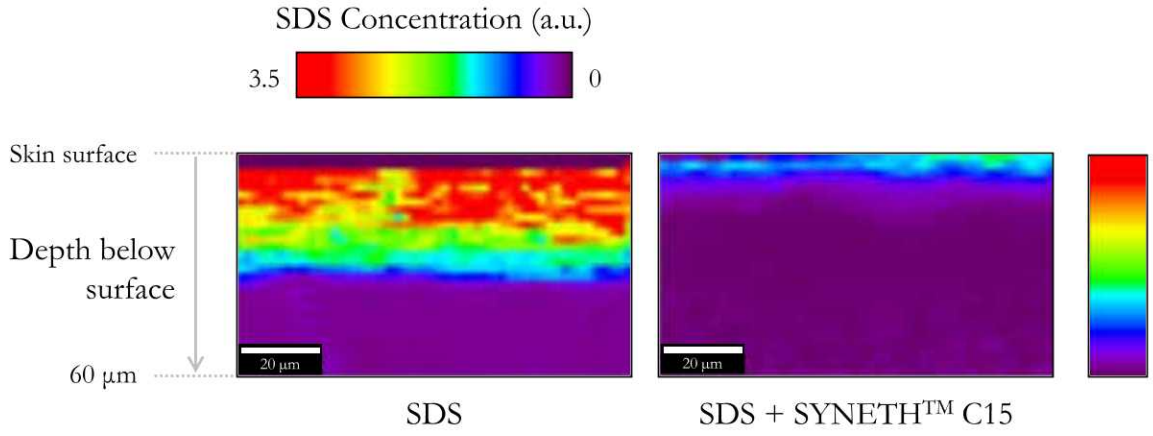


Fig. 6 Penetration of SDS into *ex vivo* surgical human abdominal skin treated with solutions of SDS (1.25%) and SDS with SYNETH™ C15 (1.25% and 0.625%, respectively). 120 µl solutions in Phosphate Buffered Saline (PBS) were applied to a surface area of 0.5 cm^2. Images were acquired with a WITec Alpha-300R Plus Confocal Raman microscope using a 532 nm laser at 20 mW power. Data analysis was performed with WITEc Project Plus software.

Clearly, SYNETH™ C15 significantly reduces the penetration of SDS into the skin's upper layers. Near the skin surface the SDS concentration is two to threefold higher in the SDS treated sample than in the sample treated with SDS and SYNETH™ C15. Furthermore, in the sample treated with SDS only, penetration is observed well into the viable epidermis (30-35 µm depth), while penetration is negligible in the sample treated with both surfactants. A likely explanation for this profound effect of SYNETH™ C15 on SDS presentation is a reduction of the overall CMC of the solution by incorporation of SDS monomers into micelles.

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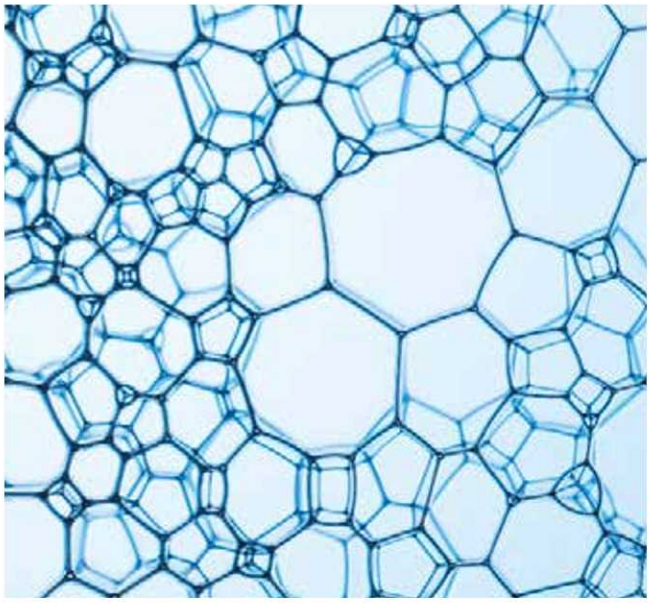

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