

U.S. Department of Commerce  
National Institute of Standards and Technology  
Chemical Science and Technology Laboratory  
Biochemical Science Division  
Gaithersburg, Maryland 20899

REPORT OF RECERTIFICATION

March 12, 2008

Submitted to: Hach Lange GmbH  
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NIST Job No.: 8-0072

Purchase Order No.: E25231

Date of Recertification: March 11, 2008

SRM 930d, Glass Filters for Spectrophotometry, Set No. 1140, was received for recertification and carefully examined for surface defects and contamination. An initial "as received" measurement was taken to determine whether or not the previously certified transmittance values remained within the stated uncertainties. The filters were cleaned and each filter of this SRM was individually recertified for optical transmittance,  $T$ , at wavelengths 440.0 nm, 465.0 nm, 546.1 nm, 590.0 nm and 635.0 nm. All transmittance measurements were performed relative to air using the high-accuracy reference spectrophotometer in the Biochemical Science Division. The effective spectral slit width used to determine the certified transmittance values was 1.0 nm. The original reference instrument and our measurement techniques are described in NBS Special Publications 260-116 [1] and 260-81 [2]. The present reference spectrophotometer has a design similar to the original.

The new certified values of optical transmittance density,  $TD$ , for each filter at  $22\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$  are given in Table 1a, and the corresponding values of transmittance,  $T$ , for these filters are given in Table 1b.\* The transmittance density values calculated from the relation  $TD = -\log_{10} T$  should be used to verify the absorbance scale of the user's spectrophotometer.

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\* The results provided herein were obtained under the authority granted by Title 15 United States Code Section 3710a. As such, they are considered confidential and privileged information, and to the extent permitted by law, NIST will protect them from disclosure for a period of five years, pursuant to Title 15 USC 3710a(c)(7)(A) and (7)(B).

The spectral slit width values indicated in parentheses are the maximum usable values at the designated wavelengths and should not be exceeded for accurate measurements. The new certified values for this filter set supersede the previous values provided in the original Certificate or in previous Reports of Recertification. The current SRM 930e Certificate is available at <http://patapasco.nist.gov/srmcatalog/certificates/930e.pdf>.

The expanded uncertainty,  $U$ , defines an interval within which the unknown value of the transmittance can be asserted to lie with a level of confidence of approximately 95 percent. The expanded uncertainties of the certified transmittance density values are given in Table 2, and were calculated from the combined standard uncertainties (i.e. estimated standard deviations) of the component uncertainties reported in Tables 3 and 4. A coverage factor  $k = 2$  was included in the calculation, based on Student's  $t$ -distribution for more than 30 degrees of freedom. The expanded transmittance uncertainties in Tables 1b and 5b are calculated from the corresponding transmittance density uncertainties.

The expanded uncertainty includes "Type A" uncertainties, which are evaluated by statistical methods, and "Type B" uncertainties, which are evaluated by other means [3]. The uncertainties are combined by the root-sum-of-squares method.

The Type A uncertainty components for each level (Table 3) were determined from the results of a statistical analysis of two replicate measurements at five wavelengths for eight filters at each of three levels (10%, 20%, and 30% transmittance). The pooled standard deviation of replicates,  $s_p$ , was computed and reported as the standard uncertainty for each level. The degrees of freedom,  $DF$ , for the pooled standard deviation was computed by multiplying the degrees of freedom for each set of replicates by the number of wavelengths at each level by the number of filters at each level:  $DF = 1 \times 5 \times 8 = 40$ .

The Type B uncertainty components (Table 4) were estimated from studies described in NBS Special Publication 260-116 [1]. The Type B uncertainty components are derived from an estimate of the range  $\pm a_i$ , with the assumption that the uncertainty is uniformly distributed. The resulting standard uncertainty component is then approximated as  $a_i/\sqrt{3}$  [3].

