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Viscosity of starch and starch products

1. Scope

1.1 This method is for measuring the viscosity (consistency) of starch suspensions or solutions by means of an instrument which automatically records the viscosity characteristics while the starch suspension is cooked through a controlled heating cycle and cooled through a controlled cooling cycle. In addition, viscosity stability, breakdown, and characteristics of the cooled past (setback) can be determined while holding the cooked starch for extended periods at high or low temperatures, respectively.

1.2 This method is applicable to unmodified starches and to modified types (oxidized and thin-boiling) and starch derivatives from cereal grains and tubers.

2. Summary

The instrument used for this determination employs a rotating cup in an air bath, driven at constant speed by a synchronous motor. A circular metal disc with several metal pins projecting vertically downward into the cup serves as the sensing element. Rotation of a starch suspension in the cup exerts a force on the sensing element which is dynamically balanced by a calibrated torsion spring. Application of this restoring force is accompanied by an angular deflection of the sensing element shaft, and this deflection is recorded continuously in torque units of cm-g on a strip-chart recorder during testing.

3. Apparatus

3.1 *Viscometer*¹ (Fig. 1), consisting of a variable speed instrument permitting measuring and recording apparent viscosity in Brabender units (B. U.) at fixed or constantly varying temperatures between 20° and 97°C (68° and 206°F). A Brabender unit is expressed in cm-g. Under the conditions specified, 1 cm-g is equivalent to 2.93 centipoises (2.93 mN • s/m²).

¹Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

NOTE 1: Instrument range can be extended by the use of zero point suppression weights and by substitution of interchangeable sensitivity cartridges (Table 1).

Table 1. Starch data

<i>Kind of starch</i>	<i>Concentration of starch, g d. b./500 g suspension</i>	<i>Approximate maximum viscosity^a, Brabender units</i>
Corn		
Unmodified	35	500-600
Moderately thin boiling	45	400-500
Thin boiling	55	300-400
Very thin boiling	160	400-500
Wheat, unmodified	45	300-400
Tapioca, unmodified	30	700-800
Potato, unmodified	15	600-700

^amaximum viscosity is peak viscosity reached in cooking cycle. No supplementary weights are added. Sensitivity cartridge 700 cm-g.

NOTE 2: Instrument parts and accessories are identified in Fig. 1. Specimen temperature control is accomplished with a heating element and cooling controlled by a mechanical thermoregulator. Temperature can be maintained at any predetermined level from 20° to 97°C, or it can be programmed to increase or decrease at a rate of 1.5°C per minute in this range.

NOTE 3: Shear force can be altered by changing cups and sensing elements (stirrers) (pin style - low shear; paddle style - high shear). Shear rate on the variable speed models can be altered by changing rotation speed of the cup. Special cups are available for high temperature applications.

3.2 pH meter, a direct reading pH meter equipped with glass and calomel reference electrodes and a temperature compensator is recommended.

3.3 Drying oven, forced circulation type, operating at $105 \pm 3^\circ\text{C}$ ($221 \pm 6^\circ\text{F}$).

3.4 Miscellaneous glassware: beakers, 600 mL; graduated cylinder, 500 mL.

4. Calibration

4.1 *Instrument preparation.* Assemble, operate, and maintain the instrument as directed in the manufacturer's detailed instruction manual. Adjust the thermoregulator to 25°C and place the temperature program control level in the "UP" position. Place the 700-cm-g sensitivity cartridge in position and adjust so that the indicator pen rests on zero on the strip chart. Set the timer switch at 45 min. Set the "COOLING" control switch in the center or "OFF" position and place the solenoid-controlled cooling probe in the "DOWN" position. The water-cooled sample cover is made inoperative by placing a clamp on the input hose. No weights are added to the zero suppression device.

4.2 *Calibration.* Weigh 40 ± 0.003 g of the calibration starch (obtainable from the instrument manufacturer) and transfer quantitatively to a 600-mL beaker. Weigh 420 ± 0.5 g of distilled water into another beaker. Add about one-half of the water to the starch sample and mix thoroughly to obtain a homogeneous suspension. Pour suspension into cup of viscometer. Rinse beaker with remaining water and add washings to suspension. Turn on the instrument.

4.3 At the end of the 45-min heating period (92.5°C), switch the thermoregulator program control lever to the center or "NEUTRAL" position, and reset the timer for 15 min. The calibration run is complete at the end of this period.

4.4 The maximum observed viscosity obtained during the heating portion of the calibration run should agree within ± 20 chart units of peak viscosity shown on the viscosity curve supplied with the calibration starch. If it does not, loosen the two Allen set screws on the chuck attached to the center shaft, and raise or lower the chuck to decrease or increase, respectively, the indicated viscosity. Tighten the set screws and reanalyze the calibration