SUCROSE OLIGOESTERS TYPE I AND TYPE II
Chemical and Technical Assessment (CTA)

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1. Summary

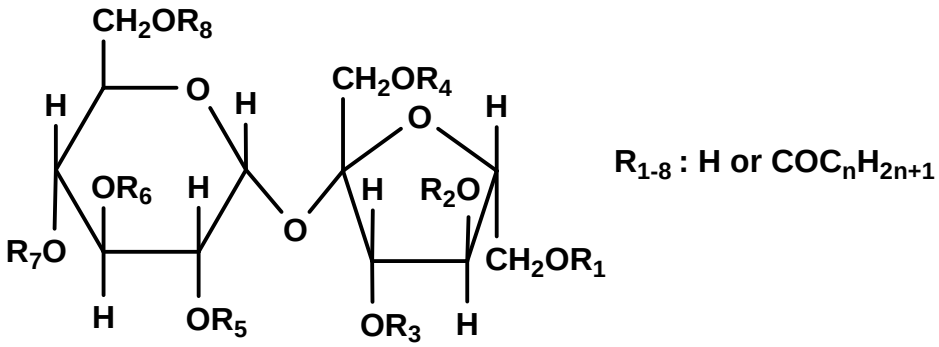
Sucrose oligoesters type I and type II are produced by interesterification of sucrose with methyl esters of fatty acids derived from edible fats and oils including hydrogenated fats and oils such as stearic acid, palmitic acid, erucic acid and other fatty acids. A sucrose molecule has eight hydroxyl groups, and so it can produce mono- to octa-esters. Sucrose esters of fatty acids, previously evaluated by JECFA, consist mainly of sucrose mono- to tri-esters, while sucrose oligoesters type I consist mainly of sucrose tetra- to octa-esters and type II consist of sucrose mono- to octa-esters. Physical and chemical properties, including lipophilic character, of the products vary depending on the degree of esterification, the chain length and the unsaturation degree of the fatty acids.

Sucrose oligoesters type I and type II are lipophilic emulsifiers, stabilizers and tableting aids. They have been used in various kinds of food, such as margarine, chocolate, ice cream, powdered seasonings and tablet form foods. This Chemical and Technical Assessment summarizes data and information on sucrose oligoesters type I and type II submitted by Mitsubishi Chemical Corporation and Dai-Ichi Kogyo Seiyaku Co., Ltd.[1].

2. Description

Sucrose oligoesters type I and type II are two groups of sucrose esters esterified with fatty acids (Figure 1). A sucrose molecule has eight hydroxyl groups, and so it can produce mono- to octa-esters.

Figure 1. Structural formula of sucrose esters esterified with fatty acids



These sucrose esters are classified into four groups depending on the number of esterified fatty acids on a sucrose molecule as shown in Table 1. Sucrose esters of fatty acids consist mainly of sucrose mono- to tri-esters, while sucrose oligoesters type I consist mainly of sucrose tetra- to octa-esters of fatty acids. Sucrose oligoesters type II consists of sucrose mono- to octa-esters and their properties lie between those of sucrose esters of fatty acids and sucrose oligoesters type I, but the composition overlaps each of these groups. “Olestra” consist mainly of sucrose octa-esters and is the most lipophilic of the groups and this compound has not been evaluated by JECFA.

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Table 1. Classification of esters esterified with fatty acids

Property	Group	Composition of esters (%)			
		mono-tri	tetra-octa	Hepta+octa	octa
hydrophilic	Sucrose esters of fatty acids	80 - 100	0 - 20	-	-
↓	Sucrose oligoesters type II	20 - 80	20 - 80	0 - 20	0 - 10
	Sucrose oligoesters type I	0 -20	80 - 100	0 - 50	0 - 20
lipophilic	Octa-ester (Olestra*)	-	97 - 100 (hexa-octa)		70 - 100

*The monograph for Olestra in the Food Chemicals Codex (FCC 6th Ed., 2008) specifies the following distribution for the number of esters: octa-esters, not less than 70%; hexa-, hepta-, and octa-esters, not less than 97%; hexa-esters, not more than 1%; penta-esters, not more than 0.5%. Olestra is used as a replacement for fats in food.

