



Sucrose esters - General Information



EXPERIENCE OUR EXPERTISE!

Introduction

Sisterna B.V. is a young and flexible organisation that is solely active in the promotion and sales of Sisterna® sucrose esters. Furthermore Sisterna has developed countless proven and innovative applications of these natural and multifunctional emulsifiers for the cosmetic industry.

Sisterna is a joint venture of Royal Cosun in the Netherlands and Dai-Ichi Kogyo Seiyaku (DKS) in Japan. Production of Sisterna® sucrose esters takes place at DKS in Japan. DKS and Sisterna are ISO certified. The production site in Japan meets the highest pharmaceutical standards.

Sisterna's exclusive distributor network ensures the availability and technological knowhow of sucrose esters in personal care applications in the Western Hemisphere. Sisterna's technical service teams are ready to co-operate with customers to find solutions to specific technical problems. Many guide formulations are available on request.

Sisterna® sucrose esters are based on sucrose and vegetable fatty acids and are a unique range of natural, high quality, PEG-free, non-ionic emulsifiers with an exceptional performance and mildness. Furthermore they improve smoothness, emolliency and moisture level of the skin. Besides emulsification Sisterna® sucrose esters can offer other unique benefits to personal care formulations. They are also approved and widely used in the food industry.

Sisterna® sucrose esters are obtained by esterifying sucrose with edible fatty acids. By varying the degree of esterification of the sucrose molecule it is possible to obtain emulsifiers with HLB values ranging from 1 up to 16 for the high mono esters. This technical bulletin presents more detailed general information about sucrose esters.

BENEFITS

Based on natural, renewable and non-GMO raw materials

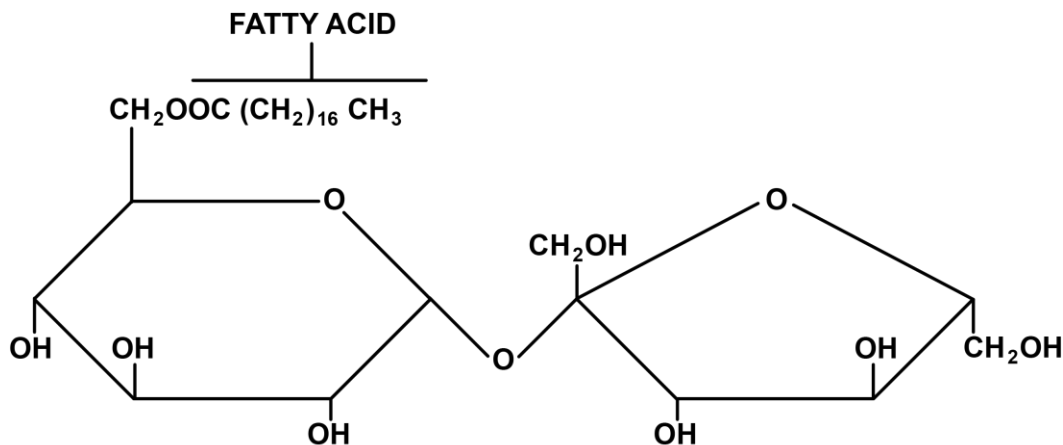
- High quality
- Easily biodegradable
- Non-ionic
- Ethylene oxide or PEG free
- Covering a wide range of HLB values
- Neutral in taste and odour
- Edible

1. CHEMICAL STRUCTURE AND PRODUCT RANGE

Chemical Structure

Sucrose esters of fatty acids are emulsifiers, obtained by esterifying one or more hydroxyl groups of the sucrose molecule with edible fatty acids. In Fig.01. the chemical structure of sucrose esters is given, R being the alkyl group of the fatty acid. The fatty acids react with one or more of the hydroxyl groups of sucrose to form mono-, di-, tri- or higher esters.

Fig.01. Chemical structure of sucrose esters



Product Range

The use of sucrose as the hydrophilic part of the molecule permits the production of mono-, di-, tri- and higher esters, giving a wider range of HLB-values (from 1 to 16) than can be obtained with any other polyol-derived surfactant. This is particularly valuable to formulators as it offers a wide range of high HLB, non-ionic and PEG-free surfactants.

The relation between sucrose ester grade, mono-ester content and HLB value is shown in Fig.02.

