National Institute of Standards & Technology

Certificate

Standard Reference Material® 1922

Liquid Refractive Index - Mineral Oil

This Standard Reference Material (SRM) is intended for use as a calibration material for refractometers, especially for the refractive index range applicable to solutions of sugar and water. A unit of SRM 1922 is a mineral oil characterized for refractive index, *n*, in the visible light range, and consists of one bottle of approximately 30 mL of liquid. Certified values are given in Table 1 for the refractive indices at six wavelengths, λ, at 20 °C, and for the change in *n* with respect to temperature, d*n*/dT.

Certified Values and Uncertainties: The measurements of refractive index were conducted on a precision spectrometer-goniometer using the classical method of minimum deviation [1,2]. A cadmium lamp was used for measurements at 643.8 nm, 508.6 nm, 480.0 nm, and 467.8 nm, and a mercury lamp was used for measurements at 546.1 nm. The measurements were performed at a series of temperatures between 15 °C and 35 °C. The mineral oil was contained in a hollow prism and the temperature was controlled by a water bath.

The uncertainties of the temperature measurements are estimated to be on the order of ± 0.1 °C. The refractive indices at 20 °C and the slopes (d*n*/dT) were determined by linear fits to the measured data. The certified values at 589.3 nm were determined by fits of a standard dispersion (Cauchy) equation to the refractive index and d*n*/dT values derived from the linear regressions. The homogeneity of the oil was tested by measurements on multiple aliquots, using both the minimum deviation technique and an Abbϑ-type refractometer. Uncertainties in the certified values were calculated in accordance with NIST policy [3-4] and are expanded uncertainties with a coverage factor *k* = 2 incorporating a Type B error in temperature of ± 0.1 °C.

Expiration of Certification: The certification of **SRM 1922** is valid indefinitely, within the uncertainty specified, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Use"). The certification is nullified if the SRM is damaged, contaminated or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate this notification.

The overall direction and coordination of the technical measurements leading to certification was provided by J.R. Verkouteren and R.A. Velapoldi of the NIST Surface and Microanalysis Science Division.

Characterization of this SRM was performed in the NIST Surface and Microanalysis Science Division by J.R. Verkouteren.

Statistical analysis was provided by S.D. Leigh of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

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See Certificate Revision History on Last Page

Table 1. Certified values and uncertainties of refractive index[(a)] at 20 °C and dn/dT at six wavelengths valid over the temperature range from 15 °C to 35 °C

λ (nm)	n at 20 °C	dn/dT °C^{-1}
467.8	$1.47685 \pm 2\times10^{-5}$	$-3.74\times10^{-4} \pm 3\times10^{-6}$
480.0	$1.47583 \pm 3\times10^{-5}$	$-3.75\times10^{-4} \pm 4\times10^{-6}$
508.6	$1.47373 \pm 2\times10^{-5}$	$-3.72\times10^{-4} \pm 2\times10^{-6}$
546.1	$1.47149 \pm 2\times10^{-5}$	$-3.70\times10^{-4} \pm 2\times10^{-6}$
643.8	$1.46744 \pm 2\times10^{-5}$	$-3.66\times10^{-4} \pm 3\times10^{-6}$
589.3[(b)]	$1.46945 \pm 6\times10^{-5}$	$-3.68\times10^{-4} \pm 2\times10^{-6}$

(a) The refractive index corresponds to approximately 71.6 on the Brix scale.
(b) By convention, the most common wavelength for reporting refractive index is 589.3 nm, the intensity-weighted mean wavelength of the sodium doublet, D_1, D_2.

