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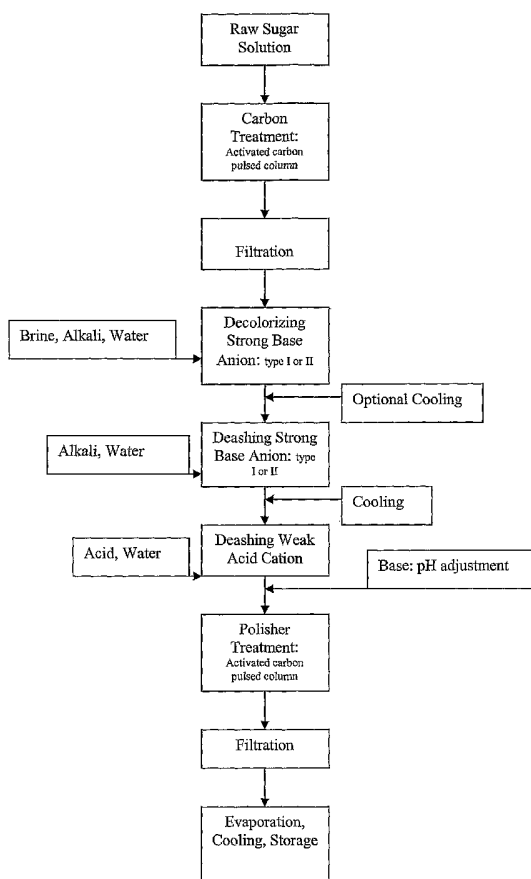
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(54) Title: METHOD OF REFINING SUCROSE



(57) Abstract: Processes for refining raw liquid sucrose are disclosed that include contacting raw liquid sucrose with activated carbon and/or an ion exchange resin to produce a first liquid sucrose intermediate product. The first liquid sucrose intermediate product may be contacted with a strong base anion exchange resin and a weak acid cation exchange resin to produce a second liquid sucrose intermediate product. The second liquid sucrose intermediate product may be contacted with activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

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METHOD OF REFINING SUCROSE

Cross Reference to Related Application

5 This application claims the benefit of U.S. Provisional Patent Application No. 60/476,810 filed June 6, 2003, which is incorporated herein by reference.

Field

10 The present disclosure relates to refining raw sucrose to produce a more pure sucrose product.

Background

15 The conventional refining of raw sucrose for producing refined liquid sucrose using crystallization is an expensive endeavor. Typically, these processes involve repeatedly crystallizing the sucrose to remove the impurities from the sucrose. The use of crystallization produces a high quality product, but consumes a significant amount of energy resulting in high costs. Moreover, in order to obtain a liquid product the refined crystallized sugar must be
20 liquefied by dissolving the refined crystallized sugar in water. A process that does not include any, or only a few, crystallization steps but that can still produce a high quality refined sucrose product would be very useful.

Summary of the Disclosure

25 Disclosed herein are processes for refining raw liquid sucrose.

 According to one approach, raw liquid sucrose may be contacted with at least activated carbon to produce a first liquid sucrose intermediate product. The first liquid sucrose intermediate product may be contacted with a strong base anion exchange resin and a weak acid
30 cation exchange resin to produce a second liquid sucrose intermediate product. The second liquid sucrose intermediate product may be contacted with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

 According to a second approach, raw liquid sucrose may be contacted with at least one
35 media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product. The first intermediate liquid sucrose product may be contacted with a strong base anion exchange resin and a weak acid cation exchange resin to produce a second

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intermediate liquid sucrose product. The second intermediate liquid sucrose product may be passed through an activated carbon column resulting in a refined liquid sucrose product.

According to a third approach, raw liquid sucrose may be contacted with at least one media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product. The first intermediate liquid sucrose product may be contacted with a strong base anion exchange resin to produce a second intermediate liquid sucrose product. The second intermediate liquid sucrose product may be contacted with a weak acid cation exchange resin at a temperature of less than 40°C to produce a third intermediate liquid sucrose product. The third intermediate liquid sucrose product may be contacted with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

According to a fourth approach, raw liquid sucrose may be contacted with at least one media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product. The first intermediate liquid sucrose product may be contacted with a strong base anion exchange resin to produce a second intermediate liquid sucrose product. The second intermediate liquid sucrose product may be contacted with a homogeneous weak acid cation exchange resin bed to produce a third intermediate liquid sucrose product. The third intermediate liquid sucrose product may be contacted with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

Brief Description of the Figures

Certain embodiments will be described in more detail with reference to the following figure:

FIG. 1 is a schematic process flow diagram of one example of a process disclosed herein.

Detailed Description of Several Embodiments

For ease of understanding, the following terms used herein are described below in more detail:

"Ash" refers to various organic and inorganic agents that may be present in a sucrose-containing composition. Ash includes potassium, ammonium, sodium, calcium, and magnesium cations; chloride, sulfate and phosphate anions; proteins; and organic acids such as lactic acid and succinic acid. The ash content in any given sucrose-containing composition may be

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determined in accordance with conductivity ash procedures established by the International Commission for Uniform Methods for Sugar Analysis ("ICUMSA").

"De-ashing" involves removing ash impurities from a sucrose-containing composition such as liquid sucrose. De-ashing may be used interchangeably with de-mineralization in the industry. The use of "de-ashing" in this disclosure also encompasses de-mineralization to the extent that there is any distinction between the two terms.

"De-colorization" refers to removing color bodies or agents from a sucrose-containing composition such as liquid sucrose. Color bodies or agents include, by the way of example, caramels, melanoidins, polyphenolics, flavanoids, and color precursors such as amino acids, hydroxy acids, aldehydes, iron compounds that complex with phenolics, 5-hydroxymethyl-2-furfural, 3-deoxy-d-glucose, and reducing agents.

"Homogeneous ion exchange resin bed" denotes a resin bed that contains only one class of ion exchange resin (e.g., a weak acid cation exchange resin). A homogeneous bed is distinguished from a mixed bed that includes at least two different classes of ion exchange resins.

"I.C.U." is an abbreviation for "international color units" as determined in accordance with procedures established by the ICUMSA.

"Invert sugar" includes non-sucrose sugars such as glucose and fructose that typically are present in a sugar composition. The invert sugars may be present as a result of hydrolysis of sucrose. As used herein, invert sugar does not necessarily imply that the glucose and fructose are present in equimolar proportions. The amount of invert sugar in a given sugar material may be measured in accordance with several procedures such as high-pressure liquid chromatography, ion chromatography, or polarimetry, and is referred to herein as a weight percentage of invert sugar present in the composition, based on the total dry solids content.

"Liquid sucrose" refers to any material, batch, composition, or mixture that includes liquid sucrose as a significant, if not the primary, component. The sucrose typically may be at least partially, if not substantially, dissolved in a liquid medium or carrier (e.g., water). A portion of the sucrose may also be in the form of solids suspended in a liquid carrier phase (e.g., an aqueous slurry).

