Method 8.6 – Refined sugar: turbidity at 720 nm

1. Rationale

This method is applicable to all refined and white sugars and is to determine the turbidity in a refined sugar solution.

2. Principle

The sugar is dissolved in distilled water and the pH of the solution adjusted to 7.00 ± 0.02. The turbidity is calculated from the absorbance of the solution at 720 nm.

3. Definitions

3.1 Transmittance of a solution

If I_1 represents the radiant energy incident upon the first surface of the solution, and I_2 represents the radiant energy leaving the second surface of the solution. Then:

$$T = \frac{I_2}{I_1} = \text{transmittance of the solution}$$

and $100 \times T$ = percentage transmittance

3.2 Transmittancy

Let T_{soln} represent the transmittance of a cell containing the solution and let T_{solv} represent the transmittance of the same cell containing the pure solvent. Then:

$$T_s = \frac{T_{soln}}{T_{solv}} = \text{transmittancy of the solution}$$

3.3 Absorbancy (extinction) measured in absorbance units (AU)

$$A_s = -\log_{10} T_s = \text{absorbancy of the solution}$$

3.4 Absorbancy index (extinction index)

Let b represent the length (mm) of the absorbing path between the boundary layers of the solution and let c represent the concentration (g/cm^3) of the sugar solution. Then:

$$A_i = \frac{A_s}{bc} = \text{absorbancy index of the solution.}$$

3.5 ICUMSA Colour

The value of the absorbancy index multiplied by 10 000 is reported as the ICUMSA Colour of the solution and the resulting value is expressed in ICUMSA Units (IU). The wavelength of 720 nm has to be specified with the results.

4. Apparatus

4.1 **Spectrophotometer** capable of light transmission measurements at a wavelength of 420 nm with the narrowest practical bandwidth, *e.g.* ± 10 nm

4.2 Optical glass cell: 50 mm

4.3 Membrane filters: cellulose nitrate filters, 0.45 µm pore size, 50 or 47 mm ϕ

4.4 Buchner funnel or magnetic vacuum filtration funnel: 50 - 65 mm ϕ

4.5 Buchner flask and rubber bung: 500 cm^3

4.6 pH meter capable of measuring to 0.01 units

4.7 Refractometer operating at 20.0 ± 0.1°C

4.8 Magnetic stirrer with stirrer bar

4.9 Laboratory balance readable to 0.01 g

4.10 Beakers: 100, 250 and 1 000 cm^3

4.11 Measuring cylinder: 100 cm^3

4.12 Volumetric flasks: 2 × 200, 2 × 1 000 cm^3

4.13 Pipettes: 2 × 10 cm^3

5. Reagents

5.1 Hydrochloric acid solution (1 M)

Hydrochloric acid (HCl, 32%) is a corrosive acid and contact with the skin, eyes and through inhalation must be avoided. Work in a fume cupboard while wearing gloves and safety glasses.

Measure 98 cm^3 concentrated hydrochloric acid and add to approximately 700 cm^3 distilled water in a beaker. Always add the acid to the water and not the other way around. This acid dilution is exothermic and the solution will therefore heat. Allow the solution to cool down, transfer to a 1 000 cm^3 volumetric flask and make to the mark.

5.2 Hydrochloric acid solution (0.05 M)

Pipette 10 cm^3 of the 1 M hydrochloric acid solution into a 200 cm^3 volumetric flask and make to the mark with distilled water.

5.3 Sodium hydroxide solution (1 M)

Sodium hydroxide (NaOH) is a corrosive base and contact with the skin and eyes should be avoided. Wear gloves and safety glasses during use.

Weigh 40.0 g sodium hydroxide pellets and dissolve in some distilled water. This dissolution is exothermic and the solution will therefore heat. Allow the solution to cool and dilute to 1000 cm^3 in a volumetric flask.

5.4 Sodium hydroxide solution (0.05 M)

Pipette 10 cm^3 of the 1 M sodium hydroxide solution into a 200 cm^3 volumetric flask and make to the mark with distilled water.

6. Procedure

6.1 Calibration of pH meter

Following the manufacturer's directions, calibrate the pH meter using the 4.00 and 7.00 pH buffer solutions (compensated for a temperature different from 20°C) while stirring at a constant rate. Calibrations should be done at the beginning of each day or shift using fresh buffer solutions only. The buffer solutions should be at room temperature.

6.2 Sample analysis

Mix the sample of sugar thoroughly. Weigh 30.00 ± 0.02 g of the sugar into a 250 cm^3 beaker. Add 70 cm^3 of distilled water and dissolve using a magnetic stirrer and follower. Filter the solution through a 0.45 μm cellulose nitrate membrane under vacuum into a clean, dry Buchner flask.

If the pH of the solutions are to be adjusted to 7.00 ± 0.02 transfer each solution to a 100 cm^3 beaker. Stir the solution on the magnetic stirrer and adjust the pH of the solution to 7.00 ± 0.02 using either hydrochloric acid (0.05 M) to bring the pH down or sodium hydroxide (0.05 M) to bring the pH up. Allow ample time for the pH reading to stabilize (1 minute).

Measure the absorbance of the solutions in a 50 mm cell using the spectrophotometer at 720 nm against distilled water as a reference. Also measure the Brix of the solutions.

7. Calculations

Use the Brix reading at 20.0°C to obtain the concentration of total solids in g/cm^3 using the formula indicated below.

$$\text{Total solids } (g/cm^3) = \frac{Brix \times (a + b \times Brix + c \times Brix^2 + d \times Brix^3 + e \times Brix^4)}{100}$$

where a = 0.9971843
b = 3.85738×10^{-3}
c = 1.254916×10^{-5}
d = 8.125659×10^{-8}
e = 5.611455×10^{-10}

$$\text{ICUMSA 420 Colour} = \frac{A_s \times 10\,000}{bc}$$

where A_s ≡ absorbance at 420 nm (AU)
b ≡ cell length (mm)
c ≡ concentration of total solids (g/cm^3)

Report results in ICUMSA Units (IU) to the nearest 10 units.

8. Example

Obtain the concentration of total solids in g/cm^3 from the Brix reading at 20.0°C using the equation in 7.

Brix at 20.0°C = 31.1°Bx
Concentration of total solids = 0.352 g/cm^3

Absorbance at 720 nm = 0.002 AU

ICUMSA 420 colour = $\frac{0.002\ \text{AU} \times 10\,000}{50\ \text{mm} \times 0.352\ \text{g/cm}^3}$

= 1.14 IU

Report as 1 IU

9. References

SMRI (1997). Determination of the turbidity at 720 nm of white sugar in solution. *SMRI Test Methods,* TM026.