Fatty acids used for esterification are derived from edible fats and oils including hydrogenated fats and oils which consist of stearic acid, palmitic acid, oleic acid, lauric acid, myristic acid, erucic acid, behenic acid and other fatty acids.

Sucrose oligoesters are nonionic surfactants consisting of sucrose as a hydrophilic group and fatty acids as lipophilic groups. Hydrophilic and lipophilic character is determined mainly by the degree of esterification. By varying the degree of esterification, products can be designed for optimal functionality in specific foods. Type I is more lipophilic than sucrose esters of fatty acids and sucrose oligoesters type II. The lipophilicity of sucrose oligoesters type II is positioned between sucrose esters of fatty acids and sucrose oligoesters type I.

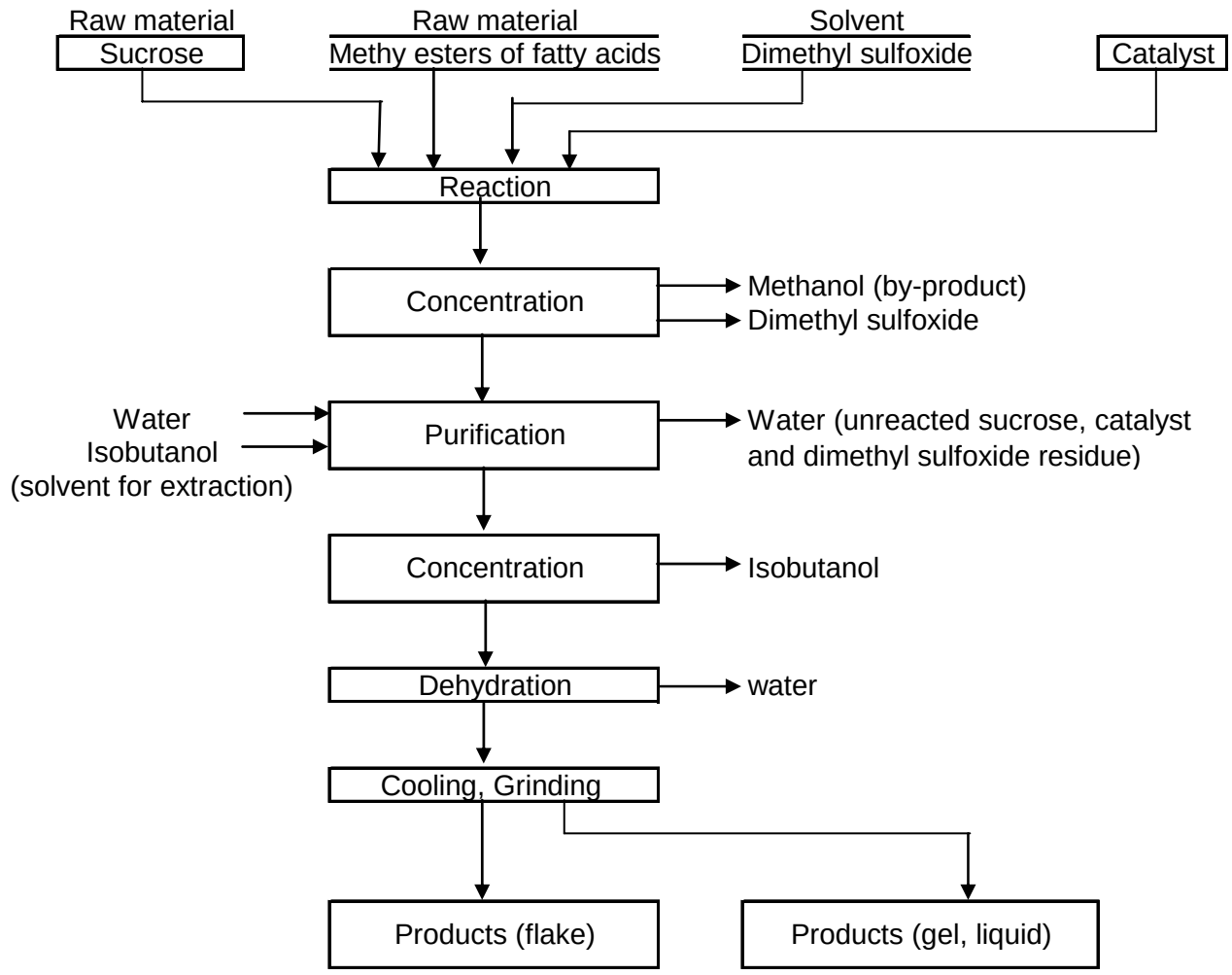
Sucrose oligoesters type I and type II occur as a powder, soft solid, stiff gel or viscous liquid. They are odourless or have a slight characteristic odour. They are insoluble in water. They are soluble in tetrahydrofuran, though the solubility varies from sparingly soluble to very soluble.