"Raw liquid sucrose" refers to liquid sucrose that is generally not commercially acceptable for human consumption, particularly for use by food and drink manufacturers. For example, raw liquid sucrose may be produced by extracting cane sugar juice from sugarcane. The cane sugar juice then is crystallized into brown sugar crystals. The brown sugar crystals or granulated raw sugar then is made available for further refining. Granulated raw sugar is a trading commodity with various grades of quality as described for example by Chen and Chou, Cane Sugar Handbook. However, for purposes herein, raw liquid sucrose does not have a

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specific classification and can be made by dissolving any quality of raw sugar into water. Raw liquid sucrose may include, but is not limited to, aqueous sucrose syrup.

"Refined liquid sucrose" refers to liquid sucrose that has been refined from raw liquid sucrose via at least one refining stage. An illustrative example of a refined liquid sucrose is
5 bottler's grade liquid sugar.

"Sensory-enhancing material" refers to a separation material that can remove agents or bodies that impart an unpleasant taste or odor to a liquid sucrose composition.

"Strong base anion exchange resin" denotes an anion exchange resin that is fully or strongly ionized as opposed to weakly ionized. A distinguishing feature between weak base
10 anion exchange resins and strong base anion exchange resins concerns their differing exchange capacity. A strong base anion exchange resin has a fixed exchange capacity per resin bead across the pH range of the liquid in which the resin is in contact. Weak base anion exchange resins, on the other hand, vary from a negligible exchange capacity to a high exchange capacity depending upon the pH of the liquid in which the resin is in contact.

15 "Weak acid cation exchange resin" denotes a cation exchange resin that is weakly ionized as opposed to fully or strongly ionized. A distinguishing feature between weak acid cation exchange resins and strong acid cation exchange resins concerns their differing exchange capacity. A strong acid cation exchange resin has a fixed exchange capacity per resin bead across the pH range of the liquid in which the resin is in contact. Weak acid cation exchange
20 resins, on the other hand, vary from a negligible exchange capacity to a high exchange capacity depending upon the pH of the liquid in which the resin is in contact. Weak acid cation exchange resins typically are functionalized by hydrolyzing an ester group with an acid or base to produce a carboxyl ion exchange group. In contrast, strong acid cation exchange resins typically are functionalized via sulfonation to produce sulfonyl ion exchange groups.

25 The above term descriptions are provided solely to aid the reader, and should not be construed to have a scope less than that understood by a person of ordinary skill in the art or as limiting the scope of the appended claims.

The processes disclosed herein relate to producing a refined liquid sucrose product from raw liquid sucrose. Due to the unique combination of process modules involving ion exchange
30 resins and, in certain embodiments, activated carbon, crystallization steps are not typically required during the refining process. Hence, the processes disclosed herein offer the possibility of substantially reduced costs. It should be recognized that the use of at least one crystallization step in conjunction with the refining processes disclosed herein is not necessarily excluded.

Moreover, despite the lack of any crystallization purification steps, the refined liquid
35 sucrose products disclosed herein exhibit product characteristics such as color, taste, odor (collectively referred to herein as "sensory" properties) and ash content that are substantially similar to those of commercially available liquefied crystal sugar that was refined using

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crystallization. The refined product also is produced in a liquid phase that can be supplied directly to customers in contrast to the current need to liquefy conventional crystal refined sugar to produce liquid sugar.

Furthermore, the processes disclosed herein are able to substantially minimize the
5 production of invert sugar during the refining process. Invert sugar is undesirable since it can reflect the degree of impurity in sucrose solutions or solids. For example, certain products such as liqueurs and candy demand the highest purity of sucrose as exemplified by Large Grain Granulated Sugar quality sucrose (see Chen and Chou, Cane Sugar Handbook). In certain examples of processes disclosed herein, the increase in the amount of invert sugar from the raw
10 liquid sucrose to the refined liquid sucrose product may be less than about 1.0 weight %, particularly less than about 0.5 weight %, more particularly less than about 0.2 weight %, and most particularly less than about 0.1 weight %. Certain process parameters have been identified in the present disclosure that can minimize the formation of invert sugar. Especially sensitive process conditions effecting invert sugar formation include temperature, pH and the contact time
15 with specific types of ion exchange resins as described below in more detail. Control of the pH during the process is particularly illustrative.

In general, the system pH can be maintained above about 7.0, more particularly about 7.5, to minimize invert sugar formation, although a pH below these levels can be tolerated depending upon the temperature and/or resin contact time. A sucrose process stream may
20 experience a pH decrease or increase as it flows through a process module. The various process modules are described below in detail. However, such a pH modulation is acceptable provided the pH is adjusted accordingly in a relatively short time after the sucrose stream exits the module and/or the sucrose stream retention time within the module unit equipment is sufficiently minimized. For example, the sucrose stream exiting a module could be immediately directed
25 into a pH trim tank for pH adjustment.

The raw liquid sucrose can be provided with any invert sugar level. With respect to producing a bottler's grade refined liquid sugar by the process described here, the concentration of invert sugar present in the feedstock should be known. The invert sugar concentration in the refined liquid sucrose product is equal to, or slightly greater than the invert concentration in the
30 feedstock. Thus, in specifying the feedstock invert sugar level the customer specifications for invert sugar concentration in the refined liquid sucrose product must be considered. If the respective customer requirements are known, the invert sugar concentration in the feedstock can be selected to meet the finished product requirements allowing for a small additional invert sugar creation in the process. However, if invert sugar levels are not of significant concern, then invert
35 sugar level requirements in the feedstock can be relaxed. Further reduction in the invert sugar concentration can be enhanced by the inclusion of crystallization/centrifuge steps before or after this process.

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The refined liquid sucrose product may have any amount of invert sugar. However, in certain instances, the refined liquid sucrose product may have an invert sugar level of less than about 1 weight %, more particularly less than about 0.5 weight %, and most particularly less than about 0.1 weight %.

5 According to a more detailed process flow description, the raw liquid sucrose initially is subjected to a pretreatment/de-colorization process module. The pretreatment/de-colorization process module can selectively remove a substantial amount of color, odor and organic compound impurities from the raw liquid sucrose feedstock. The pretreated liquid sucrose resulting from the pretreatment process module then enters a de-ashing process module. The de-
10 ashing process module can selectively remove a substantial amount of ash and an additional amount of color. The substantially de-colored/de-ashed sucrose resulting from the de-ashing process module then enters a polishing process module. The polishing process module can selectively remove flavors and odors to provide a more sensory-enhanced refined liquid sucrose product. Each one of these process modules may include one or more steps.

