National Institute of Standards & Technology

Certificate

Standard Reference Material 4337

Lead -210 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive lead-210 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 **lead-210** massic activity value, at a **Reference Time of 1200 EST, 15 June 2006**, is:

(9.037 ± 0.22) kBq•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 D.B. Golas and O. Palabrica, Research Associates of the Nuclear Energy Institute and with measurement assistance by Drs. I.Outola, L. Pibida and R.Fitzgerald of the Radioactivity Group. The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program.

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Table 1. Properties of SRM 4337

Certified values

Radionuclide	**Lead-210**
Reference time	**1200 EST, 15 June 2006**
Massic activity of the solution	**9.037 kBq•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**2.4 %** (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 with 21 µg Bi^{+3} and 11 µg Pb^{+2} per gram of solution
Solution density	(1.028 ± 0.002) g•mL^{-1} at 20.0 °C (see Note 3)
Solution mass	(5.133 ± 0.002) g (see Note 3)
Photon-emitting impurities	None detected (see Note 4)
Half-lifes used	^{210}Pb : (22.20 ± 0.22) a † ^{3}H : (12.32 ± 0.02) a †
Nuclear data used in CN2003 computations (beta-particle maximum energies; branching ratios; transitions) [1]	^{3}H : (18.594 ± 0.008) keV†; 1, allowed ^{210}Pb : (63.5 ± 0.5) keV†; (0.16 ± 0.03); non-unique first forbidden (17.0 ± 0.5) keV†; (0.84 ± 0.03); non-unique first forbidden ^{210}Bi : (1162.1 ± 1.5) keV†; 1; non-unique first forbidden
Calibration method (and instruments)	The certified massic activity for ^{210}Pb in radioactive equilibrium with ^{210}Bi and ^{210}Po was obtained by 4παβ liquid scintillation (LS) spectrometry with three commercial LS counters. The LS detection efficiency was calculated using the CN2003 code [2] for the CIEMAT/NIST method with composition matched LS cocktails of a ^{3}H standard as the efficiency detection monitor. Confirmatory measurements were also performed by high-resolution HPGe gamma-ray spectrometry, by 2πα spectrometry of separated ^{210}Po with a Si surface barrier detector, and by 4πβ(LS) - γ(NaI) anticoincidence counting.

† See Note 5

 *Notes and references are in page 4

Table 2. Uncertainty evaluation for the massic activity for SRM 4337

	Uncertainty component	Assessment Type †	Relative standard uncertainty contribution on massic activity of ^{210}Pb (%)
1	LS within measurement precision; typical standard deviation of the mean for 7 to 11 repeated measurements; values ranged from 0.008 % to 0.056 %	A	0.03
2	LS measurement precision; reproducibility in massic activity for 7 to 11 samples in two measurement series with three counters on two to three measurement occasions; standard deviation of the mean for ν = 443 degrees freedom	A	0.067
3	Background LS measurement variability; wholly embodied in components 1& 2	A	---
4	Scintillator dependencies; wholly embodied in components 1 & 2	A	---
5	LS cocktail stability and composition mismatch effect	B	0.35
6	Gravimetric (mass) measurements for LS sources and for ^{3}H standard dilution	B	0.07
7	Live time determinations for LS counting time intervals, includes uncorrected dead time effects	B	0.06
8	Decay corrections for ^{210}Pb	B	0.002
9	Decay corrections for ^{3}H	B	0.0005
10	Limit for photon-emitting impurities	B	0.02
11	Beta endpoint energy, $E_{\beta(max)}$, for ^{210}Pb for an uncertainty of 0.5 keV	B	0.033
12	Beta decay branching ratios for ^{210}Pb for an uncertainty of 0.03	B	0.39
13	$E_{\beta(max)}$ for ^{210}Bi for an uncertainty of 1.5 keV	B	0.001
14	Computed β detection efficiency for ^{210}Pb	B	1.1
15	Computed β detection efficiency for ^{210}Bi	B	0.04
16	Assumed α detection efficiency for ^{210}Po, including extrapolation to zero energy	B	0.05
Relative combined standard uncertainty			**1.2**
Relative expanded uncertainty (*k* = 2)			**2.4**

† = (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 [3] and [4]). 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 stated uncertainty is two times the standard uncertainty. See reference [4]

Note 4. The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rates, on 27 December 2005, were:

1.7 s^{-1} g^{-1} for 20 keV < E < 60 keV
0.3 s^{-1} g^{-1} for 60 keV < E < 1800 keV

Note 5. The stated uncertainty is the standard uncertainty. See reference [4].

REFERENCES

[1] Evaluated Nuclear Structure Data File (ENSDF), online database, National Nuclear Data Center, Brookhaven Laboratory (Upton, NY), October 2006. Refer to http://www.nndc.bnl.gov/ensdf/

[2] E. Gunther, Physikalisch-Technische Bundesanstalt (Braunschweig, Germany), private communication, 2003

[3] 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.

[4] 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.