Fig.02. Product range

Product	INCI-name	HLB	% Mono Ester
Sisterna PS750-C	Sucrose Palmitate	16	75
Sisterna L70-C	Aqua (and) Sucrose Laurate (and) Alcohol	15	70
Sisterna SP70-C	Sucrose Stearate	15	70
Sisterna SP50-C	Sucrose Stearate	11	50
Sisterna SP30-C	Sucrose Distearate	6	30
Sisterna SP10-C	Sucrose Polystearate	2	10
Sisterna SP01-C	Sucrose Polystearate	<1	1
Sisterna A10E-C	Sucrose Tetrastearate Triacetate	0	-

With the exception of Sisterna L70-C, which is a solution of approximate 40% sucrose laurate, all Sisterna products are free-flowing, off-white powders neutral in taste and odour. Sisterna® sucrose esters are non-toxic. Upon ingestion they are hydrolysed by digestive enzymes into their components, sugar and fatty acids, which are metabolised by the body in the normal way.

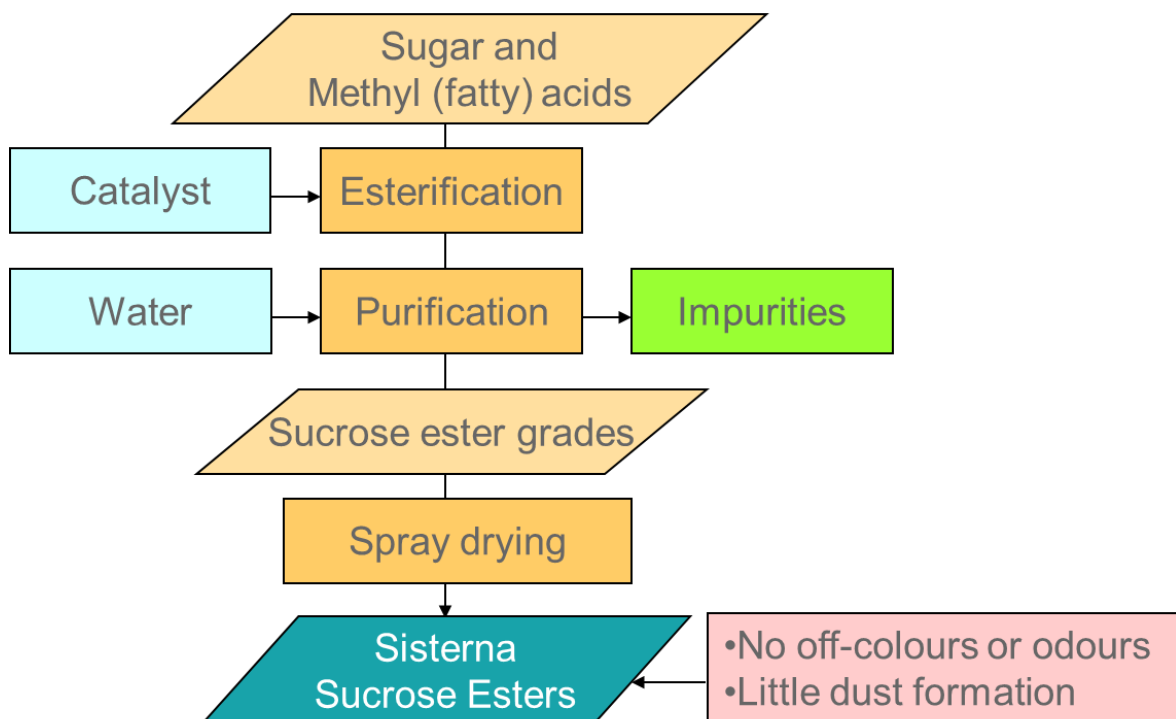
2. RAW MATERIALS AND PRODUCTION PROCESS

The raw materials for sucrose esters are sugar derived from sugar cane and sugar beet and methyl fatty acids from coconut oil and palm oil. The sugar is bleached with activated carbon from vegetable source. The oil is harvested from palm (*Elaeis guineensis*, from the fruit -not kernel) and coconut (*Cocos nucifera*).

The sucrose esters production of DKS is unique in the world: instead of using chemicals, a water purification step is applied to purify sucrose esters.

A flowchart of the sucrose ester production of the SP- and PS-grades is shown in Fig.03.

Fig.03. Production process SP -and PS-grades.



