

TITLE OF THE INVENTION

SOLVENT-FREE TRANS-ACIDOLYSIS PROCESS FOR THE
PREPARATION OF EDIBLE SURFACE-ACTIVE CARBOHYDRATE
FATTY-ACID ESTERS

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BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to process for production of edible
10 carbohydrate fatty-acid esters, and in particular, a low temperature,
solvent-free trans-acidolysis reaction between carbohydrate ester of
low molecular-weight carboxylic acid and free fatty-acid under
reduced pressure and in the presence of an acid catalyst.

15 (b) Description of the Prior Art

Carbohydrate fatty-acid esters are odorless, non-irritant nonionic
surfactants with excellent biodegradability properties. They are used
as low calorie fat substitute, or to solubilize membrane proteins, and
20 to formulate many grades of detergents, pharmaceutical, food and
cosmetic products. Carbohydrate fatty-acid esters also exhibit anti-
microbial and insecticidal activities and are used as cerebral
metabolism improving agent, and in the treatment of colonic
disorders. But the synthetic methods for carbohydrates fatty-acid
25 esters are faced with many limitations.

U.S. Patent No. 5,945,519 describes a process for the solvent-free
preparation of sucrose fatty acid esters and their mixtures with

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nonsugar polyol fatty acid esters. In this process, a sucrose is reacted with one or more fatty acid alkyl esters of a chain length of 6 to 20 carbon atoms and the reaction mixture is then reacted at reduced pressure with fatty acid alkyl ester, and then filtered without
5 addition of solvent.

U.S. Patent No. 4,614,718 discloses the synthesis of sugar or sugar-alcohol fatty acid esters by incubating an aqueous mixture of a sugar or sugar-alcohol, a C8 – C22 fatty acid and a catalytically
10 active amount of a lipolytic enzyme derived from the genus *Pseudomonas*, *Enterobacterium*, *Chromobacterium*, *Mucor* or *Candida* at a temperature from about 20 degree C to about 60 degree C, and recovering the resulting ester from the mixture.

15 U.S. Patent No. 5,908,922 (issued to Kasseri, et al, June 1, 1999) discloses a method for producing a sucrose fatty acid ester, which comprises subjecting sucrose and a lower alkyl ester of fatty acid to an ester exchanger reaction in an organic solvent in the presence of an alkali catalyst to produce the corresponding sucrose fatty acid
20 ester.

U.S. Patent No. 4,927,920 (issued to Wagner, et al, 22 May 1990) discloses a method for making sugar esters by reacting a sugar and an ester of the sugar having a degree of substitution greater than
25 about 2 in an organic solvent in the presence of a transesterification catalyst to form a sugar ester having a degree of substitution up to 2;



and recovering the sugar ester having a degree of substitution up to 2 at a temperature below the boiling point of the organic solvent.

U.S. Patent No. 4,996,309 discloses a process for preparing
5 sucrose fatty acid esters by reacting sucrose and a fatty acid alkyl ester in an aqueous reaction system in the presence of a catalyst, adding water to the reaction mixture to dissolve it, adjusting the reaction mixture to a neutral pH region, adding a neutral salt to the solution to precipitate the sucrose fatty acid esters, separating and
10 washing the precipitate with an acidic water, and subjecting the washing liquid to ultrafiltration.

The conventional methods for producing carbohydrate fatty esters are encountered with the following disadvantages and limitations:

- 15 (1) the transesterification method, currently favoured by most industrial producers of carbohydrate fatty esters, is a reversible process with poor conversion equilibria because the substrate sugars and fatty acid moieties are immiscible due to polarity differences. Thus, low product yield
20 characterize the processes;
- (2) Mutual solvents, such as pyridine, N, N-dimethylformamide (DMF), dimethylacetamide (DMA), dimethylsulfoxide (DMSO), chloroform, benzene and toluene, are required to solubilize the substrates. These mutual solvents are toxic
25 and cannot be removed to the level compatible with current regulations, thus limiting product applications.



- (3) High process cost resulting from high-energy cost and complex purification procedures.
- (4) Thermal degradation and isomerization of the reactant carbohydrates at temperatures above 100 degree C, which is normally required in most known processes.

It is a principal object of the present invention to provide a solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters, which obviates the above drawbacks and/or limitations.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters, wherein the process comprises a low temperature, solvent-free trans-acidolysis reaction between carbohydrate ester of low molecular-weight carboxylic acid (C2 to C3) and free fatty acid (C6 to C22) under reduced pressure and in the presence of an acid catalyst.

Yet another object of the present invention is to provide a solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters, wherein mono-, di- and poly-fatty esters of C2 and C3 acylated carbohydrates, with hydrophile-lipophile balance (HLB) values of 2 to 10, are obtained depending on the initial molar ratio of the reactants and chain-length of the fatty acid moiety.