15 The raw liquid sucrose for use as the starting material or process feedstock may be produced from various biomaterials such as sugarcane, sugar beet, sorghum, honey, maple sap, corn, and mixtures thereof. Cane or beet raw sugar is a particularly useful starting material because of their abundance and the feedstock for the present process can be produced with very few steps from the raw crop. As described above, the invert sugar level of the feedstock may
20 vary widely, but in the case of cane raw sugar, the invert sugar level, for example, may less than about 0.05 weight %, but it could range up to about 0.1 weight % or greater depending upon the desired invert sugar level in the refined liquid sucrose product. The presently disclosed processes can accept a wide range of ash amount and color level in the raw sucrose feedstock and still meet bottler's grade qualities in the refined product. For example, the raw liquid
25 sucrose feedstock may include as impurities or contaminants (in addition to invert sugar as described above), less than or equal to about 2.0 weight %, more particularly less than or equal to about 1.0 weight %, based on the total dry weight of raw sucrose feedstock. The minimum amount of ash in the raw feedstock may be about 0.25 weight %, more particularly about 0.15 weight %. The raw liquid feedstock may have an I.C.U. of less than or equal to about 3000,
30 more particularly less than or equal to about 1500, although the maximum I.C.U. should only be limited by the maximum amount of space available for the separation vessels used in the process. The solids content of the raw liquid sucrose can vary, although a high solids content can limit evaporation costs. For instance, the raw liquid sucrose may have a Brix degree of about 30 to about 60, with a more particular minimum of about 50. The solids content of the
35 raw liquid sucrose feedstock may range, for instance, from about 40 weight % to about 60 weight %, more particularly from about 50 weight % to about 55 weight %. The raw liquid sucrose feedstock may be provided as crystallized raw sucrose which is washed and/or affined

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and then liquefied prior to its introduction into the refining processes. Such liquefaction may be accomplished, for example, by melting the crystallized raw sucrose in an aqueous medium such as water or a sugar aqueous solution. However, as mentioned above, no crystallization steps are necessary during the refining process itself.

5 As mentioned above, the initial refining may occur within a pretreatment/de-colorizing process module. A primary component of the pretreatment/de-colorizing process module is a separation stage such as at least one activated carbon treatment and/or at least one ion exchange resin. If a combination of activated carbon and an ion exchange resin is used, the activated carbon stage and ion exchange resin stage may be arranged in any order relative to the flow
10 direction of the sucrose feedstock. The pretreatment process module may also include screening of the raw liquid sucrose to remove large-sized solid matter. The ion exchange resin may be especially useful for de-colorizing. According to one particular process scheme, the pretreatment process module includes an activated carbon column as a first stage and at least one strong base anion exchange resin as a second stage. In the second stage, there could be a first
15 strong base anion exchange resin that is tailored to absorb colorants in a high colorant-load sucrose stream followed by a second strong base anion exchange resin tailored to absorb colorants in a lower colorant-load sucrose stream. According to a second particular process scheme, the pretreatment process module includes at least one strong base anion exchange resin, but no activated carbon treatment. The second process scheme could include a first strong base
20 anion exchange resin that is tailored to absorb colorants in a high colorant-load sucrose stream followed by a second strong base anion exchange resin tailored to absorb colorants in a lower colorant-load sucrose stream.

The sucrose feedstock may be contacted with the activated carbon and/or ion exchange resin under conditions sufficient for removing a substantial amount of the color (e.g., up to about
25 90%), and a substantial amount of large organic molecules that could foul the ion exchange resins in the downstream process. In the activated carbon column followed by strong base anion exchange resin approach, the activated carbon may remove about 50% to about 90% of the color in raw sucrose feedstock. The de-colorizing resin then can remove another 50% to 90% of the color of the sucrose stream received from the activated carbon. For instance, if the raw liquid
30 sucrose feedstock has a color of 1500 I.C.U., the activated carbon may lower the color level to about 150 to about 750 I.C.U., more particularly below about 300 I.C.U. The de-colorizing resin then could lower the color level to about 40 to about 375 I.C.U., more particularly below about 50 I.C.U.

The pH of the raw sucrose feedstock may be adjusted as necessary to be at least about
35 7.0, more particularly about 7.5. The pH adjustment may be accomplished by adding a base as appropriate to the raw sucrose. Illustrative bases for pH adjustment in the disclosed processes include hydroxides and carbonates of sodium, potassium and magnesium. The amount of

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sucrose feedstock flowing through the activated carbon and/or ion exchange resin varies depending upon parameters such as pH drop, plant volume and production rates. The flowrate ranges for each process module are dependent upon each other but are not necessarily equal. For example, the flowrate through an activated carbon column may range from about 0.1 to about 1
5 bed volume/hour ("BV/hr"), but could be outside this range depending upon the specific parameters. The temperature of the feedstock flowing through the activated carbon may range from about 50°C to about 90°C, more particularly about 60°C to about 80°C, and the pH of the sucrose may range from about 6.5 to about 9, more particularly about 7.0 to about 8.5. The pH may decrease by up to about 2 units as the sucrose flows through the activated carbon, and thus
10 the pH of the incoming sucrose can be adjusted to take into account an anticipated pH drop. Alternatively, the pH of the pretreated liquid sucrose may be adjusted at a point downstream from the activated carbon. According to another approach, magnesite may be added to the activated carbon to minimize the pH drop.

The maximum temperature of the ion exchange resin (such as the de-colorizing ion
15 exchange resin) in the pretreatment/de-colorizing process module should be less than the given temperature stability limits of a specific resin. In addition, higher temperatures can avoid microbial growth. The temperature may range, for example, from less than about 40°C (e.g., down to about 10°C or 30°C) to about 80°C, more particularly about 50°C to about 80°C. In the case of a strong base anion exchange (type I) resin for the de-colorizing resin, the temperature
20 may range from less than about 40°C to about 80°C. In the case of a strong base anion exchange (type II) resin for the de-colorizing resin, the temperature may range from about less than about 40°C to about 60°C. The pH of the sucrose feeding to the de-colorizing resin may range as described above for the activated carbon treatment.

The activated carbon may be thermally or chemically activated. The activated carbon
25 may be utilized in any form such as a powdered, granular, shaped or as activated carbon cloth. The activated carbon may be a specific type of surface modification that renders the activated carbon acidic, basic, hydrophilic, or amphoteric. One example of an activated carbon is an acid-washed, granular activated carbon such as those grades commercially available from Calgon Carbon Corporation under the trade designation CPG. The activated carbon may include an
30 additive (e.g., magnesium hydroxide or magnesite) that imparts increased pH stability.

A useful activated carbon format, especially for continuous operation, is an activated carbon column. More particularly, the activated carbon is arrayed or packed within a cylindrical vessel. One example of an activated carbon column is a pulsed column. A pulsed column typically operates in a counter-current configuration with the flow moving up the column.
35 Periodically, slugs of spent activated carbon are extracted from the bottom and virgin or regenerated activated carbon is inserted into the top of the column. The flow of new to old carbon is in the direction opposite to the sucrose flow. Thus, the incoming sucrose composition

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is initially exposed to the most spent carbon and then moves through zones of cleaner activated carbon. A portion, say 5 to 10%, of the activated carbon contained in the column may be removed from the bottom every day and an equal amount of regenerated carbon is put into the top. The removed carbon is rinsed with water to remove sugar (creating sweetwater) and then it is regenerated in a furnace.

Alternatively, a batch operation may be used rather than a continuous column operation. In the batch operation the activated carbon and the sucrose feedstock are mixed together in a vessel. The resulting mixture then is filtered to remove the activated carbon fines.

The activated carbon should be regenerated as required for maintaining its operating efficiency. Various regeneration techniques can be used such as thermal, chemical, hot gas, or solvent methods. Suitable conditions for regenerating these types of resins are known in the activated carbon industry.