3. Method of manufacturing

Sucrose oligoesters type I and type II are manufactured from sucrose and methyl esters of edible fatty acids, or naturally occurring edible vegetable oils, in the presence of solvents such as dimethyl sulfoxide, isobutanol (2-methyl-1-propanol), or methyl ethyl ketone. Sucrose is originated from sugar cane or sugar beet. The origin of fatty acid methyl esters is mainly palm oil, palm kernel oil, coconut oil and rape-seed oil. The major fatty acids of these oils are stearic acid, palmitic acid, oleic acid, lauric acid, myristic acid, erucic acid and behenic acid.

The manufacturing process of sucrose oligoesters type I and type II is shown in Figure 2. Generally an alkaline catalyst is used to promote the interesterification reaction. Methanol is released as a by-product through this reaction. Reaction and extraction solvents and methanol are removed by the purification and concentration processes. Dimethyl sulfoxide is mainly used as a reaction solvent. Water and/or isobutanol are mainly used as an extraction solvent. Small amount (0.01%) of mixed-tocopherols is added as an antioxidant to some products, especially containing unsaturated fatty acid esters.

Figure 2. Manufacturing process of sucrose oligoesters



4. Characterization

4.1 Composition of esters

An un-reacted sucrose molecule includes eight hydroxyl groups available for esterification with a fatty acid. Actually products are mixtures of each according to their own ester-composition distribution.

The ester distribution of sucrose oligoesters type I and type II produced by Mitsubishi Chemical Corporation and Dai-ichi Kogyo Seiyaku Co. Ltd are shown in Tables 2 and 3, respectively. The relative hydrophilic / lipophilic balance is described as HLB value.

