OCTENYL SUCCINIC ACID (OSA) MODIFIED GUM ARABIC
Chemical and Technical Assessment (CTA)

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1. Summary

This Chemical and Technical Assessment summarizes data and information on octenyl succinic acid (OSA) modified gum arabic submitted by TIC Gums Inc[1]. OSA modified gum arabic is a cold-water soluble hydrocolloid used as an emulsifier. The modification of gum arabic involves the introduction of octenylsuccinate groups to the polysaccharide in gum arabic by controlled esterification processes analogous to the production of starch sodium octenylsuccinate (OSA - modified food starch).

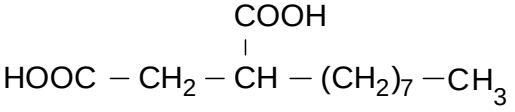
OSA modified gum arabic is intended for use as an emulsifier for flavouring agents in a variety of applications. In addition, it is permitted in the United States of America for use as an emulsifier in fruit juices, fruit flavoured drinks, beverages such as carbonated juice and energy drinks, salad dressings, sauces, icing, and select breads and cereals.

OSA modified gum arabic is a more efficient emulsifier than gum arabic, the raw material from which it is produced, with less than 50% of the modified product required for the same application.

2. Description

OSA modified gum arabic (gum arabic hydrogen octenylbutanedioate, CAS No. 455885-22-0) is a cold-water soluble hydrocolloid proposed for use as an emulsifier. The modification of gum arabic (CAS No. 9000-01-5) is made by the introduction of lipophilic octenyl succinic groups to the polysaccharide in gum arabic by controlled esterification processes. The structural formula of octenyl succinic acid (OSA) is shown in Figure 1.

Figure 1. Structural formula of octenyl succinic acid (OSA)



3. Method of manufacturing

3.1. Manufacturing principle

OSA modified gum arabic is produced from gum arabic (CAS No. 9000-01-5) derived from the exudate of the tree species *Acacia seyal* or *Acacia senegal*. The modified product is made by an esterification reaction involving the addition of octenyl succinic acid anhydride (CAS No. 26880-54-6) in a process analogous to the production of starch sodium octenylsuccinate (modified food starch, octenylsuccinate starch). OSA modified gum arabic is produced in aqueous solution, under the controlled conditions (1-1.5 h, pH 4-6, 38-60°C) and includes processing aids in some of the steps. It is subsequently spray dried to a powder. The production of OSA modified gum arabic employs food-grade ingredients.

3.2. Manufacturing Process

The manufacturing process is summarized in the process diagram in Annex 1.

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4. Characterization

4.1. Composition

The modification of gum arabic is made by the introduction of octenyl succinic groups to the polysaccharide in gum arabic by controlled esterification processes. The degree of esterification is not more than 0.6%. Not more than 0.3% of residual octenyl succinic acid can be present in the product.

4.2. Physico-chemical properties

OSA modified gum arabic is off –white to light tan, free flowing spray dried powder, freely soluble in water forming a free flowing solution, insoluble in ethanol. pH of 5% solution is 3.3-6.0.

4.3. Possible impurities

A possible source of impurities would be the original gum arabic used for the OSA-modification. The purity of gum arabic used in processing complies with the requirements in the specifications prepared by the Committee. Residual OSA is listed in the specifications as an impurity with a limit of 0.3%. Starch, dextrin and tannin-bearing gums should not be detected. Limit for lead is 2 mg/kg. Microbiological criteria are also included in the specifications monograph.

4.4. Analytical methods

Analytical methods used to support the specifications for OSA modified gum arabic are based on general tests for identity and purity (solubility, pH, loss on drying, total and acid-insoluble ash, water-insoluble matter, microbiological criteria and lead) published in the Combined Compendium of Food Additive Specifications (FAO JECFA Monographs 1, Volume 4, 2006). Other methods (precipitate formation, viscosity, degree of esterification, tannin-bearing gums and residual octenyl succinic acid) are described in the specifications monograph.

5. Functional use

5.1. Technological function

OSA modified gum arabic is a cold-water soluble hydrocolloid used as an emulsifier. The introduction of lipophilic groups to the polysaccharide by controlled esterification procedures enhances its emulsifying properties and lower use levels (Ward, 2002), thus saving costs for the manufacturer and consumer.

The advantages of OSA modified gum arabic vs. traditional gum arabic and modified starches are stated to be the following (Ward, 2002):

1. Lower usage levels comparing to gum arabic.
2. Better versatility in stabilizing of beverage concentrates with and without weighting agents.
3. Better protection against oil oxidation (based on lower limonene epoxide levels).
4. Greater stability expressed in smaller particle size distribution than control.
5. Multiple functions: fat mimetic, soluble fibre source and emulsifier.

