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MEASUREMENT OF VISCOSITY AND SUCROSE CONCENTRATION IN AQUEOUS SOLUTION USING PORTABLE BRIX METER

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Abstract

The viscosity of aqueous sucrose solution in various concentrations and the sugar content were measured by using an Ostwald viscometer and a commercial available of portable Brix meter respectively. The increasing of the concentration of sucrose would also followed by increasing viscosity of the solution. Depending on their concentration, the measured value of viscosity of solution would be automatically confirmed into the desired concentration unit. The suitability of Brix meter for other application will be checked.

Keywords: viscosity, sucrose, Brix meter, solution concentration.

Abstrak

Viskositas larutan sukrosa air di berbagai konsentrasi dan kadar gula diukur dengan menggunakan viskometer Ostwald dan Brix meter portabel komersial. Hasil penelitian menunjukkan peningkatan konsentrasi sukrosa juga akan diikuti oleh peningkatan viskositas larutan. Nilai viskositas yang diukur bergantung pada konsentrasi larutan dan akan dikonfirmasikan secara otomatis ke dalam unit konsentrasi yang diinginkan. Kesesuaian meter Brix untuk aplikasi lainnya akan diperiksa.

Kata kunci: viskositas, sukrosa, Brix meter, konsentrasi larutan.

1. INTRODUCTION

Viscosity is a fundamental characteristic property of all liquid. Viscosity of aqueous electrolyte solutions is of considerable interest due to its importance in both natural and industrial processes. When a liquid flows, it has an internal resistance to flow. The viscosity depends on temperature, pressure and the type and composition of the material. The measurement of viscosity is significant importance in both industry and academia. Accurate knowledge of viscosity is necessary for various industrial processes. In industry, viscosity allows distinguish directly the quality of the final product such as lubricating oils, fuels, inks, paints**,** and so on. Another importance of viscosity in industry is to control the progress of physicochemical reactions during manufacturing. In the food processing, knowing the viscosity of the product is beneficial in that viscosity indicates consistency, pour-ability, concentration, and firmness to define product quality. In petroleum, all the range possibilities make the vibrating viscometers as efficient on light fuels as on bitumen [1].

The viscosity depends on temperature, pressure and the type and composition of the material. It may also depend on the shear rate and can change with time by the process of flow itself. For special systems the viscosity is influenced by external electrical fields [2]. Commonly, viscosity is measured by the viscosity apparatus directly. The relationship between concentration of sucrose solution and its viscosity will be shown at the figure 1. The data of viscosity is taken from the references [3]. Increasing of concentration will influence on viscosity. From the relationship, if we know the concentration of solution, we can know its viscosity.

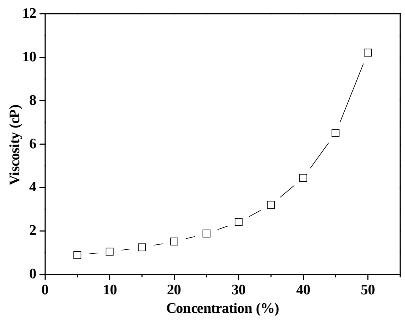


Figure 1. Viscosity of sucrose aqueous solution at 30^0C [3].

There are several types of viscometers classified into seven categories by their measurement principle as follows [4]: capillary, orifice, high temperature, rotational, falling-ball, vibrational, and ultrasonic viscometer. The vibration-type viscometer, the working principle is based on the vibration, either torsion, either translation, at resonance or controlled frequency of a module immerged in a liquid. The falling-ball viscometer, the working principle is based on measure of the time of the fell of a module placed in a vertical tube which contained a sample [1].

Capillary viscometer is most widely used for measuring viscosity. A common type of this capillary is called the "Ostwald" (shown at figure 2) with simple in operation, require a small volume of sample liquid, temperature control is simple and inexpensive. In capillary viscometer, viscosity is measured noting the time required for a known volume of liquid to flow through a small capillary between two marked lines.