INSTRUCTIONS FOR USE

Use a clean glass pipette or dropper to extract a few drops of oil from the bottle to place on the measuring surface of the refractometer. Measure the refractive index, n, at one of the wavelengths, λ, given in Table 1 and at a temperature, T, between 15 °C and 35 °C. If T≠ 20 °C, calculate n_λ^{20} by using Equation 1 and the temperature coefficient, dn_λ/dT, from Table 1. (Temperatures above 20 °C will decrease the refractive index, and temperatures below 20 °C will increase the refractive index.)

$$n_\lambda^{20} = n_\lambda^{\mathrm{T}} + (20 - \mathrm{T})(\mathrm{d}n_\lambda / \mathrm{dT}) \tag{1}$$

For example, if a measurement was taken under the following conditions resulting in an experimental value for $n_{589.3}^{28.0}$:

λ = 589.3 nm,
T = 28.0 °C,
n_λ^{T} = $n_{589.3}^{28.0}$ = 1.4665,

then the corrected value $n_{589.3}^{20.0}$ can be calculated using Equation l:

$$\mathrm{n}_{589.3}^{20.0} = 1.4665 + (20 - 28)(-0.000368) = 1.4694 \tag{2}$$

The uncertainty in the measured value will be a combination of errors arising from the measurements of refractive index and temperature and the uncertainty in dn/dT. The total uncertainty can be estimated by using a first order propagation of error [5]:

$$U \cong \sqrt{(s_{n_\lambda})^2 + (\mathrm{d}n_\lambda / \mathrm{dT})^2 (s_{20-\mathrm{T}})^2 + (20 - \mathrm{T})^2 (s_{\mathrm{d}n_\lambda / \mathrm{dT}})^2} \tag{3}$$

where s_{n_λ} is the standard error in the measured refractive index, $s_{20\text{-T}}$ is equivalent to the standard error in T, and $s_{\mathrm{d}n_\lambda/\mathrm{dT}}$ is one-half the uncertainty in dn_λ/dT from Table 1. If the standard error in the measured refractive index is $\pm 1\times10^{-4}$, then the error derived from measurements at temperatures other than 20 °C (but within the range 15 °C to 35 °C) will be very small with respect to the total uncertainty. The error in the measurement of T, however, can contribute significantly to the total uncertainty. For example, given the calibration procedure from the example with T = 28.0 °C ± 0.1 °C and a measured $n_{589.3}^{28.0}$ = 1.4665 ± 0.0001, the uncertainty is:

$$U \cong \sqrt{(0.0001)^2 + (-0.000368)^2(0.1)^2 + (-8)^2(1\cdot10^{-6})^2} = 0.00011 \quad (4)$$

Given the same example with a standard error in T of ± 0.5 °C increases U to ± 0.0002. This approach is not meant to be descriptive of all errors expected in the use of SRM 1922, but is useful for gauging the errors associated, in particular, with the measurement of temperature.

Source, Preparation, and Analysis[1]

The mineral oil is a commercial non-volatile paraffin oil and is expected to be very stable with respect to composition. The oil was supplied in a 20 L container and aliquoted into amber glass bottles with Teflon-lined lids. Each bottle contains approximately 30 mL of oil.

Storage and Handling: This SRM should be stored in its original bottle at normal ambient temperatures between approximately 20 °C and 25 °C. It must be tightly recapped after use and protected from excessive moisture and light.

REFERENCES

[1] Werner, A.J.; *Methods in High Precision Refractometry of Optical Glasses*; Appl. Opt., Vol. 7, pp. 837-843 (1968).

[2] Tentori, D.; Lerma, J.R.; *Refractometry by Minimum Deviation: Accuracy Analysis*; Opt. Eng., Vol. 29(2), pp. 160-168 (1990).

[3] ISO; *Guide to the Expression of Uncertainty in Measurement*; ISBN 92-67-10188-9, 1st ed.; International Organization for Standardization: Geneva, Switzerland (1993); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at http://physics.nist.gov/Pubs/.

[4] ANSI/NCSL Z 540-2-1997; *U.S. Guide to the Expression of Uncertainty in Measurement*; National Conference of Standards Laboratories: Boulder, CO (1997).

[5] Ku, H.H.; *Notes on the Use of Propagation of Error Formulas*, J. Res. Natl. Bur. Stand., Vol. 70C(4), pp. 263-273 (1966).

Certificate Revision History: 24 June 2009 (A footnote was added regarding the refractive index on the Brix scale for table 1.); 26 July 1999 (Original certificate date).

[1]Certain commercial equipment, instruments or materials are identified in this certificate to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.