OSA modified gum arabic can be used as the flavour oil emulsifier part of a flavour emulsion system. Currently, a typical flavour oil emulsion (or package) is comprised of 10% oils (flavours and weighting agents) and 16% gum arabic, the balance being water and a pH adjuster such as citric acid. OSA modified gum arabic is a significantly more efficient emulsifier and will be used at lower levels (Ward and Andon, 2005). When OSA modified gum arabic is used instead of gum arabic in this application a 50% reduction in concentration of the emulsifier is achieved (a maximum 8% level within the flavour emulsion package instead of 16%).

Results of the use of OSA modified gum arabic as a spray-drying carrier and emulsifier (Strohman and Reineccius, 2003) indicated that OSA modified gum arabic provided better protection against oil oxidation than the traditional gum arabic and modified starch with dextrin. Limonene epoxide, a product of limonene oxidation in orange oil was analyzed in an accelerated shelf-life study. In addition, caking problems, water activity, and oil retention were compared to those of modified starch and traditional Acacia species. Rehydration of the spray-dried powder of OSA modified gum arabic to form emulsions showed smaller particle size distributions, compared to traditional gum arabic and the modified starch.

OSA modified gum arabic may be used at 5% gum level with 10% oil and may be adjusted accordingly based on the oil content and the weighting agents (sucrose acetate isobutyrate and ester gum) (Ward 2002, 2005). The oil-in-water emulsions using OSA modified gum arabic were more stable than those using modified starches, based on particle size distribution and beverage ring tests (Ward and Andon, 2005).

Studies employing OSA modified gum Arabic instead of propylene glycol alginate (PGA) in salad dressings with 35 % oil have revealed that OSA modified gum arabic yields smaller oil droplet sizes and more stable oil-in-water emulsions after several months of storage (Nieto, 2005). Analysis of the particle size distribution of the emulsion base using an Coulter Counter shows that OSA modified gum arabic (mean size: 8.7 μm) is an excellent replacement for PGA (mean size: 11.2 μm) in salad dressings (TIC Gum Inc., Technical Report RD 05-IN-072).

5.2. Food categories and use levels

OSA modified gum arabic is proposed for use as a flavouring emulsifier for use in baked goods, beverages (non-alcoholic and alcoholic), breakfast cereals, processed cheese, chewing gum, flour confectionary and icings, egg products, fish products, frozen dairy, fruit ices, jellies and puddings, gravies, imitation dairy products, instant coffee and tea, jams and jellies, meat products, milk products, other grains, processed poultry, processed fruit juices, processed vegetable juices, snack foods, soft candy, soups, and sweet sauces. OSA modified gum arabic is also proposed for use as an emulsifier in certain fruit flavoured drinks, select beverages (carbonated juice and energy drinks), fruit juices, salad dressing, sauces, icing, certain breads (whole grain and high fibre breads), and certain cereals (high fibre, low sugar and low fat cereals). Proposed food uses and levels are listed in Table 1 in Annex 2.

6. Methods of analysis in foods

There is no existing method for the determination of OSA modified gum arabic in food. Since gum arabic also contains proteins and soluble dietary fibre and consists of arabinogalactans and other carbohydrate moieties, it is extremely difficult, or virtually impossible to quantify the exact concentration of the gum arabic after it has been added to food. The food product will almost invariably contain protein, carbohydrate, and soluble and crude fibre that will interfere with the analysis. Even after treatment with enzymes according to the AOAC method for soluble dietary fibre (AOAC 2005) there is no existing, validated method to separate fibre mixtures into its individual fibre components.

Special HPLC techniques to separate the monosaccharide products of hydrolysis from gum arabic and other gums have been developed. Chromatographic retention times are characteristic of the compounds they represent, but are not unique. Hence, coincidence of retention times of a test and reference substance can be used as a feature in the construction of an identity profile but is insufficient to establish its own identity. For identification purposes, JECFA specifications, as well as European Pharmacopoeia (2006) and the British Pharmacopoeia (2009) include in their monograph for gum arabic, a method using thin layer chromatography (TLC) for separation of monosaccharides.

After isolation from the food system which does not contain interfering gum components, the presence of gum arabic may be qualitatively determined by using the National Formulary (NF) and United States Pharmacopeia (USP) identification tests and AOAC (2005) official methods of analyses for soluble dietary fibre. Since the OSA modified gum arabic is typically used at low levels, the concentration of OSA in the finished food product is likely to be significantly below the detection levels

for free residual OSA and bound OSA. Hence, analyses should be conducted on the modified gum arabic before incorporation in food, as a quality assurance step.