3. PHYSICAL-CHEMICAL PROPERTIES

Surface tension

Depending on the degree of esterification, Sisterna® sucrose esters decrease the surface tension of water. Products with a high mono-ester content decrease the surface tension to a level comparable to that of ethoxylated surfactants. In Fig.04. the surface tension and interfacial tension of several types of sucrose esters are compared to a polysorbate with a comparable HLB-value.

Fig.04. Surface tension

Product	HLB- value	Surface tension ^{1,2}	Interfacial tension ^{1,3}
Sisterna L70-C	15	28.5	6
Sisterna SP70-C	15	34.5	25
Sisterna SP50-C	11	36.7	35
Sisterna SP30-C	6	46.8	46
Polysorbate 80	15	48.0	14

¹dyne/cm - ²Du Nouy method (0.1% sol. in water 25°C) - ³Traube's method, distilled water against kerosene (0.1 sol. 25°C)

Solubility

Although Sisterna® sucrose esters have better water solubility than other surfactants of similar nature, care must be taken when dissolving them in water, since lumps are easily formed. Generally speaking, the water solubility of sucrose mono-esters is good, while that of sucrose di- and higher esters is not. Moreover, the shorter the fatty acid chain, the better the water solubility.

Fig.05. Solubility of sucrose esters in various solvents (10% solutions).

	Temp	L70-C	PS750-C	SP70-C	SP50-C	SP30-C	SP10-C	SP01-C	A10E-C
Water	25°C	S	ST	ST	PS	PS	I	I	I
	60-80°C	S	S	S	PS	PS	I	I	I
Oil	25°C	I	I	I	I	I	PS	PS	I
	60-80°C	I	I	I	I	PS	S	S	S
Glycerine	25°C	S	PS	I	I	I	I	I	I
	60-80°C	S	S	PS-S	PS	PS	PS	I	I
Propylene glycol	25°C	S	PS	I	I	I	I	I	I
	60-80°C	S	S	S	PS	PS	I	I	I
Ethanol	25°C	S	I	I	I	I	I	I	I
	60-80°C	S	S	S	S	S	PS	I	I

S: soluble PS: partly soluble I: insoluble ST: soluble translucent

Stability

- **Thermal stability**

With the exception of Sisterna L70-C, Sisterna® sucrose esters are off-white powders which melt at temperatures between 45 and 65°C, depending upon the degree of esterification and type of fatty acid. Heating to temperatures up to 160°C can be done without any harmful effects on the performance. However, at temperatures higher than 120°C slight colour formation can occur due to caramelisation of traces of free sucrose present in the product.

- **pH stability**

Sisterna® sucrose esters are stable at pH values between 4 and 8. At pH values higher than 8, saponification of the ester bond may occur. In general terms, mono-esters degrade faster than di- or tri-esters. In acid media, Sisterna® sucrose esters are chemically stable, however at low pH they may become unstable due to acid aggregation. Adaptation of processing conditions, e.g. making the emulsion first, might already be sufficient to prevent flocculation and to enable the production of acidic formulations.

- **Electrolyte stability**

Flocculation may occur in an higher electrolyte environment. The degree of sensitivity is related to the fatty acid chain, stearates are more sensitive than the laurates and to the mono ester content with the higher mono esters being less sensitive than the lower mono esters.

4. PHYSIOLOGICAL PROPERTIES

Non-irritating properties

One of the most important properties of sucrose esters is their mildness. Several test methods are available to determine these (non-)irritant properties of Sisterna® sucrose esters.

