National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2040

PTFE Diffuser for Spectral Reflectance Factor

This Standard Reference Material (SRM) is intended for use in calibrating the photometric scale of reflectometers for the 45/0 geometry at wavelengths from 380 nm to 780 nm. SRM 2040 consists of 130 g of polytetrafluoroethylene (PTFE) and the items necessary for producing pressed samples. These items include a spatula, a ground glass plate, and a presser assembly. The presser assembly has a plunger, funnel, sample holder, and cover. A diagram of the presser assembly is shown in Figure 1. This SRM will provide approximately five 26 g samples.

Certified Values of Spectral Reflectance Factor: This SRM was batch certified. The certified 45/0 spectral reflectance factors for unpolarized incident light are given in Table 1 for wavelengths from 380 nm to 780 nm. The reflectance factors were measured using the NIST High Accuracy Reference Reflectometer [1,2], which determines spectral reflectance with an absolute technique. For the 45/0 geometry, the incident direction is 45º from the normal of the diffuser surface, while the viewing direction is along the normal.

Discussion of Uncertainties: Uncertainties were calculated according to the procedures outlined in Reference 3. Uncertainty components due to random effects are: source stability, detector noise, sample non-uniformity, and variability. The uncertainty contributions caused by these effects were evaluated as the standard deviation of the mean for repeated measurements of each sample. Uncertainty components due to systematic effects include the wavelength, incident and viewing angles, and projected solid angle. The expanded uncertainty (k = 2) of the reflectance factors listed in Table 1 is 0.006.

Expiration of Certification: The certification of this SRM lot is valid until **31 December 2005**, within the measurement uncertainties specified, provided the SRM is handled and stored in accordance with the instructions given in this certificate. However, the certification is invalid if the SRM is damaged, contaminated, or modified.

The initial research and development was conducted in the NIST Optical Technology Division by P.Y. Barnes and J.J. Hsia [4].

The technical measurements leading to certification were performed in the Optical Technology Division by P.Y. Barnes. Statistical analysis was performed by S.D. Leigh of the NIST Statistical Engineering Division. The overall direction and coordination of the technical measurements leading to certification were performed under the direction of R.D. Saunders of the NIST Optical Technology Division.

The support aspects involved in preparation, certification, and issuance of this SRM were coordinated through the NIST Standard Reference Materials Program by J.W.L. Thomas.

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Gaithersburg, MD 20899
Certificate Issue Date: 04 October 2001

John Rumble, Jr., Acting Chief
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Handling Instructions: When not in use, the diffuser should be stored in a glass dessicator, The rim of the dessicator should not be greased, nor should dessicant materials be used at the bottom. Airborne particulates, aromatics, and improper handling will adversely affect the condition of the diffuser surface. Lint-free gloves (nylon or latex) should be used when handling the diffuser to prevent fingerprints on the surface. Gently use a clean air bulb to remove dust from the diffuser surface.

Source and Preparation of Material: Bulk PTFE resin (Algoflon F7)[1] was obtained from Aussimont, Inc., Orange, TX. This resin was pulverized in a glass jar using a commercial electric blender until a powder-like consistency was obtained. The presser assembly was designed and fabricated by NIST staff.

Instructions for Use: The following steps are recommended for preparing a sample:

Step 1. Prepare a clean work area.
Step 2. Use only stainless steel, glass, or porcelain materials to handle PTFE powder.
Step 3. Clean all materials that will be used with the PTFE powder and air-dry.
Step 4. Attach the funnel to the sample holder with screws, making sure the funnel is centered.
Step 5. Place approximately 26 g of PTFE powder in the sample holder, using the spatula, to produce a sample with a density of 1 g/cm^3.
Step 6. Insert the plunger in the funnel and manually press down until it stops.
Step 7. Withdraw the plunger from the funnel.
Step 8. Remove the funnel from the sample holder, lifting straight up so that the funnel does not slide over the surface of the sample.
Step 9. Imprint the surface of the sample with the 120-grit ground glass plate with no lateral movement.
Step 10. Attach the cover to the sample holder when the sample is not in use.