The ion exchange resin that could be used in the pretreatment process module may be selected from any class of resins such as weak and strong-acid resins for removing cations, and weak and strong-base resins for removing anions. Ion exchange resins typically are copolymers of at least one monoethylenically unsaturated monomer with at least one polyunsaturated monomer. Examples of monoethylenically unsaturated monomers include polycyclic aromatics such as vinyl naphthalenes, monocyclic aromatics such as styrene and substituted styrene, and (meth)acrylic monomers. Examples of polyunsaturated monomers include di- or trivinyl aromatics such as divinylbenzene, and di- or trimethacrylates such as ethylene glycol dimethacrylate. A strong base anion exchange resin (either type I or II) may be especially suitable for de-colorizing. An example of a commercially available strong base anion exchange resin useful in the pretreatment process module is a high porous (i.e., macroporous) resin available from Mitsubishi Chemical under the tradename Diaion HPA25. Diaion HPA25 is a type I resin having a styrenic polymer backbone and a quaternary ammonium(Cl⁻) ion exchange group.

Various regenerants can be used for the de-colorizing resin such as a caustic-brine solution (e.g., a mixture of NaCl and NaOH), a brine solution (e.g., NaCl), or a caustic solution (e.g., NaOH, KOH, or NH₄OH). Specific illustrative aqueous regenerants include a 10% NaCl -- 1% NaOH mixture, a 10% NaCl solution, and a 1%-4% NaOH solution. Such resins have a particularly strong affinity for colorants when regenerated with sodium hydroxide or a sodium hydroxide/brine solution. The regenerant dose can vary as required depending upon the specific resin. For example, about 7 to about 11 pounds of NaCl/ft³ resin may be used with a contact time of greater than about 40-60 minutes and a flow rate of about 1 to about 2 BV/hr. Certain ion exchange resins are described in more detail below.

The first liquid sucrose intermediate or pretreated liquid sucrose then can be subjected to the de-ashing process module. Although the intermediate product targets may vary depending

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upon the feedstock and desired refined product, the conditions in the de-ashing module can be sufficient for generating a de-colored/de-ashed liquid sucrose intermediate having an I.C.U. of less than about 35 (especially if the pretreated sucrose has an I.C.U. of about 50 to about 375). The ash content of the de-colored/de-ashed liquid sucrose intermediate may be, for example,
5 less than about 0.03 weight %, more particularly less than about 0.01 weight %, measured as conductivity ash.

The de-ashing process module may at least include contacting the pretreated liquid sucrose with a strong base anion exchange resin and a weak acid cation exchange resin. The strong base anion exchange resin and the weak acid cation exchange resin may be provided
10 together in a mixed bed configuration. Alternatively, separate beds may be provided for the strong base anion exchange resin and for the weak acid cation exchange resin. The separate resin beds may be provided in separate vessels or they can be placed in a single vessel that includes a split bed design such that the resins do not undergo a mixing process but have a contacting boundary layer. With separate vessels, the strong base anion exchange resin bed and
15 the weak acid cation exchange resin bed can be operated at independent temperatures if desired. In the single vessel-split bed configuration both the anion bed and the cation bed will operate at the same temperature. In the separate bed option, the strong base anion exchange resin and the weak acid cation exchange resin may be placed serially in any order with respect to the flow direction of the pretreated liquid sucrose through the beds. According to one variant, the
20 pretreated liquid sucrose initially contacts the strong base anion exchange resin and thereafter contacts the weak acid cation exchange resin.

Any suitable strong base anion exchange resin may be used in the de-ashing module. Suitable strong base anion exchange resins include resins having a backbone polymer or matrix of (meth)acrylic, (poly)styrenic, or similar polymers. Strong base anion exchange resins
25 typically are styrene-divinylbenzene copolymers onto which various functional groups can be bonded to provide ion exchange groups. For example, a styrene-divinylbenzene copolymer can undergo chloromethylation followed by amination to introduce ammonium groups into the resin structure. A type I (e.g., the ion exchange group is a quaternary ammonium that includes three methyl groups substituents on the nitrogen atom) or type II (e.g., the ion exchange group is a
30 primary, secondary, tertiary, or quaternary ammonium group that includes a hydroxyethyl substituent on the nitrogen atom) strong base anion exchange resin could be used, either alone or in combination. A pre-used type II resin such as a resin that has been used in a fructose purification process, as opposed to a virgin type II resin, can be employed in the process. The resin may be microporous (i.e., gel-type) or macroporous, and it may be in the form of beads or
35 powdered. Illustrative commercially available strong base anion exchange resins include those available from Thermax (e.g., Tulsion A-72 SBA, Tulsion A-72 MP, or Tulsion A-30 MP), Dow Chemical (e.g., various resins available under the DOWEX tradename such as DOWEX

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Marathon 11 or Marathon MSA), Rohm & Haas (e.g., various resins available under the AMBERLITE tradename such as AMBERLITE FPA 91), Purolite (e.g., A-500S) and Mitsubishi Chemical (e.g., under the tradename Diaion HPA25). More than one specific type of strong base anion exchange resin may be employed in the present refining process.

5 The strong base anion exchange resin(s) may be configured as mixed beds or in serially arranged, separated homogeneous beds for a continuous flow operation. The resin bed(s) can be provided in packed columns. In addition, more than one bed of the same type of strong base anion exchange resin could be employed. For a batch operation, the resin and the sucrose may be mixed together and subsequently filtered to separate the impurity-loaded resin and the
10 sucrose.

 The strong base anion exchange resin should be regenerated as required for maintaining its operating efficiency. Various regenerants can be used as described above in connection with the de-colorizing strong base anion exchange resin. Periodic cross regeneration of the resin using an acid (e.g., HCl) could be employed to remove fouling. Sodium hydroxide may be
15 particularly effective for the de-ashing strong base anion exchange resin. The regenerant dosage can vary. In one example, about 3 to about 6 pounds of NaOH/bed ft³ can be employed, with a contact time of about 45 to about 75 minutes. In the case of a continuous operation employing a resin bed, the regenerant may be introduced through the bed in a countercurrent flow relative to the sucrose flow direction.

20 The amount of pretreated sucrose flowing through the de-ashing strong base anion exchange resin varies depending upon other parameters such as ion load and cation to anion ratio in the sucrose stream, but may range from about 0.2 to about 5, more particularly about 0.5 to about 2, BV/hr. The strong base anion exchange resin bed temperature may range from less than about 40°C (e.g., down to about 10°C or about 30°) to about 80°C (for a type I resin), and from
25 less than about 40°C (e.g., down to about 10°C or about 30°) to about 50°C (for a type II resin). If the strong base anion exchange resin shares a temperature zone with the weak acid cation exchange resin, then the strong base anion exchange resin may be less than about 40°C. The pH of the pretreated sucrose entering the strong base anion exchange resin may range from about 6 to about 8. There may be a pH adjustment at a point prior to entry into the strong base anion
30 exchange resin. The pH of the sucrose stream exiting the strong base anion exchange resin may range from about 6 to about 9.