- **Skin irritation**

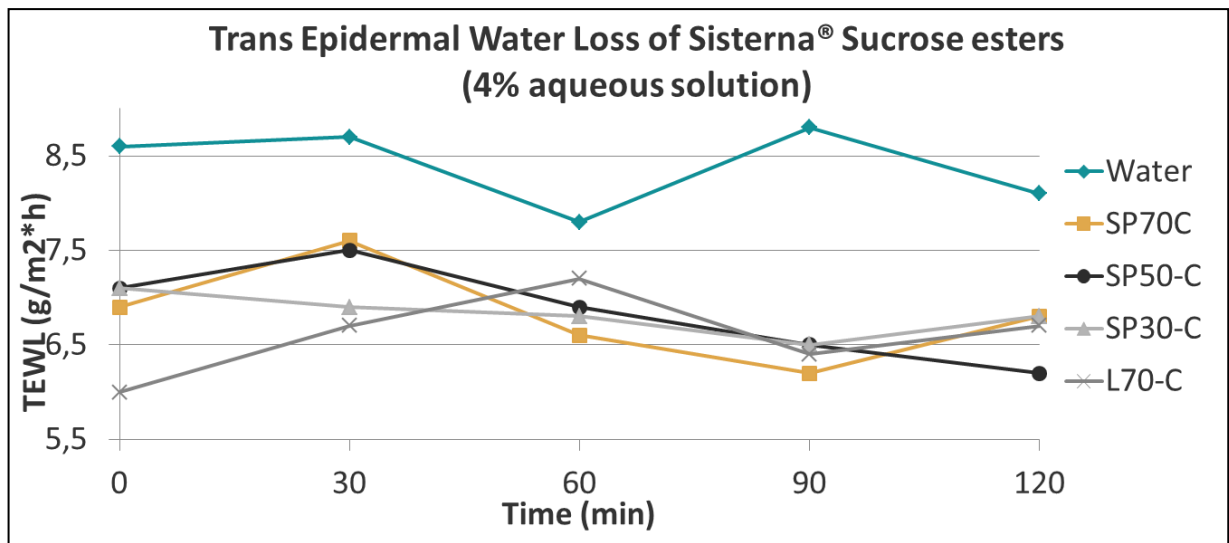
- **Primary dermal irritation:**

Testing for primary dermal irritation provides information on the irritant effect of a substance on the skin following a single dermal application. Sisterna® sucrose esters were tested according to OECD guideline 404 and proven to be non-irritating to the skin.

- **Trans epidermal water loss:**

Another method to determine the (non-)irritant power of Sisterna® sucrose esters is by determining the damage caused to the hydrolipidic barrier and the epidermis by measuring the Trans Epidermal Water Loss (TEWL) when applying the product to the skin. In the test 4% sucrose ester solutions are applied to the forearms. TEWL values measured at the initial time are compared with values obtained after product application (30, 60, 90 and 120 minutes). It can be concluded that Sisterna® sucrose esters do not interfere with the water-binding capacity of the stratum corneum.

Fig.06. Trans Epidermal Water Loss of Sisterna® sucrose esters



- **Eye irritation – HET-CAM**

The HET-CAM test is considered to be a well validated alternative method to the Draize eye irritation test. By means of the HET-CAM test (carried out on the chorioallantoic membrane of chicken embryo's), an indication can be obtained of possible damage to the mucous membranes (especially the ocular ones), caused by chemicals. Substances are classified as shown in Fig.07.

Fig.07. Classification of substances according to the HET-CAM test

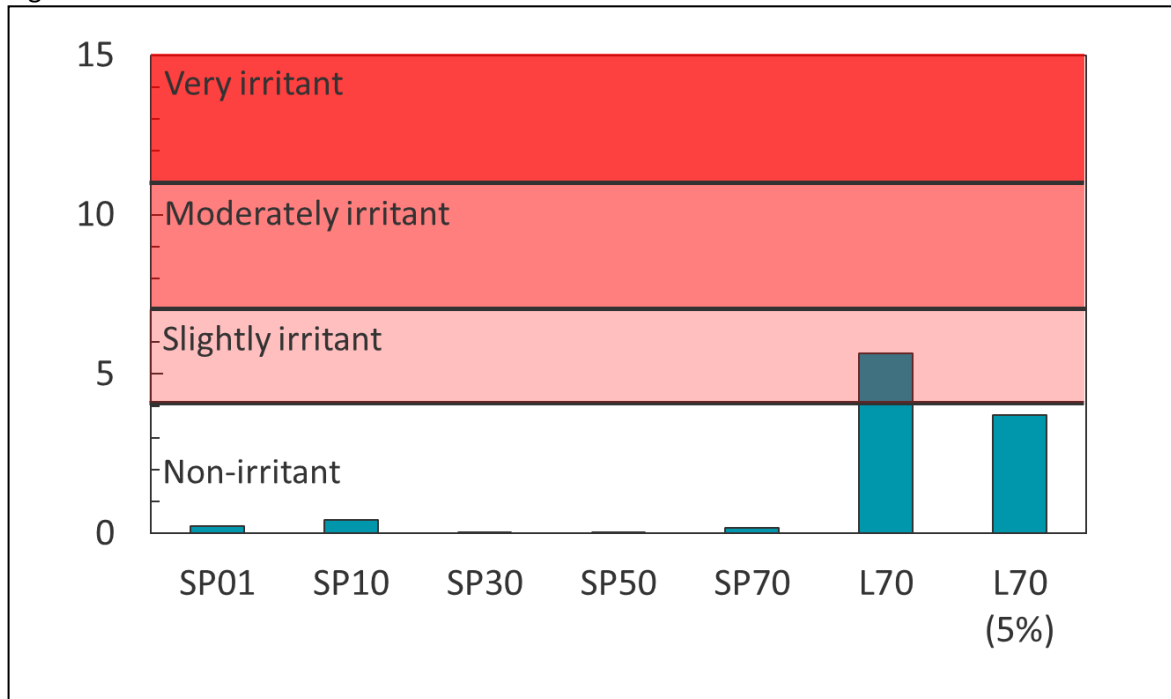
Irritation potential	Predictive irritant power in vivo
0 – 3,9	Non irritant
4 – 6,9	Slightly irritant
7 – 11	Moderately irritant
> 11	Severely irritant