Table 2. Ester distribution of sucrose oligoesters type I

Product name	HLB	Lot Number	Type of fatty acids	Composition of esters (%)								
				Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Total
S-070*	≤ 1	1	Stearic acid 70 % and palmitic acid 30 %	0.3	1.1	3.4	8.8	16.3	24.0	24.7	15.3	93.9
		2		0.3	1.2	4.0	8.8	14.7	21.1	24.8	19.1	94.0
		3		0.3	1.1	3.9	8.7	14.7	21.2	25.2	18.6	93.6
		4		0.2	0.9	3.6	8.6	14.4	21.1	25.3	19.6	93.7
		5		0.1	0.7	3.2	8.4	15.8	23.4	25.4	16.6	93.5
S-170*	ca. 1	1	Stearic acid 70 % and palmitic acid 30 %	0.6	3.5	9.9	16.8	20.6	21.0	16.6	7.5	96.4
		2		0.7	3.5	9.8	16.7	20.6	21.2	16.4	7.5	96.4
		3		0.5	3.4	9.8	16.8	20.6	20.9	16.4	8.2	96.5
		4		0.7	3.7	9.9	16.6	20.4	20.7	16.3	7.9	96.1
		5		0.6	3.5	9.9	17.0	20.8	21.0	16.1	7.4	96.4
F-10**	ca. 1	1	Stearic acid 70 % and palmitic acid 30 %	2.0	3.4	7.2	16.7	27.6	25.4	12.0	2.3	96.5
		2		1.7	3.1	7.1	17.1	28.2	25.5	11.6	2.4	96.5
		3		1.9	3.3	7.3	17.1	27.8	25.3	11.5	2.5	96.6
		4		1.5	3.3	7.4	17.1	27.8	25.5	11.6	2.0	96.4
		5		1.9	3.4	7.4	16.8	27.6	25.4	11.7	2.2	96.5
P-170*	ca. 1	1	Palmitic acid 80%, stearic acid 20%	0.1	2.5	8.6	16.9	23.2	23.3	15.5	5.9	96.1
		2		0.4	2.9	8.7	16.4	22.3	22.7	15.9	6.7	96.0
POS-135*	ca. 1	1	Palmitic acid 30%, oleic acid 40% and stearic acid 30%	0.7	3.4	9.7	17.9	23.4	21.7	13.4	4.5	94.7
		2		0.5	3.6	10.1	17.5	20.8	20.4	15.2	7.2	95.2
		3		0.6	3.6	10.2	17.3	21.1	20.3	15.6	6.4	95.1
		4		0.6	3.5	9.8	16.7	20.5	20.2	16.2	7.8	95.2
		5		0.6	3.7	10.4	17.5	20.8	20.5	15.3	6.5	95.3
O-170*	ca. 1	1	Oleic acid 80%, linolenic acid 13% and others	0.6	3.5	9.7	16.2	20.4	20.8	16.4	7.7	95.1
		2		0.5	3.4	9.6	16.6	21.7	21.3	15.0	6.4	94.5
		3		0.5	3.3	9.7	16.6	21.4	21.1	15.5	6.5	94.6
		4		0.4	3.2	9.5	16.0	20.5	21.2	16.6	7.9	95.3
		5		0.5	3.4	9.7	16.3	20.6	20.9	16.3	7.5	95.1
L-195*	ca. 1	1	Lauric acid 99.5 %	0.3	2.4	8.8	19.5	23.8	24.3	15.0	5.0	99.0
		2		0.5	2.9	9.4	17.7	21.3	22.7	17.0	7.6	99.0
		3		0.5	3.0	9.5	19.4	20.9	22.0	16.4	7.3	99.0
		4		0.6	3.1	9.6	20.1	20.4	21.5	16.3	7.4	99.0
		5		0.4	2.9	9.5	18.1	21.5	22.8	16.7	7.1	99.0
ER-190*	ca. 1	1	Erucic acid 90 %	0.2	2.6	8.8	17.2	22.3	22.1	14.4	5.4	93.1
		2		0.4	3.0	9.1	16.7	20.7	20.7	15.2	7.3	93.1
		3		0.2	2.5	8.5	17.2	22.8	22.3	14.3	5.5	93.4
		4		0.3	2.8	8.9	16.8	21.5	21.4	14.6	6.6	92.9
		5		0.2	2.8	8.9	17.2	21.9	21.8	14.4	5.8	93.0

* manufactured by Mitsubishi Chemical Corporation

** manufactured by Dai-ichi Kogyo Seiyaku Co. Ltd

Table 3. Ester distribution of sucrose oligoesters type II

Product name	HLB	Lot Number	Type of fatty acids	Ester composition (%)								
				Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Total
F-20W**	ca. 2	1	Stearic acid 70 % and palmitic acid 30 %	10.7	17.8	17.9	15.5	16.2	13.0	5.5	1.3	97.9
		2		10.5	17.1	17.0	15.4	16.9	13.8	5.9	0.9	97.6
		3		11.0	17.4	17.3	16.0	16.8	12.8	5.2	0.9	97.4
		4		10.9	17.7	17.6	16.0	16.7	12.7	5.1	1.0	97.6
		5		10.8	17.4	17.5	15.8	16.7	13.0	5.3	1.1	97.6
S-270*	ca. 2	1	Stearic acid 70 % and palmitic acid 30 %	13.3	17.1	14.9	12.8	12.2	11.6	9.2	4.7	95.8
		2		13.7	17.4	15.0	13.2	13.7	12.4	7.7	2.7	95.8
		3		13.3	17.1	15.1	13.8	13.9	12.5	7.8	2.6	96.0
		4		13.3	16.8	14.6	13.4	13.7	12.6	7.8	3.2	95.4
		5		13.6	17.4	15.1	13.1	12.6	11.7	8.4	3.6	95.6
ER-290*	ca. 2	1	Erucic acid 90 %	1.8	8.9	19.0	23.0	19.1	13.4	7.6	3.3	96.1
		2		1.8	8.8	19.0	23.6	19.5	13.7	7.3	2.6	96.2
		3		1.8	8.7	19.0	23.8	19.7	14.0	7.1	2.3	96.3
		4		1.8	8.7	18.8	23.9	19.5	14.1	7.4	2.1	96.4
		5		1.9	9.0	19.1	24.0	19.4	13.1	7.4	2.4	96.2
B-370*	ca. 3	1	Behenic acid 70 % and stearic acid 20%	16.2	24.6	26.4	18.3	9.5	3.2	0.0	0.0	98.0
		2		16.7	24.3	26.2	19.0	9.1	3.1	0.0	0.0	98.3
		3		16.9	25.1	26.3	17.5	9.6	3.0	0.0	0.0	98.4
		4		16.7	25.3	26.4	17.8	9.4	2.2	0.0	0.0	97.8
		5		16.7	25.5	26.4	17.5	8.7	3.2	0.0	0.0	98.0

