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High Fructose Corn Syrup

DEFINITION

High Fructose Corn Syrup is a clear aqueous solution of saccharides prepared from high-dextrose-equivalent corn starch hydrolysate by the partial enzymatic conversion of dextrose to fructose, using an insoluble glucose isomerase enzyme preparation that complies with 21 CFR 184.1372. It is available in two types, 42% and 55%, based on fructose as a proportion of total saccharides. High Fructose Corn Syrup 42% contains NLT 97.0% of total saccharides, expressed as a percentage of total solids, of which NLT 92.0% consists of monosaccharides, including 41.0%–50.0% of fructose, and NMT 8.0% consists of other saccharides. High Fructose Corn Syrup 55% contains NLT 95.0% of total saccharides, expressed as a percentage of total solids, of which NLT 94.0% consists of monosaccharides, including 54.0%–60.0% of fructose, and NMT 6.0% consists of other saccharides.

IDENTIFICATION

- A.**
Analysis: Add a few drops of a solution (1 in 10) of Syrup to 5 mL of hot, alkaline cupric tartrate TS.
Acceptance criteria: A copious, red precipitate of cuprous oxide is formed (distinction from sucrose).
- B.** It meets the requirements of the Assay.

ASSAY

- PROCEDURE**
Mobile phase: Water
Standard solution: Prepare a solution in water, which contains a total of 10% (w/v) saccharide solids, using [USP Dextrose RS](#), [USP Fructose RS](#), and [USP Maltose Monohydrate RS](#), in proportions that approximate, on the *Total Solids* basis, the composition of High Fructose Corn Syrup to be analyzed (see [Table 1](#)).

Table 1

Component	High Fructose Corn Syrup 42%	High Fructose Corn Syrup 55%
USP Fructose RS	4.2%	5.5%
USP Dextrose RS	5.0%	4.0%
USP Maltose Monohydrate RS	0.8%	0.5%

Sample solution: Dilute a known weight of Syrup, determined from the result of the test for *Total Solids*, with water to have 10% (w/v) solids.

Chromatographic system
(See [Chromatography \(621\)](#), [System Suitability](#).)

Mode: LC

Detector: Refractive index

Column: 7.8-mm × 30-cm; packing L19

Temperatures
Detector: 45°
Column: 85°

Flow rate: 0.6 mL/min

Injection volume: 10 µL

Run time: 20 min

System suitability

Sample: *Standard solution*

[NOTE—The relative retention times for maltose, dextrose, and fructose are about 0.83, 1.00, and 1.32, respectively.]

Suitability requirements

Resolution: NLT 1.5 between maltose and dextrose, and NLT 1.5 between dextrose and fructose

Relative standard deviation: NMT 1.0% for the fructose peak

Analysis

Samples: *Standard solution* and *Sample solution*

Inject a volume (about 10 µL) of the *Sample solution*, and measure all the peak areas. The elution pattern includes the higher degree of polymerized saccharides (DP4+), followed by tri-saccharides (DP3), maltose, dextrose, and fructose. The higher-molecular-weight polysaccharides containing more than 4 D-glucopyranosyl units can be integrated into one peak represented by the peak of DP4+.

[NOTE—The relative retention times for higher degrees of polymerized saccharides (DP4+), tri-saccharides (DP3), maltose, dextrose, and fructose are about 0.66, 0.74, 0.82, 1.00, and 1.32, respectively, from the *Sample solution*.]

Calculate the percentage of monosaccharides, P_{MS} , expressed in terms of fructose (P_F) and dextrose (P_D), in the total solid portion of

Syrup taken:

$$P_{MS} = P_F + P_D$$

$$P_F = (r_{FU}/r_{FS}) \times [C_{FS} \times V_U / (W_U \times 0.01 \times P_{Solid})] \times 100$$

$$P_D = (r_{DU}/r_{DS}) \times [C_{DS} \times V_U / (W_U \times 0.01 \times P_{Solid})] \times 100$$

r_{FU} = peak area of fructose from the *Sample solution*

r_{FS} = peak area of fructose from the *Standard solution*

C_{FS} = concentration of [USP Fructose RS](#) in the *Standard solution* (mg/mL)

V_U = volume of the *Sample solution* (mL)

W_U = weight of Syrup taken to prepare the *Sample solution* (mg)

P_{Solid} = percentage of total solids in the Syrup as determined in the test for *Total Solids*

r_{DU} = peak area of dextrose from the *Sample solution*

r_{DS} = peak area of dextrose from the *Standard solution*

C_{DS} = concentration of [USP Dextrose RS](#) in the *Standard solution* (mg/mL)

Calculate the percentage of other saccharides, P_{OS} , expressed in terms of maltose (P_{DP2}), tri-saccharides (DP3) (P_{DP3}), and higher degree of polymerized saccharides (DP4+) (P_{DP4+}), in the total solid portion of Syrup taken:

$$P_{OS} = P_{DP2} + P_{DP3} + P_{DP4+} = [(r_{U1} + r_{U2} + r_{U3})/r_S] \times [C_S \times V_U / (W_U \times 0.01 \times P_{Solid})] \times 100$$

r_{U1} = peak area of maltose from the *Sample solution*

r_{U2} = peak area of tri-saccharides (DP3) from the *Sample solution*

r_{U3} = peak area of higher degree of polymerized saccharides (DP4+) from the *Sample solution*

r_S = peak area of maltose from the *Standard solution*

C_S = concentration of [USP Maltose Monohydrate RS](#) in the *Standard solution* (mg/mL)