Fig.08. Irritation potential of Sisterna® sucrose esters according the HET-CAM test

Sample	Concentration (%)	Irritation potential
Sisterna SP01-C*	10	0,23
Sisterna SP10-C*	10	0,41
Sisterna SP30-C	10	0,00
Sisterna SP50-C	10	0,00
Sisterna SP70-C	10	0,17
Sisterna L70-C	10	5,65
Sisterna L70-C	5	3,70

* Solution contains 10% Polysorbate 20

Fig. 09. Results HET-CAM test



Conclusion:

With the exception of Sisterna L70-C, Sisterna® sucrose esters can be classified as non-irritant at 10% concentration. Sisterna L70-C can be classified as non-irritant at 5% concentration. (Fig.08.)

Irritation reduction

Sisterna® sucrose esters not only are non-irritating, they are also able to reduce the irritant properties of other substances present in a cosmetic formulation.

- **Reduction of SLS induced irritation:**

Dermatological effects of surfactants to the skin can be attributed to a number of basic mechanisms:

- Adsorption on the skin's surface
- Penetration into the lower dermal layers
- Elution of individual components
- Irritation caused by cytotoxic effects on the living skin cells

These mechanisms cause the well-known phenomena such as reddening, scaling, drying and feeling of tension.

To determine the anti-irritant properties of Sisterna® sucrose esters, an irritation is provoked on the skin (upper back), by using a known irritant Sodium Lauryl Sulphate (SLS at 2%). The reaction induced by the SLS is compared with the reactions induced by samples which contain together with SLS, increasing quantities of different types of Sisterna® sucrose esters.

The anti-irritant power of SLS and the anti-irritant power of Sisterna® sucrose esters are evaluated after 24 hours, in two ways:

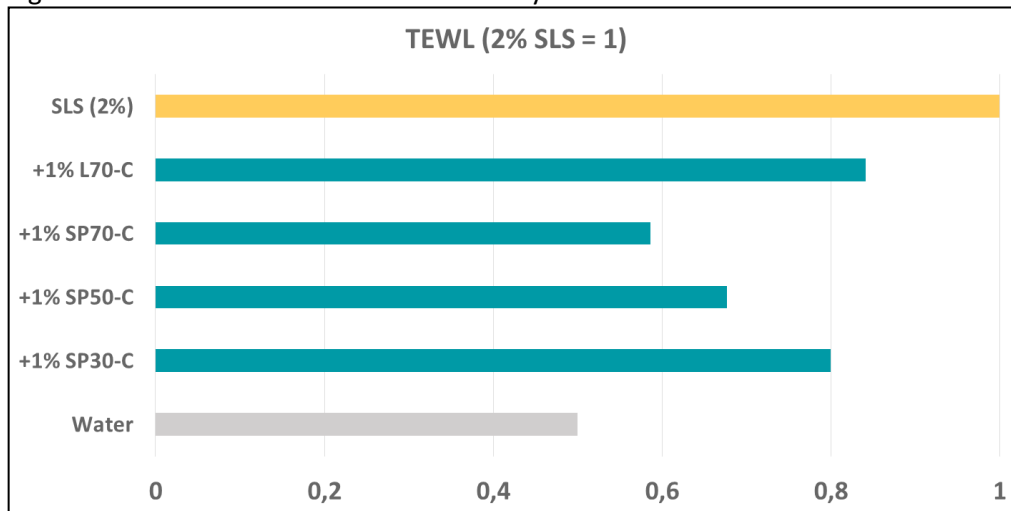
- by measuring the reduction in TEWL with an evaporimeter, allowing to assess the integrity of the stratum corneum. Skin barrier damage, like the SLS induced irritation, leads to an increase in TEWL.