Determination of Spectral Reflectance Factor: The spectral reflectance factor measurements were made using the NIST High Accuracy Reference Reflectometer [1]. Samples were prepared using the instructions given above from the same PTFE powder as that provided with this SRM. Each sample was placed on the sample goniometer so that its front surface was on the axis of rotation. The collimated incident beam, with less than 1° divergence, a 14.5 nm spectral bandwidth, and a diameter of 14 mm, was centered on the front of the sample. Radiant flux was collected and measured using a detection system mounted on an arm of the goniometer. The distance from the center of the illuminated area to the center of the limiting aperture of the detection system was 670.7 mm. The diameter of the limiting aperture was 31.85 mm.

The spectral reflectance factor was measured at wavelengths from 380 nm to 780 nm at a 10 nm interval using the 45/0 geometry for polarizations of the incident beam both parallel and perpendicular to the plane of incidence. For each wavelength and polarization, the measurement sequence was as follows. With the sample translated out of the incident beam, a signal proportional to the incident radiant flux was measured by the detection system, termed the incident signal. The reflected radiant flux was measured by centering the sample in the incident beam and rotating it with the goniometer to obtain a 45º angle of incidence. The detection system was rotated so that the viewing direction was along the normal of the sample, and a signal proportional to the reflected radiant flux was measured, termed the reflected signal. The sequence was completed by again measuring the incident signal. Also, after each signal reading, a shutter was closed on the monochromator and a dark signal was measured.

The source of radiant flux into the monochromator was a quartz-tungsten-halogen incandescent lamp, while the optical detector was a silicon photodiode. During the measurements, the ambient temperature was 20 °C ± 3 °C and the relative humidity was 40 % ± 10 %.

For each wavelength and polarization, the reflectance factor was calculated by subtracting the dark signals from the incident and reflected signals to yield net signals, dividing the net reflected signal by the average net incident signal and the projected solid angle of the limiting aperture, and multiplying by the constant π. The reflectance factor for unpolarized incident light was calculated by averaging the reflectance factors of both polarizations.

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

Table 1. Spectral Reflectance Factor of SRM 2040
Calibration Date: 30 October 2000

Wavelength [nm]	Reflectance Factor
380	1.014
390	1.014
400	1.014
410	1.014
420	1.015
430	1.015
440	1.015
450	1.015
460	1.015
470	1.015
480	1.015
490	1.015
500	1.015
510	1.015
520	1.015
530	1.015
540	1.015
550	1.015
560	1.015
570	1.015
580	1.015
590	1.015
600	1.015
610	1.015
620	1.015
630	1.015
640	1.015
650	1.014
660	1.014
670	1.014
680	1.014
690	1.014
700	1.014
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740	1.014
750	1.014
760	1.014
770	1.014
780	1.014