If there is a single gum or soluble fibre in the food, it is possible to identify and even quantify the dietary fibre in the food provided it is used at levels higher than 10%. It is important to note that OSA modified gum arabic will be used at levels not to exceed 2% and in most cases less than 1% in the finished products. After separation of the soluble fibre from the food by enzyme treatment and alcohol precipitation, the gum component in the food may be hydrolyzed and subjected to hydrolysis and compared with standards of known monosaccharides. This requires technical knowledge of the monosaccharide ratios for the relatively pure and individual gums. The monosaccharides may be subsequently analyzed by specific tests with lectins and HPLC analysis (O'Donnell and Baird, 1993). HPLC analysis after hydrolysis of the OSA modified gum arabic has been conducted by Ward (2005). Results showed differences in the galactose/rhamnose and arabinose ratios of various *Acacia* species.

7. Reactions and fate in foods

In the manufacturing process of the spray-dried OSA modified gum arabic (Ticamulsion), reactants are subjected to prolonged heating in solution and to more than 200^{o} C during spray drying. In spite of these high temperature conditions, the octenylsuccinylated gum typically does not yield excessive levels of free OSA as an index of ester hydrolysis. The producer states that this is shown by the historical production data obtained during manufacturing. Stability tests are not submitted.

According to the manufacturer, the OSA ester linkage is typically stable in an aqueous solution at the pH range of foods and beverages and under usual food and processing conditions. The other components in the food serve to protect the OSA-gum ester linkage from direct degradation. To break the ester linkage in modified gum arabic or starches, extreme alkaline or acidic conditions are required that are not typical of food processing operations. In general, the processing conditions of foods and beverage containing OSA modified gum arabic do not employ extreme pH levels. Temperature controls to avoid damage to lipids (which also contain ester bonds) and proteins are observed by the food manufacturer to avoid degradation in food components and to protect its sensory qualities.

Specific tests for free or residual OSA in octenylsuccinylated starch and OSA modified gum arabic have been developed as indices of stability. A methodology for analyzing free and bound OSA for octenylsuccinylated starches based on gas chromatography and mass spectrometry was reported by Park and Goins (1995). The bound OSA may be used as a more specific index of the esterified moieties in the gum substrate. The bound OSA can be released from the polysaccharide after alkali treatment. Routine analyses for free OSA from the modified gum arabic and modified starches can be conducted by the method for residual OSA in JECFA specifications monograph.

8. References

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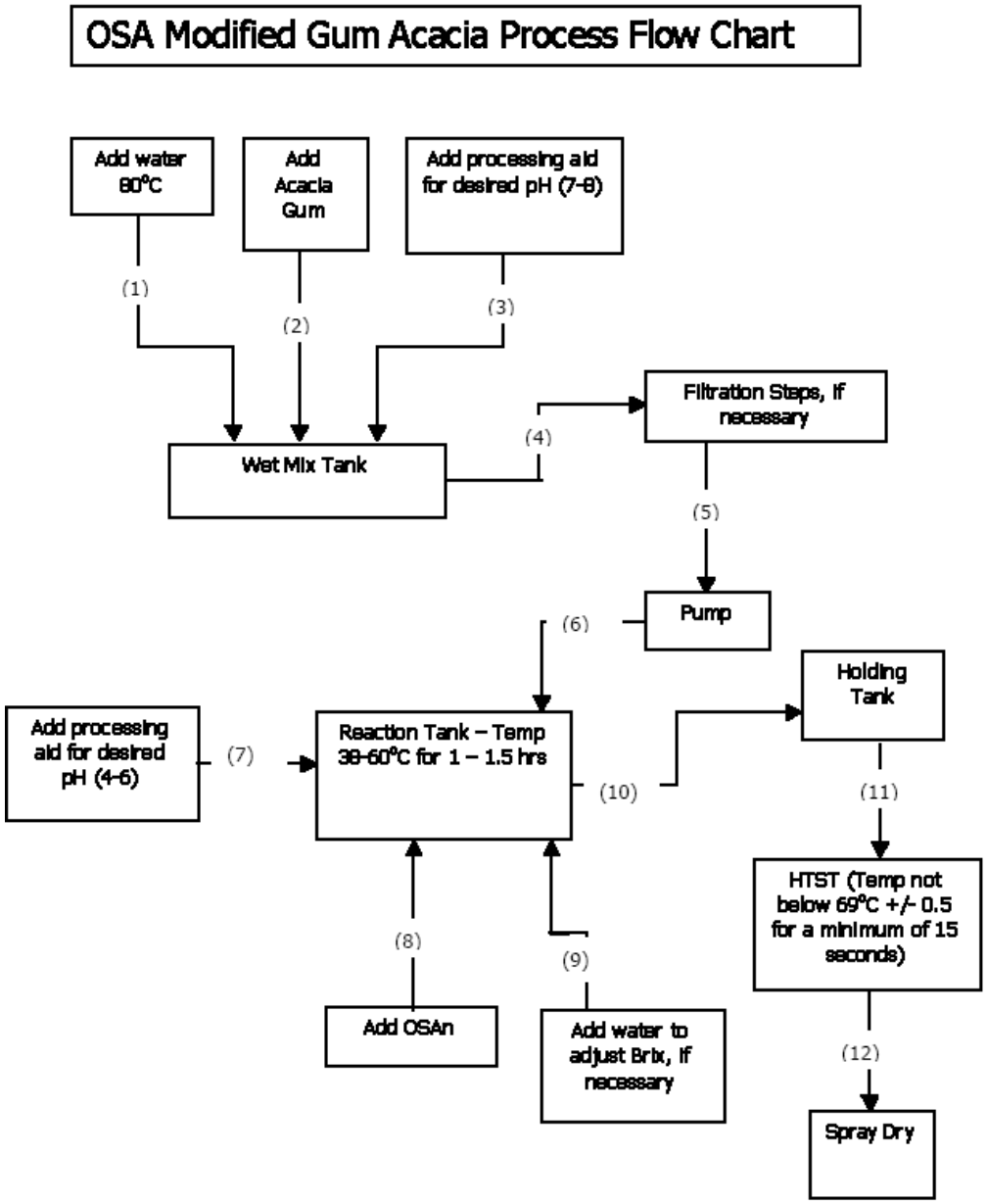
Annex 1