- by visually scoring skin redness.

The results obtained by visual and instrumental evaluation show the anti-irritant effects of Sisterna® sucrose esters.

At the tested concentrations, Sisterna® sucrose esters show a protective effect towards the barrier damage of the stratum corneum as well as towards the irritation of the deeper cell layers, caused by SLS. This anti-irritant effect is proportional to the sucrose ester concentration.

Fig.10. Reduction of SLS-induced irritation by Sisterna® sucrose esters



Moisturising properties

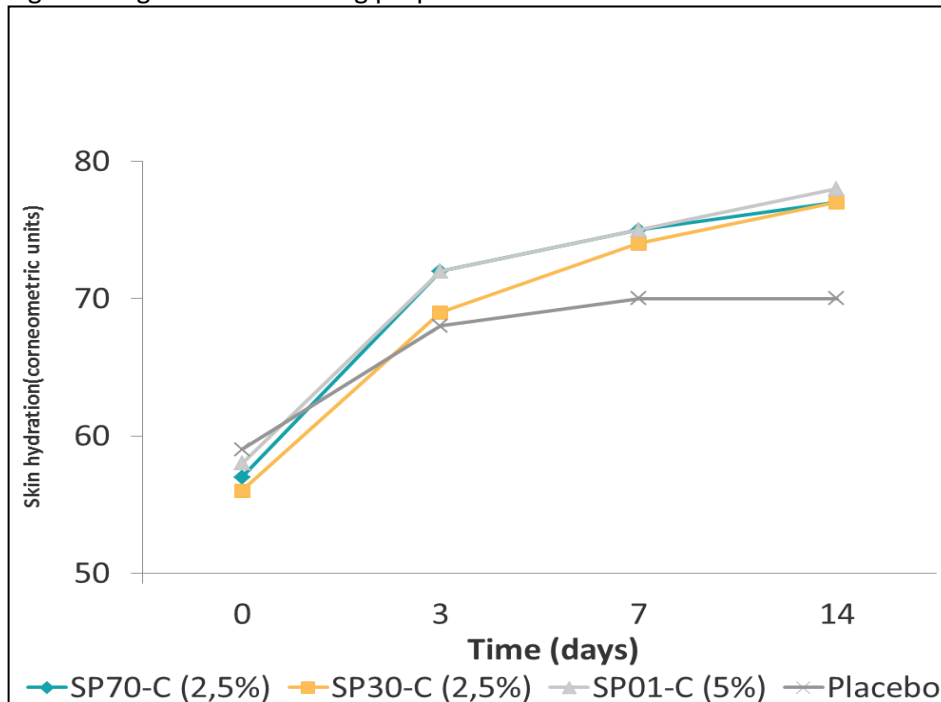
For some time, sucrose esters of fatty acids have been known to have moisturising properties. A study was carried out to evaluate the long-term moisturising properties of different grades of Sisterna® sucrose esters.

Subjects applied emulsions based on different grades of Sisterna® sucrose esters, as well as a placebo emulsion, on their forearms twice a day for 14 days.

Skin hydration was measured before treatment and after 3, 7 and 14 days of treatment by means of a corneometer.

It was demonstrated that emulsions containing Sisterna® sucrose esters induce a gradual and constant improvement of the skin moisture level (see Fig.10.). Comparison between emulsions containing Sisterna® sucrose esters and the placebo show a significant difference.

Fig.11. Long term moisturising properties of Sisterna® sucrose esters



SELECTIVE ANTI-MICROBIAL ACTIVITY

It has long been known that fatty acids and fatty acid esters can have an inhibiting effect on the growth of certain bacteria, yeast and fungi. The effectiveness of the inhibition not only depends on the chain length of the fatty acids, but also on the degree of substitution. Sisterna® sucrose esters are no exception to this rule.

