National Institute of Standards & Technology

Certificate

Standard Reference Material® 4342A
Thorium-230 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive Thorium-230 in a suitably stable and homogeneous matrix. It is intended primarily for the calibration of instruments that are used to measure radioactivity and for the monitoring of radiochemical procedures. The solution, whose composition is specified in Table 1, is contained in a flame-sealed, 5 mL, NIST, borosilicate-glass ampoule (see Note 1)*.

The certified **thorium-230** massic activity value, at a **Reference Time of 1200 EST, 1 April 2007**, is:

$$\mathbf{(40.83 \pm 0.16)\ Bq{\bullet}g^{-1}}$$

Additional physical, chemical, and radiological properties for the SRM, as well as details on the standardization method, are given in Table 1. Uncertainty intervals for certified quantities are expanded (k = 2) uncertainties calculated according to the ISO and NIST Guidelines (see Note 2). Table 2 contains a specification of the components that comprise the uncertainty analyses.

The certification of this SRM, within the measurement uncertainties specified, is valid for at least five (5) years after receipt. The solution matrix, in an unopened ampoule, is believed to be indefinitely homogeneous and stable, within its half-life-dependent, useful lifetime. NIST will monitor this material and will report any substantive changes in certification to the purchaser. Should any of the certified values change, purchasers of this SRM will be notified of the change by NIST.

This SRM may represent a radiological hazard and a chemical hazard. Consult the Material Safety Data Sheet (MSDS), enclosed with the SRM shipment, for details (see Note 1).

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, Dr. M.P. Unterweger, Acting Group Leader. The overall technical direction and physical measurements leading to certification were provided by Drs. R. Collé, and L. Laureano-Pérez of the Radioactivity Group, with production assistance by Dr. L.L. Lucas of the Radioactivity Group and D.B. Golas and O. Palabrica, Research Associates of the Nuclear Energy Institute, with confirmatory measurement assistance by Dr. I. Outola, and with impurity analyses by Dr. L. Pibida. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Measurement Services Division.

Lisa R. Karam, Deputy Chief
Ionizing Radiation Division

Gaithersburg, Maryland 20899
July 2007

Robert L. Watters, Jr., Chief
Measurement Services Division

*Notes and references are on page 4

Table 1. Properties of SRM 4342A

Certified values

Radionuclide	**Thorium-230**
Reference time	**1200 EST, 1 April 2007**
Massic activity of the solution	**40.83 Bq•g^{-1}** (See Note 3)
Relative expanded uncertainty (*k* = 2)	**0.38 %** (see Note 2)*

Uncertified information

Source description	Liquid in flame-sealed, 5 mL NIST borosilicate ampoule (see Note 1)
Solution composition	1.0 mol•L^{-1} HNO_3
Solution density	(1.032 ± 0.002) g•mL^{-1} at 20 °C (see Note 4)
Solution mass	(5.1626 ± 0.0003) g (see Note 4)
Alpha-particle-emitting impurities	^{229}Th: 0.016 ± 0.008 Bq•g^{-1} (See Note 5) ^{232}Th: 0.000024 ± 0.000002 Bq•g^{-1} (See Note 5)
Photon-emitting impurities	None detected (see Note 6)
Half-lifes used	^{226}Ra : (1600 ± 7) a ‡ ^{229}Th: (7340 ± 160) a ‡ ^{230}Th : (7.538 ± 0.030) x10^{4} a ‡ ^{232}Th: (1.405 ± 0.006) x 10^{10} a ‡
Calibration method (and instruments)	The certified massic activity for ^{230}Th was obtained by 4παβ liquid scintillation (LS) spectrometry with three commercial LS counters, with corrections for the ingrowth of the ^{226}Ra subseries. Confirmatory measurements were also performed by 2πα spectrometry with a Si surface barrier detector.

‡ See Note 7

*Notes and references are on page 4

Table 2. Uncertainty evaluation for the massic activity for SRM 4342A

	Uncertainty component	Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{230}Th (%)
1	LS measurement precision; reproducibility in massic activity for 1 cocktail composition, with 3 samples, measured in 3 counters on 1 or 2 measurement occasions; weighted standard deviation of the mean for approximately $\nu = 21$ effective degrees freedom (normally distributed)	A	0.037
2	LS detection efficiency for ^{230}Th	B	0.1
3	LS detection efficiency for ^{226}Ra (ingrowth)	B	0.0006
4	LS detection efficiency for ^{222}Rn subseries (ingrowth)	B	0.06
5	Correction for ^{226}Ra massic activity at measurement time	B	0.1
6	Decay corrections for ^{230}Th (for half life uncertainty of 0.40%)	B	2.0×10^{-9}
7	Ingrowth correction for ^{226}Ra subseries	B	0.015
8	Gravimetric (mass) measurements for LS sources	B	0.07
9	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
10	Radionuclidic impurities	B	0.05
Relative combined standard uncertainty			**0.19**
Relative expanded uncertainty (*k* = 2)			**0.38**

† = (A) denotes evaluation by statistical methods; (B) denotes evaluation by other methods.

NOTES

Note 1. Refer to http://physics.nist.gov/Divisions/Div846/srm.html for the standardized ampoule dimensions and for assistance and instructions on how to properly open an ampoule. Information on additional storage and handling requirements is also included in the website.

Note 2. The uncertainties on certified values are expanded uncertainties, $U = ku_c$. The quantity u_c is the combined standard uncertainty calculated according to the ISO and NIST Guides (see references [2] and [3]). The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ and was chosen to obtain an approximate 95 % level of confidence.

Note 3. The master solution was chemically purified on 8 June 1993.

Note 4. The stated uncertainty is two times the standard uncertainty. See reference [3].

Note 5: Based upon mass spectrometric measurements made by the Oak Ridge National Laboratory (Oak Ridge, TN). Based on impurity analyses for alpha-particle-emitters performed in July 2007, no other impurities were detected. The estimated limit of detection for alpha-emitting-impurities were:

0.003 $s^{-1} \bullet g^{-1}$ for energies 3.0 MeV < E < 4.4 MeV,
0.002 $s^{-1} \bullet g^{-1}$ for energies 4.8MeV < E < 9.0 MeV.

Note 6. The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, on 11 May 2007, were:

0.16 $s^{-1} \bullet g^{-1}$ for 30 keV < E < 1800 keV.

Note 7. The stated uncertainty is the standard uncertainty. See reference [3].

REFERENCES

[1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Data Center, Brookhaven Laboratory (Upton, NY), April 2007. Refer to http://www.nndc.bnl.gov/ensdf/.

[2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993 (corrected and reprinted, 1995). Available from Global Engineering Documents, 12 Inverness Way East, Englewood, CO 80112, U.S.A. Telephone 1-800-854-7179.

[3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.