National Institute of Standards & Technology

Certificate

Standard Reference Material® 4326a

Polonium-209 Radioactivity Standard

This Standard Reference Material (SRM) consists of a solution of a standardized and certified quantity of radioactive polonium-209 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. A unit of SRM 4326a consists of approximately 5 mL of a solution, whose composition is specified in Tables 1 and 2, contained in a flame-sealed borosilicate-glass ampoule [1].

The certified **polonium-209 massic alpha-particle emission rate**, at a **Reference Time of 1200 EST, 01 December 2013**, is:

$$\mathbf{(39.01 \pm 0.18)\ s^{-1} \bullet g^{-1}}$$

A NIST certified value, as used within the context of this certificate, is a value for which NIST has the highest confidence in its uncertainty assessment. It is a "measurement result" [2] obtained directly or indirectly from a "primary reference measurement procedure" [3]. The certified value is traceable to the derived SI unit, reciprocal second (s^{-1}).

Additional physical, chemical, and radiological properties for this SRM, as well as details on the standardization method, are given in Tables 1 and 2. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO/JCGM and NIST Guides [4,5]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4326a** is valid indefinitely, within the measurement uncertainty specified, provided that the SRM is handled and stored properly and that no evaporation or change in composition has occurred. The solution matrix, in an unopened ampoule, is homogeneous and stable within its half-life-dependent useful lifetime provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Handling and Storage"). Periodic recertification of this SRM is not required. The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

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

Radiological and chemical hazard: Consult the Safety Data Sheet (SDS), enclosed with the SRM shipment, for radiological and chemical hazard information.

This SRM was prepared in the NIST Physical Measurement Laboratory, Radiation Physics Division, under the direction of M.P. Unterweger, Group Leader of the Radioactivity Group. The overall production, technical direction, and physical measurement leading to certification were provided by R. Collé, L. Laureano-Pérez, and R. Fitzgerald of the NIST Radiation Physics Division, Radioactivity Group. Photon-emitting impurity analyses were provided by L. Pibida of the NIST Radiation Physics Division, Radioactivity Group.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

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Certificate Issue Date: 08 May 2015

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Table 1. Certified Massic Alpha-Particle Emission Rate of SRM 4326a

Radionuclide	**Polonium-209**
Reference time	**1200 EST, 01 December 2013**
Massic alpha-particle emission rate of the solution	**39.01 s^{-1}•g^{-1}**
Relative expanded uncertainty (*k* = 2)	**0.46 %[(a)]**

(a) 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/JCGM and NIST Guides [4,5]. The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ and was chosen to obtain an approximate 95 % level of confidence.

Table 2. Uncertified Information of SRM 4326a

Source description	Liquid in a flame-sealed 5 mL borosilicate-glass ampoule [1]
Solution composition	2.0 mol•L^{-1} HCl
Solution density	(1.032 ± 0.002) g•mL^{-1} at 20 °C[(a)]
Solution mass	(5.169 ± 0.003) g[(a)]
Photon-Emitting Impurities	None detected[(b)]
Total alpha-emitting impurities	None detected[(c)]
Half-lives used	^{209}Po: (125.2 ± 3.3) a [(d)]
Calibration methods (and instruments)	The certified massic alpha-particle emission rate for ^{209}Po was obtained by $4\pi\alpha$ liquid scintillation (LS) spectrometry in two commercial LS counters with corrections for detection of the low-energy conversion electrons from the 2-keV isomeric transition in ^{205}Pb and for radiations accompanying the small 0.45 % electron-capture branch to ^{209}Bi [6]. See uncertainty component 1 in Table 3 for measurement conditions.

(a) The stated uncertainty is two times the standard uncertainty. See reference 5.

(b) The estimated lower limits of detection for photon-emitting impurities, expressed as massic photon emission rate, in January 2014, ranged from 0.001 to 0.002 s^{-1}•g^{-1} in the region 30 keV ≤ E ≤ 2000 keV (except in the region 880 keV ≤ E ≤ 910 keV). The detection limit was 0.003 s^{-1}•g^{-1} in the 880 keV ≤ E ≤ 910 keV, provided that the photons are separated in energy by 4 keV or more from photons emitted in the decay of ^{209}Po or progeny.