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A further object of the present invention is to provide a solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters, wherein acid or base catalyzed partial deacylation lead to carbohydrate fatty esters with free hydroxyl groups, and having HLB values of 8-18.

Yet a further object of the present invention is to provide a solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters, wherein the unreacted free fatty acids and carbohydrate esters of low molecular-weight carboxylic acids, which are removed during purification and recycled to the starting reactant mixture.

The advantages of the process in accordance with the present invention, which circumvent the above limitations, are

- (1) avoiding solvent as a reaction medium. The C2-C3 acyl group attached to the reactant carbohydrate is a good protecting and leaving group and, at the same time, enhances the solubility of the carbohydrate moiety in the fatty acid;
- (2) using low pressure to drive the reaction equilibrium forward at a reduced energy demand. This results in high yield (>90), less isomerization and degradation of products.
- (3) The feedstock is renewable natural resources, readily available and cheap. Unreacted substrates are recycled. This process is thus commercially viable.



- (4) The invention is applicable to both batch-wise carbohydrate fatty ester synthesis and to continuous synthesis.
- (5) High-grade (98% pure) carbohydrate fatty acid esters can be obtained.
- (6) This process is adaptable for producing a number carbohydrate fatty acid esters.

Other objects and advantages of the invention will become apparent upon reading the following detailed description.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

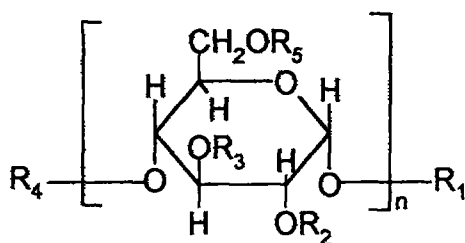
The present invention will be described in detail.

In accordance with the solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters of the present invention, acylated carbohydrate with chain-length C2-C3 includes mono to trisaccharide carbohydrates [see molecular structure], and the free fatty acid has chain-length C6 – C22.

In the present process, the acid catalyst includes concentrated sulphuric acid and alky sulfonic acid polysiloxanes. The carbohydrate fatty-acid esters of the present process has the following molecular structures:

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wherein R2, R3, R5 are each selected from the group consisting of H, CH₃CO, CH₃CH₂CO, and C6-C22 fatty acyl group; R1, and R4 are each selected from the group consisting of a partially or peracylated mono- or di-saccharide, H, CH₃CO, CH₃CH₂CO or C6-C22 fatty acyl group; and n is an integer with value equal to 1, 2, or 3; wherein the primary monosaccharide unit, i.e. the [---]_n unit, could be a furanosyl, pyranosyl or C2-C6 open-chain structure.

10

In this process, acylated (C2 to C3) carbohydrate, preferably, mono to tri-saccharide) is reacted with free fatty acid (C6 to C22) and the reaction temperature ranges from 60 to 95 degree C, preferably from 80 to 90 degree C, in the presence of an acid catalyst, under reduced pressure within the range of 4 to 20 Torr, preferably from 5 to 10 Torr and, without adding any solvent. Next, the reaction mixture is decolorized and separated into unreacted fatty acid layer and a carbohydrate fatty-ester layer.

The unreacted C2-C3 acylated carbohydrate is then precipitated out by cooling the carbohydrate fatty-ester layer to 10 to 0 degree C. If desirable, the free hydroxyl groups are liberated by partial hydrolysis in the presence of an acid or base catalyst. The unreacted free fatty acids and carbohydrate esters of low molecular-



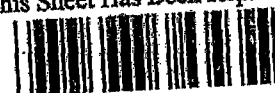
weight carboxylic acids, which are removed during purification, are then reused. The low molecular weight carboxylic acid, which is a by-product of the trans-acidolysis, is trapped and recycled.

5 In accordance with the preferred embodiment of the present invention, the process is carried out at low temperature, within the range of 60 to 95 degree C.

The following examples will further illustrate the present
10 invention.

EXAMPLE 1: Preparation of acetylated glucose laurate and the partially deacetylated glucose laurate

0.03 mol (6.00g) of lauric acid (Fluka Chemika, Switzerland) was
15 added into a three-necked, round-bottom flask equipped with a magnetic stirrer, stopcocks, a vacuum take-off line leading to a liquid nitrogen cold-trap and a vacuum pump. 0.01 mol (3.90g) of Glucose pentaacetate, GPA, (Fluka Chemika, Switzerland) was added and the mixture was heated to 80-100°C in an oil bath with continuous stirring until a homogenous solution
20 was formed. 0.1 % w/w (0.01g) of concentrated sulphuric acid was then added and 10-20 Torr pressure was applied. The reaction was continued for 3 to 6 hours. The reaction was then stopped and taken up with 100ml of n-propanol. The solution was then neutralized with 5.0ml aqueous 1M



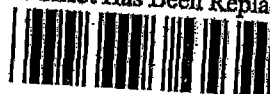
NaHCO_3 , decolourised with 1.0g activated charcoal and filtered warm. (Ethyl acetate or acetonitrile could also be used in place of n-propanol). N-propanol was then removed by vacuum distillation.