The integrity of the intrinsic transmittance properties of these delicate optical filters may be seriously compromised by user-induced surface defects or contamination resulting from improper storage or mishandling of the filters. Transmittance density changes due solely to natural aging processes should not exceed the estimated uncertainty limits of the NIST certified values for at least two years from the time of recertification.

The performance of the filter set over the prior certification period may be assessed by comparison of the "as received" measurements given in Tables 5a and 5b with the prior certification. This comparison has been made at NIST, and any measurements found to be outside of the certified uncertainty range are marked with an asterisk (\*).

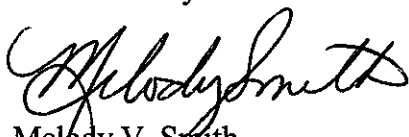
If any such measurements are noted, a footnote (which may suggest corrective action) will be placed under the table. Since the NIST uncertainties represent 95 % confidence intervals, a single deviation may be random in nature.

The filter set should be returned to NIST at two-year intervals for cleaning, recertification and validation of the filters' integrities. However, if before the two-year interval has expired, the user of this SRM determines that the filters have been exposed to adverse conditions that may alter their optical transmittance, an immediate recertification is necessary.

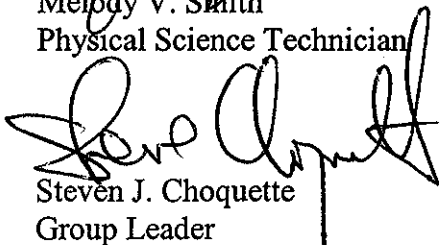
**For instructions on submitting the filter set for recertification, please visit our website at [http://www.cstl.nist.gov/nist839/839.04/molecular\\_absorption.html](http://www.cstl.nist.gov/nist839/839.04/molecular_absorption.html). You may also email us at [filter.recert@nist.gov](mailto:filter.recert@nist.gov) or call the Optical Filters Hotline at 301-975-4115.**

- [1] R. Mavrodineanu, R.W. Burke, J.R. Baldwin, M.V. Smith, J.D. Messman, J.C. Travis and J.C. Colbert, Standard Reference Materials: Glass Filters as a Standard Reference Material for Spectrophotometry - Selection, Preparation, Certification, and Use of SRM 930 and SRM 1930, NIST Special Publication 260-116, Government Printing Office, Washington, DC 20402, (1994).
- [2] R.W. Burke and R. Mavrodineanu, Accuracy in Analytical Spectrophotometry, NBS Special Publication 260-81, (1983).
- [3] "Guide to the Expression of Uncertainty in Measurement," ISBN 92-67-10188-9, 1st Ed. ISO, Switzerland, 1993.

Recertified by:



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Table 1a. Certified Transmittance Density Values for SRM 930d, Set Number 1140

Wavelength, nm (Maximum Spectral Slit Width, nm)	Transmittance Density ( $-\log_{10} I$ )		
	Filter Identification - Set Number		
	10-1140	20-1140 (Slit Width, nm)	30-1140
440.0 (2.2)	$0.9557 \pm 0.0024$	$0.7377 \pm 0.0023$	$0.5219 \pm 0.0023$
465.0 (2.7)	$0.8931 \pm 0.0024$	$0.6904 \pm 0.0023$	$0.4735 \pm 0.0023$
546.1 (6.5)	$0.9322 \pm 0.0024$	$0.7122 \pm 0.0023$	$0.4876 \pm 0.0023$
590.0 (5.4)	$0.9830 \pm 0.0024$	$0.7489 \pm 0.0023$	$0.5175 \pm 0.0023$
635.0 (6.0)	$0.9455 \pm 0.0024$	$0.7209 \pm 0.0023$	$0.5029 \pm 0.0023$