(c) The estimated lower limits of detection for the alpha-particle emission rate at energy E_α, expressed as a ratio to that for ^{209}Po, as of January 2014 are:

≤ 10^{-3} for E_α ≤ 4.5Mev

< 2 x 10^{-5} for E_α ≥ 5.0MeV

The most common impurity associated with ^{209}Po is ^{208}Po. The activity ratio ^{208}Po/^{209}Po < 10^{-7}.

(d) The stated uncertainty is the standard uncertainty. See reference 5. This value is a new determination made by this laboratory over the course of 20.7 years [7]. Neither the sole original ^{209}Po half-life determination [8] nor the tabulated reference value given in reference [6] will withstand critical scrutiny.

Table 3. Uncertainty Evaluation for the Massic Alpha-Particle Emission Rate of SRM 4326a

Uncertainty component		Assessment Type[(a)]	Relative standard uncertainty contribution on massic alpha-particle emission rate of ^{209}Po (%)
1	LS measurement precision; standard deviation for $n = 31$ mean determinations, includes both within - and between – variability for (i) $n = 3$ measurements on each LS counting source; (ii) use of $n = 2$ different LS counters on either one or two separate measurement occasions; (iii) $n = 3$ to 6 sources for each solution/LS cocktail composition; (iv) $n = 11$ separate sets of sources/solutions of varying compositions.	A	0.17
2	Background LS measurement variability and cocktail stability; wholly embodied in component 1	B	---
3	LS Spectra analysis method[(b)]	B	0.15
4	LS detection inefficiency, includes wall effect[(b)]	B	0.01
5	LS response correction for electron capture branch decay	B	0.015
6	Gravimetric (mass) dilution factor	B	0.025
7	Counting source aliquot mass determinations, includes mass measurement precision[(b)]	B	0.05
8	Decay corrections for ^{209}Po half-life uncertainty of 2.6 %	B	0.011
9	Potential alpha and photon emitting impurities	B	0.005
Relative combined standard uncertainty			**0.23**
Relative expanded uncertainty (*k* = 2)			**0.46**

(a) Letter A, denotes evaluation by statistical methods; B denotes evaluation by other methods.

(b) Uncertainty is partially embodied within component 1.

INSTRUCTIONS FOR HANDLING AND STORAGE

Handling: If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of both the radioactivity and the strong acid. Only persons qualified to handle both radioactive material and alkaline and/or acidic solutions, should open the ampoule. To minimize personnel exposure, appropriate shielding and/or distance should be used. Refer to the SDS for further information.

Storage: SRM 4326a should be stored and used at a temperature between 5 °C and 65 °C. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material.

REFERENCES

[1] NIST Physical Measurement Laboratory; *Storage and Handling of Radioactive Standard Reference Materials, Ampoule Specifications and Opening Procedure*, available at http://www.nist.gov/pml/div682/grp04/srm.cfm (accessed May 2015). Note: This SRM is contained in a generic borosilicate-glass ampoule and not in the standard NIST ampoule.

[2] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; Joint Committee for Guides in Metrology (JCGM); p. 19 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf (accessed May 2015).

[3] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; JCGM; p. 18 (2012); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf (accessed May 2015).

[4] JCGM 100:2008; *Evaluation of Measurement Data - Guide to the Expression of Uncertainty in Measurement;* (GUM 1995 with Minor Corrections), JCGM (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed May 2015).

[5] 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://www.nist.gov/pml/pubs/index.cfm (accessed May 2015).

[6] Chisté, V.; Bé, M.M.; *October 2009, ^{209}Po*; LNE-LNHB/CEA Table of Radionuclides, available at http://www.nucleide.org/DDEP_WG/Nuclides/Po-209_tables.pdf (accessed May 2015).

[7] Collé, R.; Fitzgerald, R.P.; Laureano-Perez, L.; *J. Phys. G: Nucl. Part. Phys.*, Vol. 41, p. 105103 (2014).

[8] André, C.G.; Huizenga, J.R.; Mech, J.F., Ramler W.J., Rauh E.G., Rocklin S.R..; *Phys. Rev.*, Vol. 101, pp. 645–651 (1956).

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.