 Minimization of invert sugar generation may be particularly difficult during de-ashing. However, the present inventors have determined that a weak acid cation exchange resin may be the most effective ion exchange resin class for minimizing formation of invert sugar. A weak
35 acid action exchange resin bed temperature of less than about 40°C can be particularly suitable for this purpose.

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Any suitable weak acid cation exchange resin may be used. Suitable weak acid cation resins include resins having a backbone polymer or matrix of (meth)acrylic, (poly)styrenic, or similar polymers. Weak acid cation exchange resins typically are copolymers of divinylbenzene with acrylic acid or methacrylic acid. Various functional groups can be bonded to the copolymer network to provide ion exchange groups. The resin may be microporous (i.e., gel-type) or macroporous, and it may be in the form of beads or powdered. Particularly useful resin matrices include gel-type polyacrylics. The carboxyl ion exchange group may be regenerated with an acid such as sulfuric acid so that the resin operates as in H^+ form, but other cation types such as Na^+ may also be used. Resin particle sizes can vary depending upon the operating conditions. For example, the particle size can be greater than about 40 mesh when utilizing a mixed bed or split bed, but smaller particle sizes can be utilized in homogeneous beds. Illustrative commercially available weak acid cation exchange resins include those from Purolite (e.g., Purolite C-104E, Purolite C-115E), Dow Chemical (e.g., various resins available under the DOWEX tradename such as MAC 3), and Rohm & Haas (e.g., IMAC HP 33 and various resins available under the AMBERLITE tradename).

More than one specific type of weak acid cation exchange resin may be employed. The different types of weak acid cation exchange resin may be configured as mixed beds, split beds, or in serially arranged, separated homogeneous beds for continuous flow operation. The resin bed(s) may be provided in packed columns. The weak acid cation exchange resin is provided as a homogeneous bed according to certain variants. A homogeneous weak acid cation exchange resin bed allows the preceding anion exchange resin to be maintained at a higher temperature. Consequently, cooling only occurs across the cation exchange resin bed which minimizes the low temperature zone volume and may be more beneficial for inhibiting microbial growth. In addition, more than one bed of the same type of weak acid cation exchange resin could be employed. For a batch operation, the resin and the sucrose may be mixed together and subsequently filtered to separate the impurity-loaded resin and the sucrose.

The weak acid cation exchange resin should be regenerated as required for maintaining its operating efficiency. Various regenerants can be used such as an aqueous mineral acid (e.g., hydrochloric acid or sulfuric acid). Suitable conditions for regenerating these types of resins are known in the ion exchange resin industry. In one model, a 1 to 4% HCl aqueous solution can be passed through the bed at about 4 to about 8 BV/hr with a contact time of about 30 to about 45 minutes. In the case of a continuous operation employing a resin bed, the regenerant may be introduced through the bed in a countercurrent flow relative to the sucrose flow direction.

The amount of pretreated sucrose flowing through the weak acid cation exchange resin varies depending upon other parameters such as retention time and temperature, and should be balanced to minimize invert sugar formation. For example, at a bed temperature of about 35°C to about 40°C, the flow rate may range from about 2 to about 4 BV/hr to maintain the invert

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sugar increase to less than about 0.1 weight %. The weak acid cation exchange resin bed temperature may be less than about 46°C, more particularly less than about 40°C, and most particularly less than about 35°C. The pH of the liquid sucrose composition entering the weak acid cation exchange bed may be about 6 to about 9. There may be a pH decrease of about 3 to about 4 units across the weak acid cation exchange resin bed, and thus a pH basic solution can be added to the sucrose stream at point immediately downstream of the weak acid cation exchange resin bed discharge. In certain instances, the pH of the sucrose composition may be adjusted to be at least 8.

The de-ashing process module could include other classes of ion exchange resins in addition to the strong base anion exchange resin and the weak acid cation exchange resin. For example, a strong acid cation exchange resin could also be used for de-ashing. The strong acid cation exchange resin could be provided in a mixed bed with the weak acid cation exchange resin or as a separate bed that is located in the flow direction either before or after the weak acid cation exchange resin.

According to one specific scheme for the de-ashing process module, the ion exchange resin separated bed order relative to the sucrose flow direction may be a strong base anion exchange resin bed followed by a weak acid cation exchange resin bed. In a further specific scheme, the separated bed order may be a first strong base anion exchange resin bed, a second strong base anion exchange resin bed, and then a weak acid cation exchange resin bed.

As mentioned above, the strong base anion exchange resin and the weak acid cation exchange resin can have significantly different sucrose throughputs. The bed sizes and/or number of beds can be designed accordingly to accommodate this difference. For instance, the anion resin bed can be up to six times larger than the cation resin bed or multiple anion resin beds can be employed. With the former option, then both the anion bed and cation bed could be taken out of service for regeneration at the same time. With the latter option, the anion resin beds could be rotated in and out of service as they reach their operating capacity. As one bed continues to remove ions, the other bed can be regenerated.

A recycle system can be employed around the de-ashing module or the de-ashing module and the pretreatment/de-colorizing module to minimize retention times, and thus minimize invert sugar formation. Such a recycle stream also could be employed to achieve a minimum flowrate through a resin bed to minimize the resin particles from floating in a high brix sucrose process.

The de-colored/de-ashed liquid sucrose intermediate product exiting the de-ashing process module may still include an amount of impurities such that its sensory quality is inadequate compared to commercially available sucrose refined with crystallization. Hence, a polishing process module for improving the sensory characteristics may be instituted at the backend of the process flow. The polishing process module includes contacting the de-

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colorized/de-ashed liquid sucrose intermediate product with at least one sensory-enhancing material such as activated carbon and/or an ion exchange resin. The activated carbons and ion exchange resins disclosed above in connection with the pretreatment process module may also be used for polishing. However, it has been determined that at least one activated carbon
5 column may be especially advantageous for polishing. If an ion exchange resin is used (either with or without an activated carbon treatment), the ion exchange process typically does not involve ion exchange chromatography (i.e., separation of mixed sugars into two or more fractions).

The amount of de-colorized/de-ashed sucrose flowing through the polishing module
10 varies depending upon parameters such as temperature, contact time and pH drop, but may range from about 0.2 to about 2, more particularly about 0.2 to about 1, BV/hr. The polishing module (activated carbon and/or ion exchange resin) temperature may range from about 50°C to about 90°C, and the pH of the sucrose may range from about 6.5 to about 9, more particularly about 7.5 to about 8.5.

15 The polishing module also could include a final step of adjusting the pH of the liquid sucrose product to be at least 8 so as to avoid invert sugar formation. The pH may be adjusted in any suitable manner such as by continuously adding a base (e.g., NaOH) via a trim tank. Additional treatments could be included in the polishing module such as filtration to remove carbon fines.

20 Sweetwater generated in any of the process modules may be recycled to the pretreatment process module. Sweetwater is created when a process module is exhausted or evacuated or a slug is removed from an activated carbon column. Water is used to displace the sucrose composition forward into the process system until the % Brix drops to a predetermined amount, typically about 10 to about 20%. At this point, the sucrose composition is diverted to a
25 sweetwater system. Conversely, a regenerated unit can be sweetened-on with syrup until the syrup exiting the unit rises into the 10 to 20% Brix range. At this point, the regenerated unit is then inserted back into the product process flow. Temperature and/or pH control of the sweetwater may be applied to avoid inversion and microbial problems.