Table 1b. Certified Transmittance Values for SRM 930d, Set Number 1140

Wavelength, nm (Maximum Spectral Slit Width, nm)	Transmittance (T)		
	Filter Identification - Set Number		
	10-1140	20-1140 (Slit Width, nm)	30-1140
440.0 (2.2)	$0.1107 \pm 0.0006$	$0.1829 \pm 0.0010$	$0.3007 \pm 0.0016$
465.0 (2.7)	$0.1279 \pm 0.0007$	$0.2040 \pm 0.0011$	$0.3362 \pm 0.0018$
546.1 (6.5)	$0.1169 \pm 0.0007$	$0.1940 \pm 0.0010$	$0.3255 \pm 0.0018$
590.0 (5.4)	$0.1040 \pm 0.0006$	$0.1783 \pm 0.0009$	$0.3038 \pm 0.0016$
635.0 (6.0)	$0.1134 \pm 0.0006$	$0.1902 \pm 0.0010$	$0.3142 \pm 0.0017$

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TABLE 2. Transmittance Density Uncertainty for SRM 930d

Item	Filter Identification		
	10	20	30
Combined Type A	0.00049	0.00036	0.00027
Combined Type B	0.0011	0.0011	0.0011
Combined Uncertainty ( $u_c$ )	0.0012	0.0012	0.0011
Coverage Factor	2	2	2
Expanded Uncertainty ( $U$ )	0.0024	0.0023	0.0023

TABLE 3. Type A Components of Transmittance Density Uncertainty for SRM 930d

Source	Filter ID	Standard Uncertainty	DF
Replicate Measurements	10	0.00049	40
Replicate Measurements	20	0.00036	40
Replicate Measurements	30	0.00027	40

Table 4. Type B Components of Transmittance Uncertainty for SRM 930d

Source	Standard Uncertainty	DF
Homogeneity	0.00075	$\infty$
Transmittance Stability	0.00061	$\infty$
Temperature	0.00050	$\infty$
Linearity/Geometry	0.00025	$\infty$
Combined Type B Uncertainty	0.0011	Combined Type B

Effective Degrees of Freedom &gt; 30

Table 5a. "As Received" Transmittance Density Values for SRM 930d, Set Number 1140

Wavelength, nm (Maximum Spectral Slit Width, nm)	Transmittance Density ( $-\log_{10} T$ )		
	Filter Identification - Set Number		
	10-1140	20-1140	30-1140
440.0 (2.2)	$0.9572 \pm 0.0024$	$0.7377 \pm 0.0023$	$0.5221 \pm 0.0023$
465.0 (2.7)	$0.8946 \pm 0.0024$	$0.6901 \pm 0.0023$	$0.4733 \pm 0.0023$
546.1 (6.5)	$0.9334 \pm 0.0024$	$0.7121 \pm 0.0023$	$0.4876 \pm 0.0023$
590.0 (5.4)	$0.9845 \pm 0.0024$	$0.7486 \pm 0.0023$	$0.5178 \pm 0.0023$
635.0 (6.0)	$0.9466 \pm 0.0024$	$0.7208 \pm 0.0023$	$0.5026 \pm 0.0023$

Table 5b. "As Received" Transmittance Values for SRM 930d, Set Number 1140

Wavelength, nm (Maximum Spectral Slit Width, nm)	Transmittance (T)		
	Filter Identification - Set Number		
	10-1140	20-1140	30-1140
440.0 (2.2)	$0.1104 \pm 0.0006$	$0.1829 \pm 0.0010$	$0.3006 \pm 0.0016$
465.0 (2.7)	$0.1275 \pm 0.0007$	$0.2041 \pm 0.0011$	$0.3363 \pm 0.0018$
546.1 (6.5)	$0.1166 \pm 0.0007$	$0.1941 \pm 0.0010$	$0.3255 \pm 0.0018$
590.0 (5.4)	$0.1036 \pm 0.0006$	$0.1784 \pm 0.0009$	$0.3036 \pm 0.0016$
635.0 (6.0)	$0.1131 \pm 0.0006$	$0.1902 \pm 0.0010$	$0.3144 \pm 0.0017$

Date of Measurement: March 6, 2008

**This filter set has fully passed its certification. However, our last certification measurement was on September 10, 1984. We recommend that these filters be recertified every two years.**