Unreacted lauric acid was extracted with 50 X 4 ml hexane. Hexane
5 was vacuum distilled to recover unreacted lauric acid and kept for reuse. The glucose fatty ester was redissolved in warm n-propanol, cool to 0 °C and filtered to give unreacted GPA as precipitate. The filtrate n-Propanol was then vacuum distilled off to give 70-85% pure acetylated glucose laurate. Repeated fatty acid extraction and GPA precipitation gave 90-95% pure
10 product (90.2% yield).

Partial deacetylation of acetylated glucose laurate

Acetylated glucose laurate obtained above was divided into four equal portions. Each portion was refluxed in 150ml 1M HCl (aqueous) solution for various lengths of time, to give partially deacetylated glucose fatty esters of
15 various HLB values, depending on the length of reflux. The solvent was distilled off under reduced pressure.

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Example 2: Preparation of acetylated sucrose oleate and the partially deacetylated sucrose oleate

0.06mol (16.93g) of oleic acid (Fluka Chemika, Switzerland) was
5 weighed into a three-necked, round-bottom flask equipped with a magnetic
stirrer, stopcocks, a vacuum take-off line leading to a liquid nitrogen cold-
trap and a vacuum pump. 0.01mol (6.79g) of sucrose octaacetate, SOA,
(Fluka Chemika, Switzerland) was added and the mixture was heated to 80-
100°C in an oil bath with continuous stirring until a homogenous solution
10 was formed. 0.1 % w/w (0.024g) of concentrated sulphuric acid (or 0.5g
alkyl sulfonic acid polysiloxane) was then added and 10-20 Torr pressure
was applied. The reaction was continued for 3 to 6 hours. The product was
taken up in 250ml of ethyl acetate, neutralized with 5.0ml aqueous 1M
NaHCO₃, decolourised with 2.0g activated charcoal, and filtered. Ethyl
15 acetate was then removed by vacuum distillation.

Unreacted oleic acid was extracted with 50x4 ml hexane and kept for
reuse. The sucrose fatty ester was redissolved in warm n-propanol, cool to 0
°C and filtered to give unreacted GPA as precipitate. The filtrate n-Propanol
was then distilled off to give 70-85% pure acetylated sucrose oleate.
20 Repeated hexane extraction and SOA precipitation gave 90-95% pure
product (90.2% yield).



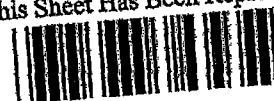
Partial deacetylation of acetylated sucrose oleate

Acetylated sucrose oleate obtained above was divided into four equal portions. 150 ml aqueous ammonia solution was added to of the portions and
5 agitated for various times, to give sucrose fatty esters of various HLB values, depending on the length of treatment with the ammonia solution. The solvent was distilled off under reduced pressure.

While the invention has been described with respect to
10 preferred embodiment, it will be clear to those skilled in the art that modifications and improvements may be made to the invention without departing from the spirit and scope of the invention. Therefore, the invention is not to be limited by the specific illustrative embodiment, but only by the scope of the appended claims.

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CLAIMS

1. A solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters comprising the steps of:
- 5 (a) reacting acylated carbohydrate with free fatty acid in the presence of an acid catalyst, under reduced pressure;
- 10 (b) decolorizing and separating the reaction mixture obtained in step (a) into unreacted fatty acid layer and a carbohydrate fatty-ester layer;
- (c) precipitating out the unreacted acylated carbohydrate;
- (d) liberating the free hydroxyl groups by partial hydrolysis in the presence of an acid or base catalyst;
- 15 (e) removing the unreacted free fatty acids and carbohydrate esters of low molecular-weight carboxylic acids during purification, and recycling the removed unreacted free fatty acids and carbohydrate esters to the starting reactant mixture
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2. A solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters as set forth in Claim 1, wherein in step (a), no solvent is added thereto.
3. A solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters as set forth in Claim 1, wherein the unreacted acylated carbohydrate is
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precipitated out by cooling the carbohydrate fatty-ester layer to 10 to 0 degree C.

- 5 4. A solvent-free trans-acidolysis process for preparing edible surface-active carbohydrate fatty-acid esters as set forth in Claim 1, wherein step (a) is processed at a temperature ranging from 60 to 95 degree C.

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