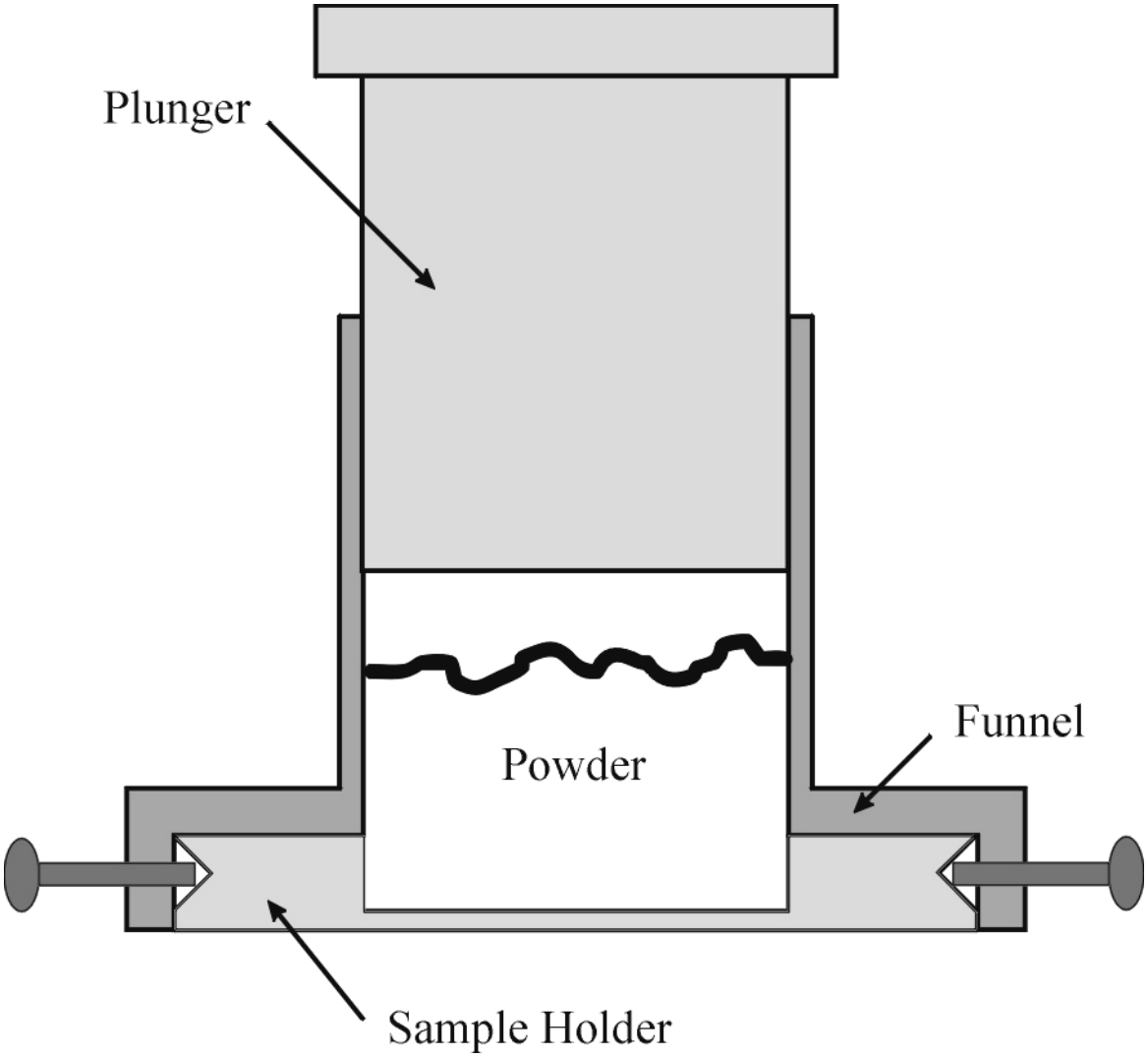

Figure 1. Presser Assembly

REFERENCES

[1] Proctor, J. E. and Barnes, P.Y., "NIST High Accuracy Reference Reflectometer," J. Res. Natl. Inst. Stand. and Tech., **101**, pp. 619-627, (1996).

[2] Barnes, P.Y., Early, E.A., and Parr, A.C., "NIST Measurement Services: Spectral Reflectance," NIST Special Publication 250-48, U.S. Department of Commerce, U.S. Government Printing Office, Washington, DC, (1998).

[3] *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st Ed., ISO, Geneva, Switzerland, (1993); see also Taylor, B.N. and 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] Barnes, P.Y. and Hsia, J.J., "45°/0° Reflectance Factors of Pressed Polytetrafluoroethylene (PTFE) Powder," NIST Technical Note 1413, U.S. Government Printing Office, Washington, DC, (1995).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet http://www.nist.gov/srm.