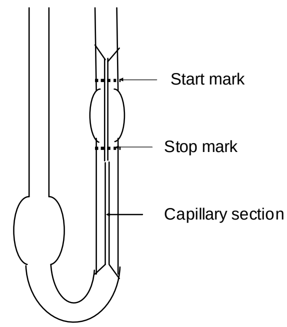


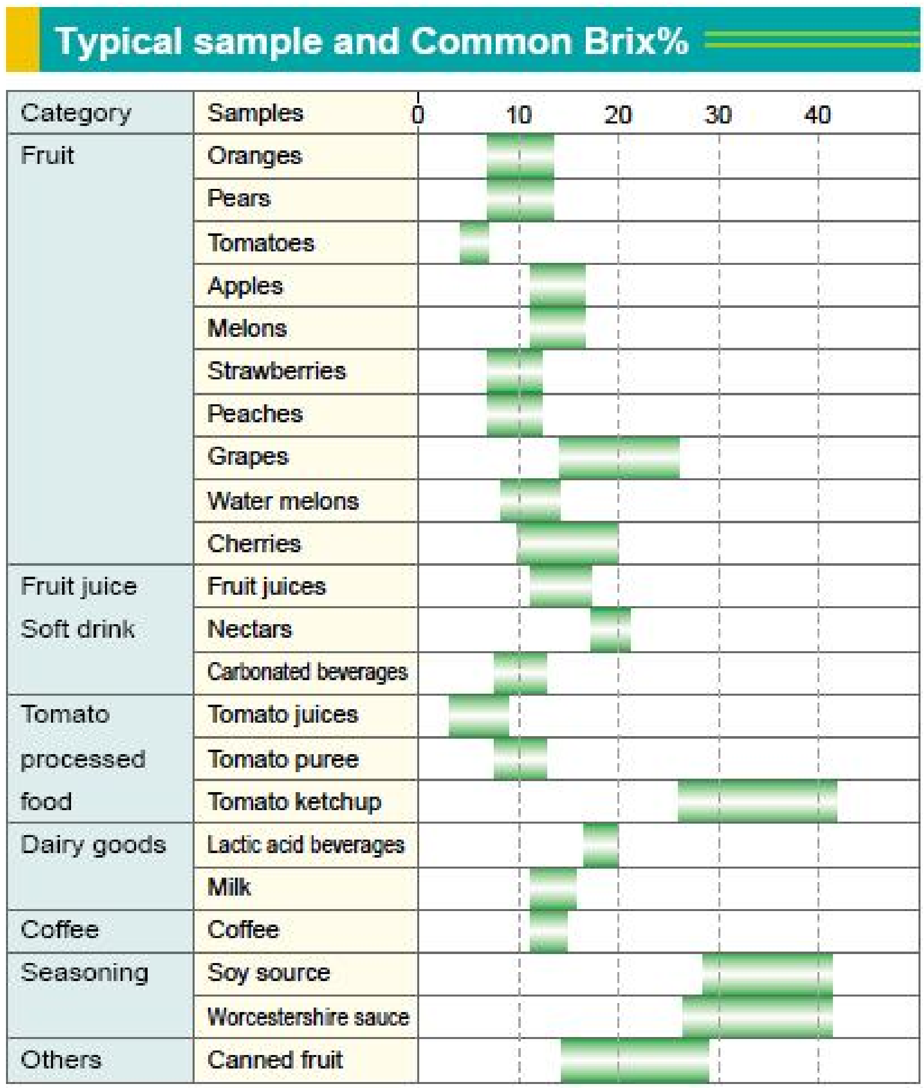
Figure 2. Ostwald viscometer

Refractive index of a medium or a solution is a very important characteristic parameter and some associated parameters such as temperature, concentration, viscosity, etc., may be estimated from it. Those parameters are used very often in optical, chemical, and biomedical industries. A simple and direct measurement of reflectivity could provide the refractive index of the test medium by using only Fresnel's equation, it is related to the measurement of light intensity variations [5]. The refractive index correlates closely to the molar fractions of the components in solution, and constant for a substance under standard conditions of temperature and pressure. The refractive index has been widely used to determine the concentration of sugar such as in food, fruit juices, etc. as the Brix Value (BV) [6-8].

