

REFRACTIVE INDEX

PRINCIPLE

The index of refraction of a substance is the ratio of the velocity of light in a vacuum to its velocity in the substance. This, in turn, is dependent on composition, concentration (e.g. dry substance) and temperature of the substance. When solids composition and temperature are known, index of refraction is a measure of dry substance (Note 1).

SCOPE

The method is applicable to corn syrup (including those containing high fructose), maltodextrin solutions, dextrose and sucrose solutions, invert sugar and blends.

SPECIAL APPARATUS

1. Refractometer: An instrument is necessary with a range of indices from 1.32 or lower to 1.53 or higher, accurate to 0.0001 unit. It should be so constructed that samples can be introduced with ease and speed, and the instrument should be easily cleaned.

Follow the manufacturer's instructions for use of the particular instrument. Standardize using purified water and the test block supplied with the instrument; calibration with the test block or immersion (calibration) oil must be performed at the temperature specified by the supplier.

2. Water Bath: Operate at a temperature of 20° C or 45° C. It should be sufficient in size to allow circulation of water, by means of a pump, through the refractometer so that the refractometer temperature, especially the prism faces, is controlled within $\pm 0.2^\circ$ C of that prescribed for the bath (Note 2). Certain instruments with automatic temperature control may not need water baths.
3. Light Source: Frosted incandescent bulb.

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Dilute syrups are best applied with a dropper, while concentrated syrups are handled most conveniently with a fire-polished glass rod. After water bath and refractometer have reached the prescribed temperature, apply sample to the prism face, and close the prism in minimum time possible, so as to avoid sample concentration change (Note 3). Examine the optical field through refractometer observation lens; if the light and dark fields are not separated by a sharp line, remove the sample, clean and dry the prism faces, and apply a fresh sample. Read the index, estimating to the nearest 0.0001 unit, as soon as temperature equilibrium is indicated by constant readings (not more than 3 minutes) (Note 4). Prior to applying any sample, rinse the prism faces with purified water at the bath temperature (20° C or 45° C), to facilitate temperature equilibration.

CALCULATIONS

If desired, obtain the percent dry substance of the sample by referencing the CRA RI-DS calculation program located at <http://corn.org/rids.htm>.

NOTES AND PRECAUTIONS

1. The RI-DS tables on the CRA website relate refractive index to dry substance for commercial corn syrups, high fructose corn syrups and selected blends. They were developed based on investigations by Augustana Research Foundation (Rock Island, Illinois), with the financial support of the Corn Refiners Association, Inc. See: Anna M. Wartman, Caroline Hagberg and Morton A. Eliason, *Journal of Chemical Engineering Data*, Vol. 25, No. 3, July 1980, pages 277-282. See also: Frank A. Kurtz and Morton A. Eliason, *Journal of Chemical and Engineering Data*, Vol. 24, No. 1, January 1979, pages 44-45. Tables relating refractive index and concentration for pure dextrose solution have been reported by F. W. Zerban and M. Martin, *Journal of the Association of Official Agricultural Chemists*, Vol. 27, 1944, page 295. Similar data for solutions of pure fructose, pure maltose and pure sucrose are given in the following articles: U. S. Department of Commerce, National Bureau of Standards, Circular No. C440, Table 129, R.C. Weast, *Handbook of Chemistry and Physics*, 53rd Edition, Chemical Rubber Company, Cleveland, Ohio, 1972, page D-196; and *International Sugar Journal*, Vol. 39, 1937, page 225.

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2. If the refractometer temperature is lower than room temperature, there is a tendency for the prism to fog, especially at high relative humidities. Also, thick viscous syrups present difficulties which are best overcome at higher temperatures where their viscosities are sharply decreased.

Hose connections between the water bath and refractometer must be the shortest length possible to avoid temperature differences. Hose insulation is recommended. A 1° C temperature discrepancy corresponds to a dry substance discrepancy of about 0.1%.

3. For accurate measurements, particularly with warm samples, speed in application of the sample and closing the prism is imperative. No more than 2-3 seconds should be consumed in this operation. Also, water used to rinse the prism faces should be at the measuring temperature specified.
4. When analyzing freshly prepared solutions of crystalline sugars, mutarefracton equilibrium must be attained before accurate refractive index values can be obtained. Equilibration can be hastened by heating and is obtained when the optical rotation stabilizes. In addition, solutions of pure sugars, and syrups exhibiting a crystallization tendency, must be completely free of all crystalline materials because they prohibit accurate refractive index measurement.
5. The refractive index/dry substance relationship will vary with composition. A computer program, RI-DS, which will produce tables based upon user-supplied saccharide compositions, is available on the Corn Refiners Association, Inc. website <http://corn.org/rids.htm>. Tables suited for the needs of particular end-users of these products may be produced, e.g., tables contained in Quality Guidelines and Analytical Procedures Bibliography for "Bottlers" High Fructose Corn Syrup 42 and 55, International Society of Beverage Technologists (www.bevtech.org). For discussion of the mathematical models necessary for construction of tables for products of different composition, see J. Chem. Eng. Data, No. 1, January 1979, pp. 44-45, J. Chem. Eng. Data, Vol. 25, No. 3, July 1980, pp. 277-282 and J. Agr. Food Chem., Vol. 32, 1984, pp. 974-979.

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