V_U = volume of the *Sample solution* (mL)

W_U = weight of Syrup taken to prepare the *Sample solution* (mg)

P_{Solid} = percentage of total solids in the Syrup as determined in the test for *Total Solids*

Calculate the percentage of total saccharides, P_{TS} , expressed as a percentage of total solids:



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$$P_{TS} = P_{MS} + P_{OS}$$

Calculate the percentage of monosaccharides in total saccharides:

$$\text{Result} = (P_{MS}/P_{TS}) \times 100$$

Calculate the percentage of fructose in total saccharides:

$$\text{Result} = (P_F/P_{TS}) \times 100$$

Calculate the percentage of other saccharides in total saccharides:

$$\text{Result} = (P_{OS}/P_{TS}) \times 100$$

Acceptance criteria

For High Fructose Corn Syrup 42%

Total saccharides: NLT 97.0%, expressed as a percentage of total solids. Total saccharides contain monosaccharides and other saccharides as follows.

Monosaccharides: NLT 92.0%

Fructose: 41.0%–50.0%

Other saccharides: NMT 8.0%

For High Fructose Corn Syrup 55%

Total saccharides: NLT 95.0%, expressed as a percentage of total solids. Total saccharides contain monosaccharides and other saccharides as follows.

Monosaccharides: NLT 94.0%

Fructose: 54.0%–60.0%

Other saccharides: NMT 6.0%

IMPURITIES

• **RESIDUE ON IGNITION (281):** NMT 0.05%

• **LIMIT OF LEAD**

[NOTE—For the preparation of all aqueous solutions and for the rinsing of glassware before use, use water that has been passed through a strong-acid, strong-base, mixed-bed ion-exchange resin. For digestion, use acid-cleaned, high-density polyethylene, polypropylene, polytetrafluoroethylene, or quartz tubes. Select all reagents to have as low a content of lead as practicable, and store all reagent solutions in borosilicate glass containers. Cleanse glassware before use by soaking in warm 8 N nitric acid for 30 min and rinsing with deionized water. Store final diluted solutions in acid-cleaned plastic or polytetrafluoroethylene tubes or bottles.]

Matrix modifier solution: 200 mg/mL of magnesium nitrate. Just before use, transfer 1.0 mL of this solution to a 10-mL volumetric flask, and dilute with 5% nitric acid to volume.

Alternate matrix modifier solution: Just before use, add 0.3 mL of commercially available 10,000 µg/mL palladium standard solution and 5 mL of commercially available 10,000 µg/mL magnesium nitrate standard solution to 9.7 mL of 5% nitric acid, and mix well. [NOTE—*Alternate matrix modifier solution* can be used to replace the *Matrix modifier solution*. Then the air ashing step in the furnace program (see [Table 2](#)) can be omitted.]

Standard stock solution: Transfer 10.0 mL of lead nitrate stock solution TS to a 100-mL volumetric flask, add 40 mL of water and 5 mL of nitric acid, and dilute with water to volume. Transfer 1.0 mL of this solution to a second 100-mL volumetric flask, dilute with 5% nitric acid to volume, and mix. This solution contains 0.1 µg/mL of lead.

Standard solutions: Transfer portions of *Standard stock solution* to four suitable containers, and dilute with 5% nitric acid to obtain *Standard solutions* having lead concentrations of 100, 50, 25, and 10 ng/mL, respectively.

Sample solution: [NOTE—It is recommended to perform this procedure in a fume hood. To ensure that a representative subsample of Syrup is used for analysis, ultrasonic and/or vortex mixing of Syrup samples prior to weighing is recommended.] Transfer 1.5 g of Syrup to two digestion tubes, labeled “Sample solution” and “Temperature monitor solution,” and add 0.75 mL of nitric acid to each tube. Place a thermometer in the tube labeled “Temperature monitor solution,” then use the *Temperature monitor solution* solely to monitor the temperature to be within ranges specified by the method. Warm both solutions slowly to 90°–95° to avoid spattering. Heat until all brown vapors have dissipated and the samples no longer have a rust-colored tint. This typically takes 20–30 min. Allow the samples to cool. Add 0.5 mL of 50% hydrogen peroxide dropwise to both solutions, heat to 90°–95° for 5 min, and cool. Add a second 0.5-mL portion of 50% hydrogen peroxide dropwise to both solutions, and heat to 90°–100° for 5–10 min or until the solutions are clear. Cool, and transfer the *Sample solution* to a 10-mL volumetric flask. Rinse the tube labeled “Sample solution” with 5% nitric acid, add the rinsing to the volumetric flask, dilute with 5% nitric acid to volume, and mix.

Standard blank: 5% Nitric acid