OSA Modified Gum Acacia Process Flow Chart
Add water 80°C
Add Acacia Gum
Add processing aid for desired pH (7-8)
(1)
(2)
(3)
Wet Mix Tank
(4)
Filtration Steps, if necessary
(5)
Pump
(6)
Add processing aid for desired pH (4-6)
(7)
Reaction Tank – Temp 38-60°C for 1 – 1.5 hrs
(10)
Holding Tank
(11)
HTST (Temp not below 69°C +/- 0.5 for a minimum of 15 seconds)
(12)
Spray Dry
(8)
Add OSAn
(9)
Add water to adjust Brix, if necessary

Annex 2

Table 1. OSA modified gum arabic use levels (mg/kg) and food categories

Food Category	Levels as a Flavouring Emulsion (mg/kg)	Levels for Other Emulsifier Uses (mg/kg)
Baked Goods	500	--
Beverages Type I, Non-alcoholic (Other emulsifier uses only in carbonated juice and energy drinks)	220	780
Beverages Type II, Alcoholic	220	--
Breakfast Cereals	300	--
Cheese (processed)	120	--
Chewing Gum	60	--
Confectionery & Icings (Includes icing portion of iced baked goods, peanut butter at 240 mg/kg for flavouring use only)	240, 300	10,000
Egg Products	140	--
Fish Products	500	--
Frozen Dairy	500	--
Fruit Ices	500	--
Gelatins & Puddings	500	--
Gravies	400	--
Imitation Dairy Products	240	--
Instant Coffee & Tea	240	--
Jams & Jellies	240	--
Meat Products	240	--
Milk products	220	--
Other Grains	240	--
Processed Poultry	500	--
Processed Fruits (juices) (Other emulsifier uses in vitamin or mineral fortified juice containing drinks only)	400	600
Beverages Containing Fruit Juice	--	1,000

Food Category	Levels as a Flavouring Emulsion (mg/kg)	Levels for Other Emulsifier Uses (mg/kg)
Processed Vegetable Juice	400	
Salad Dressing	--	10,000
Snack Foods	440	--
Soft Candy	300	--
Soups	240	--
Sauces	--	10,000
Sweet Sauce	400	--
Select breads (whole grain and high fibre breads > 5 g per serving)	-	400
Select cereals (low fat, low sugar and high fibre health foods, meeting three conditions: high in fibre (≥ 5 g per serving); low in fat (≤ 3 g per serving), and low in sugar (≤ 20 g per serving); use level of (350 mg/kg for foods with large serving size (55g/serving) and 650 mg/kg for foods with smaller serving (30g/serving).	-	350 or 650