The disclosed refining processes may be performed in a continuous manner or in a batch
30 manner. The various process modules are typically carried out in an aqueous medium. The ion exchange resins and activated carbon may be contacted with the sucrose stream via known techniques such as fixed beds, pulsed beds, fluidized beds or expanded beds.

The continuous flow method which can be utilized based on the present disclosure contemplates a multi-step process wherein the steps are performed in a manner such that a
35 sucrose stream flows continuously through the modules (e.g., beds or columns) defined by the steps. Of course, the continuous flow does not have to be on a constant 24/7 hours/days basis (i.e., there can be down times for maintenance, process adjustment or simple lack of demand).

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An example of a specific refining process is depicted schematically in FIG. 1. A raw sugar solution is initially passed through a pulsed column of activated carbon. The raw sugar solution may be heated to reach the desired activated carbon column operating temperature set forth above. The resulting first intermediate product then is filtered, particularly to remove carbon fines. The filtered intermediate product then passes through a first strong base anion exchange resin for de-colorization. The de-colorizing strong base anion exchange resin may be regenerated by a brine or caustic brine solution. The substantially de-colored intermediate product then passes through a second strong base anion exchange resin for de-ashing. The de-ashing strong base anion exchange resin may be regenerated by an alkali solution. The substantially de-colored intermediate product may optionally undergo cooling to reduce the intermediate product stream temperature to satisfy the temperature requirements of the weak acid cation exchange resin if the de-ashing strong base anion exchange resin is within the same temperature zone as the weak acid cation exchange resin bed. The partially de-ashed intermediate product then undergoes any additional required cooling to reduce the intermediate product stream temperature to less than about 46°C, more particularly less than about 40°C, and most particularly less than about 35°C. The partially de-ashed intermediate product subsequently is passed through a de-ashing weak acid cation exchange resin. The weak acid cation exchange resin may be regenerated by an acid solution. The pH of the substantially de-ashed intermediate product then is heated and adjusted to be in a range of about 7 to about 9 prior to introduction into an activated carbon pulsed column for polishing. The de-ashed intermediate product may be heated via a heat exchanger or some other heat source. The resulting polished product then is filtered, particularly to remove carbon fines. The final refined product then may undergo evaporation and/or cooling for storage purposes.

The refined liquid sucrose products described herein may have human sensory properties (particularly odor and taste) that are substantially similar to commercially available refined bottlers grade liquefied sugar. The taste and odor of the refined liquid sucrose product should be clean or not unpleasant.

The refined sucrose product may have a unique ion contents profile. For instance, depending upon the pH basic material (i.e., NaOH) used for pH adjustment after the de-ashing module, the refined sucrose product can have a potassium ion content of less than about 15, more particularly less than about 10 mg/Kg (dry); a magnesium ion content of less than about 5, more particularly less than about 1 mg/Kg (dry), and most particularly less than about 0.5 mg/Kg (dry); and a total chloride and sulfate ion content of less than about 10, more particularly less than about 5 mg/Kg (dry). If KOH is used as pH adjuster, then potassium ion content will be higher, but the sodium ion content will be reduced. The total ash content of the refined sucrose product may be less than about 0.020 weight %, more particularly less than about 0.015 weight

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% (as defined by conductivity ash). The refined sucrose product may also have an I.C.U. of less than about 35, more particularly less than about 25.

The refined liquid sucrose product is particularly useful as a sweetener for the food and beverage industries (e.g., as bottler's grade liquid sugar), but could also be used for the pharmaceutical industry and for direct sale to consumers.

The specific examples described below are for illustrative purposes only and should not be considered as limiting the scope of the appended claims.

Examples 1-3

10

A raw liquid cane sugar feedstock (I.C.U. 1022, solids of 55% Brix, 0.2% ash) was subjected to an initial activated carbon treatment. This treatment involved mixing 3500 ml of the raw liquid cane sugar feedstock with 750 g of regenerated Calgon Carbon CPG activated carbon. The mixture was stirred for six hours at 75°C and then separated by filtration through a 0.7 micron filter to remove carbon fines.

The syrup batch from the carbon treatment was fed through 100 ml of Thermax A-72 strong base anion exchange resin (for de-colorizing) in the chloride form at 1 BV/hr and a feed temperature of 56°C and a pH of 8.0. The strong base anion exchange resin was regenerated with 3 BV of a 10%NaCl-1%NaOH solution and rinsed with 5 BV of deionized water prior to treating the syrup batch.

The batch from the de-colorizing resin was collected in a period of about 3 hours. The batch was protected by cooling as it was collected.

The batch from the de-colorizing resin was fed at a rate of 8 BV/hr (based on the BV of the cation resin), a temperature of 42°C, and a pH of about 7 to a first de-ashing column that contained 300 ml Thermax A-72 strong base anion exchange resin and then to a second de-ashing column that contained 20 ml Purolite C-104E weak acid cation exchange resin. The anion resin was regenerated with 3 BV of a 4% NaOH solution at a flow rate of 3 BV/hr then rinsed with 5 BV of deionized water at 3 BV/hr prior to treating the batch. The cation resin was regenerated with 3 BV of a 7% HCl solution at a flow rate of 3 BV/hr followed by a 5 BV of deionized rinse water prior to treating the batch.

The pH of the product resulting from the de-ashing columns was raised to 8.0 with addition of NaOH, filtered with a 1 micron filter and evaporated to 67.5 Brix. This sample was split to prepare samples 1-3 in Table 1 below. Example 2 is the analysis of the product from the de-ashing module with only the subsequent filtration and evaporation. Example 1 was submitted to a post-treatment involving passing a portion of the sample through 30 ml of DOWEX Optipore SD-2 adsorbent resin at 3 BV/hr at 43°C. The DOWEX Optipore SD-2 adsorbent resin had been previously regenerated with a weak caustic solution. Example 3 was generated by

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passing a portion of the sample product through 400 g Calgon CPG regenerated activated carbon supported on a filter inside a funnel. The syrup was heated and then poured into the funnel for gravity feed for over an hour. All the samples were allowed to remain at room temperature for storage.

- 5 A comparison of the ion profile of refined liquid sucrose products produced according to Examples 1-3 to several commercially available sucrose products produced via crystallization is shown below in Table 1. The exemplified refined liquid sucrose product is diluted to an aqueous solution that includes 10 weight % dry solids sucrose. The commercially available crystal sugars are dissolved into solution at a 10 weight % dry solids sucrose level. Both the
- 10 exemplified samples and the commercial samples can be analyzed for ion content using standard ion chromatography techniques. With respect to the anions, a Dionex Ion Chromatograph with a conductivity detector can be used with a column temperature at room temperature, a conductivity cell temperature of 35°C, a suppressor current of 100 mA, and a KOH mobile phase flow rate of 1.0 mL/minute. With respect to the cations, the same equipment and conditions can
- 15 be used except that the mobile phase is a methane sulfonic acid solution. The results may then be extrapolated to a dry mg/Kg basis.