The commercially available Brix Meter refers the light refraction. A refractometer takes the refraction angles and correlates them to the refractive index values that have been established. Using these values, it can determine the concentrations of solutions [9]. With predefined formulas or concentration tables, the density meter converts the measured density value automatically into the desired concentration unit [10]. The Brix measuring ranges for several samples are listed in Table 1. [11].

The purpose of this study is to apply the suitability of this Brix meter to other portable viscometer by knowing the relationship between the measured value of concentration and viscosity of analyzed sample solution.

Table 1. Brix measuring range for several samples [11]



2. EXPERIMENTAL

The viscosity of sucrose was be determined by using Ostwald viscometer (Sougo Rikagaku Galasu Seisakusho, Kyoto, Japan). The distilled water obtained by Elix 5 is used for preparation of sucrose ($C_{12}H_{22}O_{11}$; Nacalai Tesque, Inc Kyoto Japan; GR grade) standard solution. The viscosity is determined by measuring its rate of flow through a capillary tube. At a constant temperature of 303 K, the sucrose solution is added from the pipette to the Ostwald viscometer as illustrated at Figure 3(a). With the aid of a piece of rubber tubing or pipette filler, the liquid is sucked up the capillary arm of the viscometer until the surface of the liquid is above the upper mark as illustrated at Figure 3(b). The liquid is then allowed to flow down the arm. The time required for the surface of the liquid to pass from the upper mark to the lower mark is noted, as illustrated at Figure 3(c).

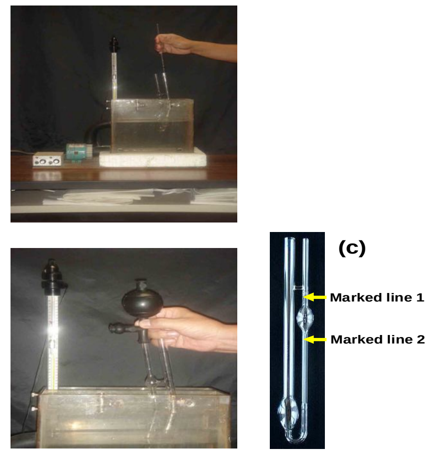


Figure 3. Measurement of viscosity of sucrose solution using Ostwald viscometer. (a) adding solution; (b) sucking up solution; (c) measuring time

Sucrose solution in many various concentrations are made by using mass formula of $\left[\dfrac{\text{mass of sucrose}}{\text{mass of sucrose} + \text{water}}\right]$. Then viscosity could be calculated using Poiseuille equation. The concentration of sucrose solution was measured by portable Brix meter of RA-250HE (Kyoto Electronics Manufacturing Co. Ltd.) by dropping the sample onto the prism, then pressing the read key and the result will appeared on the display, like as illustrated at figure 4. It can be calibrated with a drop of distilled water and cleaned by rinsing or wiping.

Figure 4. Measurement of concentration of sucrose solution using portable Brix meter.

3. RESULTS AND DISCUSSION

Standard pure water that used to determine the capillary constant has the density and the viscosity are 0.99571 g/cm^3 and 0.00798 g/cm.s respectively [12]. Using the equation: $\eta = \rho kt$, and the time required for the surface of the liquid to pass from the upper mark to the lower mark, the capillary constant is 4.1286 x 10^{-5} cm^2/s^2. The time required for sucrose solution is also noted, then its viscosity in various concentrations can be calculated and experimental value is compared to the reference. Table 2 shows the concentration values of sucrose solution by direct preparing using mass formula of $\left[\frac{\text{mass of sucrose}}{\text{mass of sucrose} + \text{water}}\right]$ and the measured values using portable Brix meter and the measured value of concentration of sucrose solution by portable Brix meter and by direct preparing is nearly similar, that describe at figure 5. It was seen at the figure 5 that there is relationship between the concentration and the viscosity. It was shown that increasing the concentration of sucrose solution gives rise to increasing viscosity. With this tendency, the value of solution viscosity can be predicted base on the read value of concentration on this portable Brix meter. So that, the Brix meter is applicable to other uses than concentration measurement