The anti-microbial effect of various types of Sisterna® sucrose esters has been tested on different micro-organisms that occur on human skin naturally. In Fig.11. part of the results of these tests is summarised. It can be concluded that the growth of certain, less desirable micro-organisms is inhibited by Sisterna® sucrose esters, while that of others is not or only partly effected. Effective concentrations of Sisterna® sucrose esters are considerably lower than for other commonly applied fatty acid based products.

The effectiveness of the inhibition depends on the chain length of the fatty acid and the degree of substitution. Sisterna® sucrose esters with a shorter fatty acid chain length and a higher mono-ester content have better selective anti-microbial properties. Recommended Sisterna® sucrose esters are Sisterna L70-C and Sisterna SP70-C.

It should be stressed that Sisterna® sucrose esters are not general applicable bacteriocides and cannot be used to preserve finished formulations. On the other hand, Sisterna® sucrose esters do not interfere with the normal used preservatives, such as parabens, phenoxyethanol or urea derivatives. The effectiveness of Sisterna® sucrose esters to inhibit the growth of certain less desirable micro-organisms was determined by inoculating media containing various concentrations of different types of sucrose esters with various strains of micro-organisms and measuring the inhibition of microbial growth after 20-28 hours.

Fig. 12. Inhibition of micro-organisms by Sisterna® sucrose esters (in vitro - contact time= 20-28h.)

Micro-organisms involved in:	Sisterna SP70-C (1.600 mg/l)	Sisterna L70-C (1.600 mg/l)
a) Odour formation <i>Corynebacterium xerosis</i> <i>Corynebacterium minutissimum</i>	+++++ ++++	+++++ ++++
b) Diaper rash <i>Corynebacterium ammoniagenes</i> <i>Staphylococcus aureus</i> <i>Candida albicans</i>	+++++ +++++ 0	+++++ +++++ +++++
c) Dental caries <i>Streptococcus mutans JC-2</i> <i>Streptococcus mutans V310</i>	0 0	+++++ +++++
d) Athlete's foot <i>Trychophyton rubrum</i> <i>Trychophyton mentagrophyton</i>	+++++ +++++	+++++ +++++
e) Dandruff <i>Malassezia furfur</i>	0	+++++ (1.5%)
f) Normal skin flora <i>Staphylococcus epidermus</i> <i>Micrococcus luteus</i>	0 ++++	0 0

0 = 0% inhibition ++++ = 60-80% inhibition +++++ = 80-100% inhibition

Sisterna® sucrose esters against odour formation

Body odour develops when components from perspiration fluids are metabolised by micro-organisms. Immediately after excretion, perspiration fluids are sterile and odourless. Micro-organisms present on the skin, however, are capable of transforming components in these fluids into odorous substances, some of which even may cause skin irritation. Only a few species, like *Corynebacterium xerosis*, *Corynebacterium minutissimum* and other *Corynebacterium* species, are responsible for the formation of odour.

- In vitro test
Sisterna L70-C and Sisterna SP70-C at low concentrations (1.600mg/l in the medium) are effective in inhibiting the growth of the odour forming bacteria, whereas the other strains are not or only partially affected.
- In vivo test (sniff test)
To confirm the results of the in vitro test, a sniff test was carried out with Sisterna L70-C and Sisterna SP70-C as well as Triclosan at various concentrations.
After one week of pre-treatment, during which subjects were asked not to use deodorants or anti-bacterial soaps, solutions of Sisterna L70-C, SP70-C or Triclosan were applied on the armpit every day for 15 days. Odour was determined 6 and 24 hours after the final application.
The olfactory evaluations showed that Sisterna SP70-C at concentrations of 0.5, 1.0 and 1.25% and Sisterna L70-C at concentrations of 0.75 and 1.5% are as effective to reduce the intensity of auxiliary odour as Triclosan at concentrations of 0.25 and 0.5%.
These results indicate the use of Sisterna® sucrose esters in deodorant emulsions, transparent roll-on deodorants and anti-perspirants.

Sisterna® sucrose esters against diaper rash

Diaper rash (diaper dermatitis) is one of the most common skin problems occurring in infants. As most common causes for the formation of diaper rash, faeces and urine are mentioned in literature, but also *Corynebacterium ammoniagenes*, *Staphylococcus aureus* and *Candida albicans* are known to be involved in the formation of diaper dermatitis.

- in vitro test
It could be concluded, that Sisterna SP70-C at concentrations as low as 400 mg/l is effective in inhibiting the growth of *Corynebacterium ammoniagenes* and *Staphylococcus aureus*.
Sisterna L70-C, in addition, also inhibits the growth of *Candida albicans*.