Table 1

20

Ion acid amount (mg/Kg dry basis)

Sample	Sodium	Ammonium	Potassium	Magnesium	Calcium	Chloride	Nitrate	Sulfate	Phosphate	Citrate
Example 1	15.9	0.3	5.2	0.2	1.0	1.8	0.1	0.5	1.6	0.2
Example 2	14.4	0.6	5.3	0.1	0.8	3.1	0.4	0.8	1.7	0.2
Example 3	14.5	0.7	4.3	0.3	1.4	0.8	0.9	1.2	0.8	0.2
C&H Brand granular pure cane	4.3	0.2	18.1	1.3	5.8	3.3	0.1	5.1	0.3	0.2
Domino brand granular pure cane	5.9	0.2	35.3	1.1	14.6	15.1	0.5	1.8	0.3	0.2
Kroger brand granular	2.3	0.2	24.6	1.0	9.9	6.9	0.1	7.1	0.3	0.2
Pioneer brand granular	2.0	0.2	20.7	1.0	10.6	5.8	0.1	8.0	0.3	0.2
Amalgamated brand granular	10.0	0.2	36.2	0.1	1.3	4.8	3.1	4.1	0.4	1.0

- 25 It is apparent from Table 1 that the presently disclosed refined liquid sucrose product can include a significantly lower amount of potassium, magnesium, calcium, chloride, and sulfate ions compared to several commercially available sucrose products produced via crystallization.

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Having illustrated and described the principles of the disclosed methods and products with reference to several embodiments, it should be apparent that these methods and products may be modified in arrangement and detail without departing from such principles.

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What is claimed is:

1. A process for refining raw liquid sucrose, comprising:
 - 5 contacting raw liquid sucrose with at least activated carbon to produce a first liquid sucrose intermediate product;
 contacting the first liquid sucrose intermediate product with at least one strong base anion exchange resin and a weak acid cation exchange resin to produce a second liquid sucrose intermediate product; and
 - 10 contacting the second liquid sucrose intermediate product with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.
2. The process of claim 1, wherein the refined liquid sucrose product is produced without
15 crystallizing the raw liquid sucrose, the first liquid sucrose intermediate product, or the second liquid sucrose intermediate product.
3. The process of claim 1, further comprising selecting process conditions to substantially
20 minimize forming invert sugar.
4. The process of claim 1, wherein the refined liquid sucrose product includes an amount of
invert sugar that is higher than the amount of invert sugar in the raw liquid sucrose by not more
than about 1.0 weight %, based on the total dry solids content of the refined liquid sucrose
product.
- 25 5. The process of claim 1, wherein the contacting of the second liquid sucrose intermediate
product with at least one ion exchange resin does not include ion exchange chromatography.
6. The process of claim 1, wherein the contacting of the raw liquid sucrose with activated
30 carbon comprises passing the raw liquid sucrose through at least one activated carbon column at
a temperature of about 50°C to about 90°C.
7. The process of claim 1, wherein the second liquid sucrose intermediate product has an I.C.U.
of less than about 35, and an ash amount of less than about 0.03 weight %.
- 35 8. The process of claim 1, wherein the strong base anion exchange resin and the weak acid
cation exchange resin are each configured as a separate bed, and the first liquid sucrose

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intermediate product initially flows through at least one strong base anion exchange resin bed and subsequently through at least one weak acid cation exchange resin bed.

9. The process of claim 8, wherein the weak acid cation exchange resin comprises an H⁺ resin
5 that includes carboxyl ion exchange groups.

10. The process of claim 1, wherein the first liquid sucrose intermediate product flows through, in order, a first strong base anion exchange resin bed, a second strong base anion exchange resin bed, and a weak acid cation exchange resin bed.

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11. The process of claim 10, wherein the first strong base anion exchange resin bed temperature is about 30°C to about 80°C, the second strong base anion exchange resin bed temperature is about 30°C to about 80°C, and the weak acid cation exchange resin bed temperature is less than about 46°C.

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12. The process of claim 11, wherein the raw liquid sucrose is passed through a first activated carbon column, and the second liquid sucrose intermediate product is passed through a second activated carbon column.

20 13. A process for refining raw liquid sucrose, comprising:

contacting raw liquid sucrose with at least one media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product;

contacting the first intermediate liquid sucrose product with a strong base anion exchange resin and a weak acid cation exchange resin to produce a second intermediate liquid
25 sucrose product; and

passing the second intermediate liquid sucrose product through an activated carbon column resulting in a refined liquid sucrose product.

14. The process of claim 13, wherein the raw liquid sucrose is contacted with activated carbon.
30

15. The process of claim 13, wherein the second intermediate liquid sucrose product is passed through the activated carbon column at a column temperature of about 50°C to about 90°C.

16. A process for refining raw liquid sucrose, comprising:

35 contacting raw liquid sucrose with at least one media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product;

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contacting the first intermediate liquid sucrose product with a strong base anion exchange resin to produce a second intermediate liquid sucrose product;

contacting the second intermediate liquid sucrose product with a weak acid cation exchange resin at a temperature of less than 40°C to produce a third intermediate liquid sucrose product; and

contacting the third intermediate liquid sucrose product with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

17. The process of claim 16, further comprising selecting process conditions to substantially minimize forming invert sugar.

18. The process of claim 16, wherein the first intermediate liquid sucrose product is contacted with a strong base anion exchange resin bed at a bed temperature of about 30°C to about 80°C.

19. The process of claim 16, wherein the raw liquid sucrose is contacted with activated carbon and the third intermediate liquid product is contacted with activated carbon.

20. A process for refining raw liquid sucrose, comprising:

contacting raw liquid sucrose with at least one media selected from activated carbon or an ion exchange resin to produce a first intermediate liquid sucrose product;

contacting the first intermediate liquid sucrose product with a strong base anion exchange resin to produce a second intermediate liquid sucrose product;

contacting the second intermediate liquid sucrose product with a homogeneous weak acid cation exchange resin bed to produce a third intermediate liquid sucrose product; and

contacting the third intermediate liquid sucrose product with at least one sensory-enhancing material selected from activated carbon or an ion exchange resin resulting in a refined liquid sucrose product.

21. The process of claim 20, wherein the refined liquid sucrose product is produced without crystallizing the raw liquid sucrose, the first liquid sucrose intermediate product, the second liquid sucrose intermediate product, or the third intermediate liquid sucrose product.

22. The process of claim 20, wherein the refined liquid sucrose product includes an amount of invert sugar that is higher than the amount of invert sugar in the raw liquid sucrose by not more than 1.0 weight %, based on the total dry solids content of the refined liquid sucrose product.

