Method 8.1 – Refined sugar: pol

1. Rationale

The method is used in statutory analyses and is applicable to white sugar and other white refined products of low colour and turbidity which does not need filtration prior to analysis and has a moisture content of not more than 0.1%. A wavelength in the visible (589 nm) or in the NIR (*e.g.* 882 nm) range may be used.

2. Principle

The pol (polarisation) of a solution is defined as the concentration (in grams of solute per 100 g of solution) of a solution of pure sucrose in water having the same optical rotation as the sample at a specified temperature. For solutions containing only pure sucrose in water, pol is a measure of the concentration of sucrose present; for solutions containing sucrose and other optically active substances, pol represents the sum of the rotations of the constituents present and is therefore referred to as "apparent sucrose". In cane sugar, the contribution of sucrose to this sum far exceeds that of other constituents. Pol is expressed in °Z according to the International Sugar Scale. It is recommended that the measurement be made at 20.0 ± 0.1°C.

3. Apparatus

3.1 **Polarimeter/saccharimeter** calibrated in sugar degrees (°Z) with a visible light source at *ca.* 589 nm or a near infrared (NIR) light source at *ca.* 882 nm

3.2 **Polarising tube**: 200 mm

The tube should either be connected electronically to the polarimeter *via* a temperature sensor or be jacketed and connected with tubes to a thermostatically-controlled water bath to maintain a solution temperature of 20.0 ± 0.1°C during measurement.

3.3 **Quartz control plate**: ± 100°Z, officially certified at 20.0 ± 0.5°C to two decimal places

3.4 **Analytical balance** readable to 0.0001 g

3.5 **Pol dish**: stainless steel

3.6 **Pol flasks** (calibrated): 100 cm^3

3.7 **Water baths** (optional)

If the polarising tube is not equipped with a temperature sensor a thermostatically controlled circulating water bath connected to the tube and maintained at 20.0 ± 0.1°C is absolutely necessary.

If the polarising tube is not equipped with a temperature sensor a sample water bath at 20.0 ± 0.1°C is also needed.

4. Procedure

4.1 Preparation of the sample solution

- Weigh 26.0000 ± 0.0002 g of the sugar as rapidly as possible accurately in a pol dish.
- Transfer the sugar to a 100 cm^3 calibrated pol flask by washing with distilled water to a volume not exceeding 70 cm^3 and dissolve the sugar by swirling.
- Add distilled water until the bulb of the flask is full and mix by gentle swirling. (If the polarising tube is not equipped with a temperature sensor adjust the temperature of the sugar solution to 20.0°C by standing the flask in the water bath for at least 30 minutes. Include a beaker with distilled water.)
- Dry the inside wall of the neck of the flask with rolled filter paper.
- Using a dropper or Pasteur pipette, make the solution to the mark with the 20.0 ± 0.1°C distilled water against a well-lit background.
- Remove any further drops from the neck of the flask.
- Mix the flask contents thoroughly.

4.2 Preparation of the polarimeter

4.2.1 Quartz plate

- Zero the polarimeter on air with the cell compartment empty.
- Record the reading of the quartz plate.
- When using a **saccharimeter** no temperature measurement is needed. The difference between the quartz plate reading and the certified quartz plate value must be subtracted from any subsequent sample readings.
- When using a **polarimeter** where the quartz plate is not equipped with a temperature sensor and the temperature of the quartz plate is other than 20.0 ± 0.5°C, a temperature correction must be applied using Equations 1a or 1b.

At 589 nm (visible):

$$Q_R = Q_T - 0.000144 \times (T-20) \times Q_{20} \qquad \text{(Equation 1a)}$$

At 882 nm (NIR):

$$Q_R = Q_T - 0.000139 \times (T-20) \times Q_{20} \qquad \text{(Equation 1b)}$$

where $T \equiv$ temperature of the quartz plate in °C
$Q_T \equiv$ quartz plate reading at temperature T
$Q_R \equiv$ quartz plate reading corrected to 20.0°C
$Q_{20} \equiv$ certified quartz plate value at 20.0°C

- Calibrate the **polarimeter** to show the correct adjusted value for the quartz plate.

4.2.2 Polarising tube

- Determine the optical rotation of the polarising tube by filling it with distilled water (at 20.0 ± 0.1°C if the polarising tube is not equipped with a temperature sensor). If the reading is not 00.00°Z do the following:
  - clean the polarising tube
  - adjust the side glass ends, or
  - correct the final reading by subtracting the water blank reading.

4.3 Reading of the sample

- Pour the filtrate into the polarising tube using three portions to ensure complete displacement of the previous solution in the tube.
- Record the reading once it stabilizes.
- Record the temperature of the filtrate if the polarising tube is not equipped with a temperature sensor.

5. Calculations

The pol of the sugar is the polarisation reading to the nearest ± 0.01°Z at 20.0 ± 0.1°C corrected for the water blank and the quartz plate difference when using a saccharimeter. If the temperature of the sample is other than 20.0 ± 0.1°C correct the reading for the effect of this temperature according to Equations 2a or 2b.

At 589 nm (visible):

$$P_{20} = \frac{\text{pol reading}}{1 - 0.000455 \times (T - 20.0)} \qquad \text{(Equation 2a)}$$

At 882 nm (NIR):

$$P_{20} = \frac{\text{pol reading}}{1 - 0.000474 \times (T - 20.0)} \qquad \text{(Equation 2b)}$$

where P_{20} ≡ polarisation reading at 20.0°C
T ≡ temperature of solution in °C
P_T ≡ corrected polarisation reading at temperature T

The value is finally adjusted for the pol flask calibrated volume using Equation 3.

$$\text{Pol (°Z)} = P_{20} - (100 - \text{pol flask volume})\ \text{cm}^3 \qquad \text{(Equation 3)}$$

where P_{20} ≡ polarisation reading (°Z) at 20.0°C

Report results in °Z to two decimal places.

6. Example

When using a polarimeter at 882 nm:

Instrument reading on air	=	0.00°Z	
Quartz plate value at 20.0°C	=	99.97°Z	(certified)
Quartz plate reading	=	100.00°Z	
Quartz plate temperature	=	23.1°C	
Quartz plate at 20.0°C	=	99.96°Z	(Equation 1b)
Quartz plate difference	=	-0.01°Z	

The instrument therefore needs to be calibrated to show the correct quartz plate reading.

Water blank	=	0.00°Z	
Polarimeter reading	=	99.83°Z	
Solution temperature	=	22.7°C	
Pol value at 20.0°C	=	99.96°Z	(Equation 2b)
Calibrated pol flask volume	=	100.03 cm³	
Final pol	=	99.99°Z	(Equation 3)

7. Precision

The tolerance associated with the analysis is ± 0.05°Z.

8. References

ICUMSA (2002). Polarisation of white sugar. *ICUMSA Methods Book*, GS2/3-1.

Mellet P (1987). Laboratory control procedures for South African sugar factories. *SMRI Technical Note,* No. 1473.

Natbev Coca-Cola (2004). *Sugar Analytical Procedures*.

SMRI (2004). Determination of the polarisation (pol) of white sugar. *SMRI Test Methods*, TM046.

van Staden LF, Naidu C and Simpson R (1999). Updated methods and recommendations for mill laboratories. *SMRI Technical Note,* No. 1817.