These results indicate the use of Sisterna® sucrose esters in baby creams and lotions, baby wipes containing low-viscous emulsions or baby diapers.

Sisterna® sucrose esters against dental caries

Dental caries is initiated by acid end-products of microbial metabolism, especially by those acids that are produced from sucrose and glucose by the metabolic activity of specific *Streptococcus mutans* species, which are encapsulated in the polysaccharide film on the outer surface of the enamel (plaque). These acids dissolve the hydroxy apatite crystals in the enamel and, at a later stage, also the calcium phosphates in the dentin. Inhibiting microbial growth, thus decreasing acid formation, therefore is an effective way to prevent caries.

- In vitro test
Sisterna L70-C is effective in inhibiting the growth of *S. mutans* species, isolated from human dental plaque (*Streptococcus mutans* JC-2 and *Streptococcus mutans* V310).
At a concentration of 1.600 mg/l, growth of *S. mutans* is inhibited almost completely.
These results indicate the use of Sisterna® sucrose esters in toothpaste and mouthwashes.

Sisterna® sucrose esters against athlete's foot

Athlete's foot is a fungal infection, mostly caused by *Trichophyton rubrum*, but infections with *Trichophyton mentagrophytes* also occur.

Under constantly humid conditions, these keratinolytic fungi can grow uninhibited, thus causing skin problems such as interdigital maceration.

- In vitro test
At concentrations as low as 400 mg/l Sisterna SP70-C and Sisterna L70-C are effective in inhibiting the growth of both *T. rubrum* as *T. mentagrophytes*.
These results indicate the use of Sisterna® sucrose esters in foot balm and foot spray.

Sisterna® sucrose esters against dandruff

Dandruff is a group of dermatological disorders, characterised by the formation of large flakes on the scalp, containing thousands of dead cells. Also cradle's cap, a common infant skin problem, belongs to this group of disorders. Although the mechanism responsible for the formation of dandruff is still ambiguous, it is generally accepted that micro-organisms are involved. From these micro-organisms, the yeast *Malassezia furfur* (= *Pityrosporum ovale*) is considered to be the most important one.

- In vitro test
At concentration levels normally used in shampoos (>1%), Sisterna L70-C is capable of inhibiting the growth of *M. furfur*.
These results indicate not only the use of Sisterna[®] sucrose esters in anti-dandruff shampoos, but also e.g. in lotions against cradle's cap.

Note

The anti-microbial activity of Sisterna[®] sucrose esters against several micro-organisms is reported. It is known however, that Sisterna[®] sucrose esters are active against other micro-organisms as well. Furthermore, it is known that Sisterna[®] sucrose esters, in combination with other emulsifiers or surfactants, inhibit microbial growth due to synergistic effects.

Sisterna® sucrose esters: Product range and functionalities

Grade	PS750-C	L70-C	SP70-C	SP50-C	SP30-C	SP10-C	SP01-C	A10E-C
INCI-name	Sucrose Palmitate	Aqua (and) Sucrose Laurate (and) Alcohol	Sucrose Stearate	Sucrose Stearate	Sucrose Distearate	Sucrose Polystearate	Sucrose Polystearate	Sucrose Tetrastearate Triacetate
HLB value	16	15	15	11	6	2	<1	-
Physical form	powder	liquid (40% sol)	powder	powder	powder	powder	powder	powder
% mono ester	75	70	70	50	30	10	1	0
emulsifier O/W	●	●	●	●	●			
co-emulsifier W/O						●	●	
co-surfactant / mild cleanser	○	●	○					
skin feel modifier	●	●	●	●	●	●	●	●
lipidic phase modifier								●
selective anti-microbial activity		●	●					
non-irritant properties	●	●	●	●	●	●	●	●

● First choice ○ good alternative

Sisterna® sucrose esters: Application concepts

Concepts	PS750-C	L70-C	SP70-C	SP50-C	SP30-C	SP10-C	SP01-C	A10E-C
main emulsifier			●		●			
co-emulsifier o/w and w/o	●		●			●	●	
cold emulsifier	●	●	●					
gel-to-milk emulsions	●		●					
spray & wipe emulsions	●	●	●					
mild cleansing systems	○	●	○					
anhydrous systems						●	●	●

● First choice ○ good alternative

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