Table 2. Concentration and viscosity of sucrose solution*

DP	Concentration (Brix %) Measurement by PBM			Viscosity (cP)			
				Theo. [10]	Measurement		
	Ave	SD	RSD		Ave	SD	RSD
5	4.9	0.12	2.37	0.8872	0.8994	0.0022	0.2509
10	9.7	0.21	2.15	1.0389	1.0539	0.0019	0.1774
15	14.6	0.23	1.58	1.2380	1.2418	0.0040	0.3261
20	19.6	0.17	0.88	1.5055	1.5077	0.0029	0.1948
25	24.6	0.21	0.85	1.8760	1.9020	0.0029	0.1516
30	29.5	0.17	0.59	2.4068	2.4480	0.0024	0.0987
35	34.6	0.21	0.60	3.1987	3.2786	0.0052	0.1581
40	39.5	0.21	0.53	4.4397	4.5696	0.0021	0.0471
45	44.4	0.26	0.60	6.5050	6.7306	0.0235	0.3493
50	49.4	0.23	0.47	10.2094	10.7237	0.1138	1.0612

*DP: sucrose concentration by direct preparing, PBM: sucrose concentration by portable Brix meter; Ave: average value of concentration and viscosity in 3 times measurements, SD: standard deviation of measurement, RSD: relative standard deviation (%) of measurement, Theo.: theoretical value of sucrose viscosity [3].

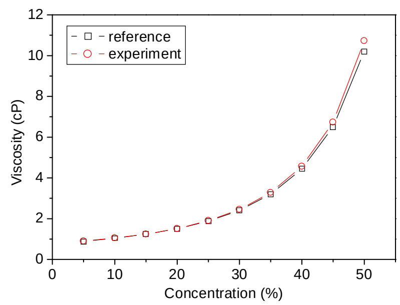


Figure 5. Viscosity of sucrose solution in various concentrations at 303 K.

4. Conclusions

By using the easy and simply measurement of the viscosity of aqueous sucrose solution in various concentrations and the sugar content using an Ostwald viscometer and a commercial of portable Brix meter, the relationship between these parameters can be known. The experiment results indicate that increasing of the concentration of sucrose would followed by increasing viscosity. Depending on their concentration, the measured value of viscosity of solution would be automatically confirmed into the desired concentration unit. With this tendency, the value of solution viscosity can be predicted base on the read value of concentration on this portable Brix meter. So that, portable Brix meter is applicable to other uses than concentration measurement.

REFERENCES

[1] http://www.process-viscometer.com/_ENG/viscosity-measurement.html.

[2] Block, H., Kelly, J.P.: *J. Phys.* **D21** (1988) 1661.

[3] G. Roberto, "Calculations on Pure Sucrose Solution," 1997 on http://www.seas.upenn.edu/courses/belab/ReferenceFiles/Viscometer/SucroseCalculator.html

[4] D. S. Viswanath, T. K. Ghosh, D. H. L. Prasad, N. V. K. Dutt, K. Y. Rani. Viscosity of Liquids. In: Introduction. Dordrecht, Netherlands: Springer; p.1-14.

[5] C. Hsu, K. Chen, D. Su, *Optics Communications*, **218** (2003), 205–211.

[6] Pomeranz Y, Meloan CE. Refractometry and polarimetry. In: Pomeranz Y, Meloan CE, editors. Food analysis. New York: Chapman & Hall; 1994. p. 430–48.

[7] Bradley RL. Moisture and total solids analysis. In: Nielsen SS, editor. Introduction to the chemical analysis of foods. Boston: Jones and Bartlett; 1994. p. 95–111.

[8] W. K. Chang, S. A. McClave, Y. C. Chao, *Clinical Nutrition*, **23** (2004), 105–112.

[9] http://www.coleparmer.com/techinfo/techinfo.asp?htmlfile=Refractometers.htm

[10] http://us.mt.com/mt/filters/applications_analytical_density-determination-analytics/Density_concentration_tables_browse_0x000248e100025ba40005d031.jsp

[11] http://www.kyoto-kem.com/en/pdf/catalog/ra250he.pdf

[12] http://www.thermexcel.com/english/tables/eau_atm.htm