* manufactured by Mitsubishi Chemical Corporation

** manufactured by DKS: Dai-ichi Kogyo Seiyaku Co. Ltd

4.2 Possible impurities

The possible impurities in sucrose oligoesters type I and type II are similar in nature. Reaction by-products include methanol, fatty acids and salts of fatty acids. Methanol is released through the interesterification of methyl esters of fatty acids. Fatty acid residues come from methyl esters of fatty acids and/or dissociation from sucrose esters. Moreover fatty acids and alkaline catalyst may produce salts of fatty acids. Other impurities are solvents used for reaction and purification, such as dimethyl sulfoxide, isobutanol and methyl ethyl ketone, as well as unreacted raw materials, such as sucrose, and methyl esters of fatty acids.

Regarding solvents, dimethyl sulfoxide, methyl ethyl ketone, methanol and isobutanol were shown to be below the limits specified in the JECFA specifications monograph as analysed with the methods described in the same. Taking account of other impurities (fatty acids, salts of fatty acids, free sucrose, and methyl esters of fatty acids), the purity of sucrose oligoesters type I and type II are over 90%.

5. Functional Use

Sucrose oligoesters type I and type II are lipophilic emulsifiers. They are nonionic surfactants consisting of sucrose as a hydrophilic group and fatty acids as lipophilic groups. Table 4 shows intended food uses and use levels of sucrose oligoesters type I and type II.

Sucrose oligoesters type I provide stable emulsions for water-in-oil emulsified foods, such as shortening, margarine and fat spreads. In whipping cream and ice-creams, sucrose oligoesters type I are sometimes used together with sucrose esters of fatty acids. It is used as a lubricant for food ingredients in tablet form foods (candy, supplements) and seasonings.

Sucrose oligoesters type II is used as a lubricant for food ingredients in tablet form foods. It is also used improve dispersion of solid types of sauce mixes and to prevent caking of hydroscopic powdered seasonings. It is used in margarine, fat spreads, chocolate, whipping cream and ice cream as well as type I.

Table 4. Intended food-uses and use-levels of sucrose oligoesters type I and type II

Food category		Use level (%)	
		Average	Maximum
Fats and oils, fat emulsions	Shortening	0.2	0.5
	Margarine, fat spread	0.2	0.5
	Fats and oils used as raw materials in foods	0.3	0.5
Chocolate		0.3	0.5
Cream and similar products	Creams for whipping, whipped cream	0.2	0.5
	Coffee whitener	0.2	0.5
	Ice cream	0.2	0.3
Tablet form foods	Candy in pressed tablet form	1.0	2.0
	Dietary supplements in pressed tablet form	1.0	2.0
Seasonings and condiments	Solid type sauce mixes	0.2	0.5
	Powdered seasonings	1.0	2.0

6. Reactions and fate in foods

In the foods listed in Table 4, sucrose oligoesters type I and type II are not expected to cause degradation or reaction with constituents. There is no evidence that ingestion of sucrose oligoesters type I and type II at the proposed levels would interfere with the absorption of fat-soluble vitamins.