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23. The process of claim 20, wherein the raw liquid sucrose is contacted with a first activated carbon column, and the third intermediate liquid sucrose product is contacted with a second activated carbon column.
- 5 24. The process of claim 8, wherein the strong base anion exchange resin bed and the weak acid cation exchange resin bed are provided in a single vessel configured with a split bed.
25. The process of claim 10, further comprising regenerating the first strong base exchange anion with a brine or caustic brine solution, regenerating the second strong base anion exchange
10 resin bed with an alkali solution, and regenerating the weak acid cation exchange resin bed with an aqueous mineral acid.
26. The process of claim 12, wherein the raw liquid sucrose is passed through the first activated carbon column at a temperature of about 50°C to about 90°C, and the second liquid sucrose
15 intermediate product is passed through the second activated carbon column temperature of about 50°C to about 90°C.
27. The process of claim 10, wherein the activated carbon removes about 50% to about 90% of the color in the raw liquid sucrose, and the first strong base exchange anion removes about 50%
20 to about 90% of the color in the first liquid sucrose intermediate product.
28. The process of claim 1, wherein the refined liquid sucrose product includes less than about 0.020 weight % ash, less than about 1 weight % invert sugar, and has an I.C.U. of less than about 35, the weight percents being based on the total dry solids content of the refined liquid sucrose
25 product.
29. The process of claim 1, wherein the refined liquid sucrose product includes less than about 0.015 weight % ash, less than about 0.5 weight % invert sugar, and has an I.C.U. of less than about 25, the weight percents being based on the total dry solids content of the refined liquid
30 sucrose product.
30. A refined liquid sucrose product produced according to claim 1, wherein the refined liquid sucrose product includes less than about 0.020 weight % ash, less than about 1 weight % invert sugar, and has an I.C.U. of less than about 35, the weight percents being based on the total dry
35 solids content of the refined liquid sucrose product.

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31. A refined liquid sucrose product produced according to claim 1, wherein the refined liquid sucrose product includes less than about 0.015 weight % ash, less than about 0.5 weight % invert sugar, and has an I.C.U. of less than about 25, the weight percents being based on the total dry solids content of the refined liquid sucrose product.

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32. A refined liquid sucrose product produced according to claim 20, wherein the refined liquid sucrose product includes less than about 0.020 weight % ash, less than about 1 weight % invert sugar, and has an I.C.U. of less than about 35, the weight percents being based on the total dry solids content of the refined liquid sucrose product.

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33. A refined liquid sucrose product that includes sucrose, less than about 5 mg/Kg (dry) magnesium ions, and less than about 10 mg/Kg (dry) total chloride and sulfate ions.

34. The refined liquid sucrose product of claim 33, wherein the refined liquid sucrose product includes less than about 0.020 weight % ash, less than about 1 weight % invert sugar, and has an I.C.U. of less than about 35, the weight percents being based on the total dry solids content of the refined liquid sucrose product.

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35. The refined liquid sucrose product of claim 33, wherein the product includes less than about 5 mg/Kg (dry) total chloride and sulfate ions.

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36. The process of claim 13, wherein the raw liquid sucrose is contacted with at least one strong base anion exchange resin, and is not contacted with activated carbon.

37. The process of claim 16, wherein the raw liquid sucrose is contacted with at least one strong base anion exchange resin, and is not contacted with activated carbon.

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38. The process of claim 20, wherein the raw liquid sucrose is contacted with at least one strong base anion exchange resin, and is not contacted with activated carbon.

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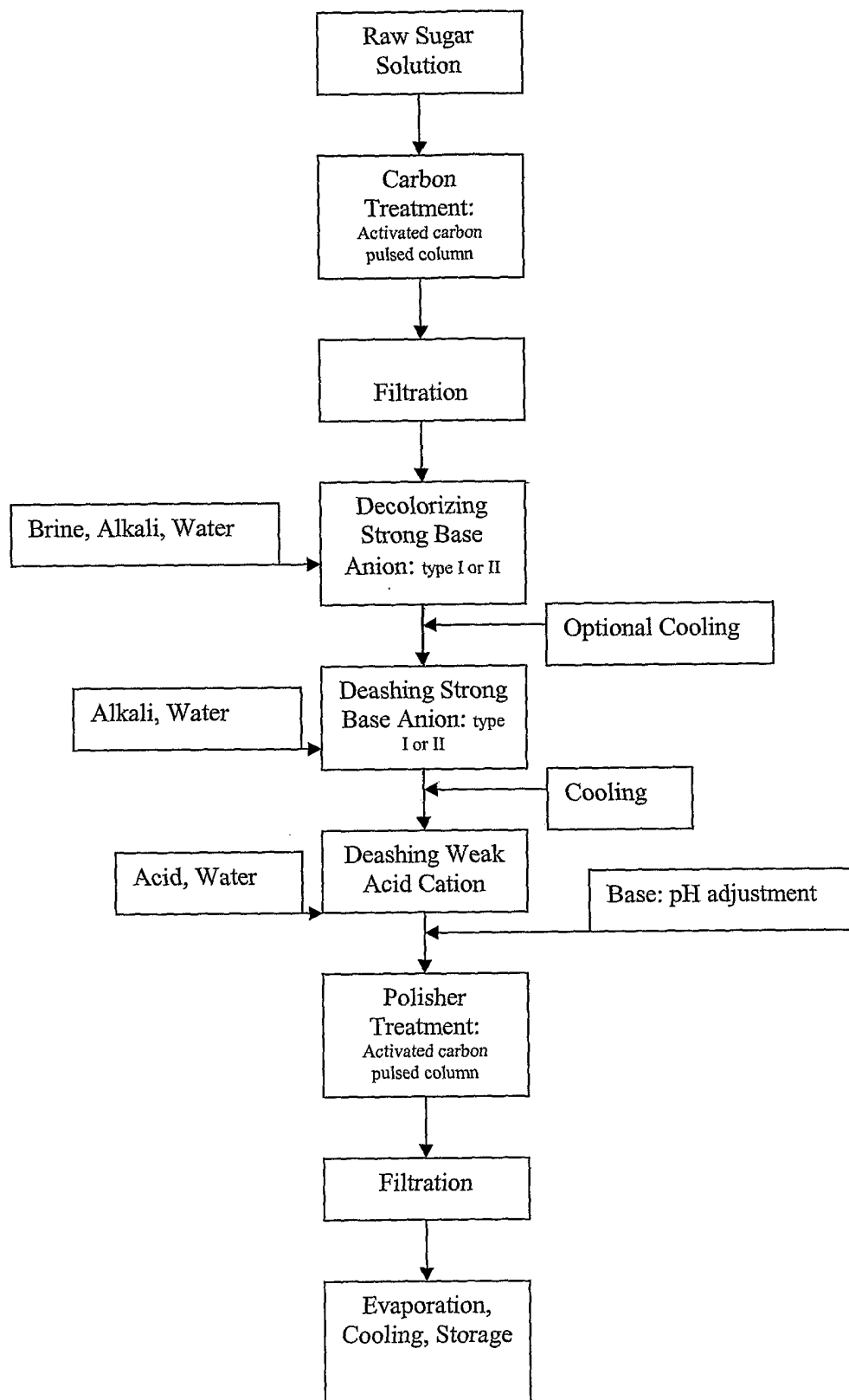


FIG. 1

INTERNATIONAL SEARCH REPORT

National Application No

PCT/US2004/018014

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 C13D3/12 C13D3/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 C13D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, FSTA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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