



Certificate of Analysis

Certified Reference Material

GADS-1

Isotopic Certified Reference Material of Natural Gadolinium

GADS-1 is an isotopic Certified Reference Material (CRM) of natural gadolinium. A unit of GADS-1 consists of approximately 1 mL aliquot of gadolinium solution at 1000 mg kg⁻¹ in 2 % HNO₃. This material is intended for the calibration of instruments and evaluation of analysis methods for the determination of isotope ratios of gadolinium.

Certified values for atomic weight, molar mass, isotopic abundances and isotope amount ratios of gadolinium have been established for this isotopic CRM. These are listed in the table below. Certified values are based on results from data generated at the National Research Council Canada (NRC). The expanded uncertainty associated with the certified value were calculated according to the JCGM Guide [1] and protocols [2], and correspond to approx. 95 % confidence ($k = 2$).

Table 1: Certified quantity values and expanded uncertainties ($k = 2$) of atomic weight, molar mass, isotopic abundances and isotope ratios of gadolinium in GADS-1

Quantity	Value	Expanded uncertainty	Unit
Atomic weight, $A_r(\text{Gd})$	157.2502	0.0012	1
Molar mass, $M(\text{Gd})$	157.2502	0.0012	g/mol
Isotopic abundance, $x(^{152}\text{Gd})$	0.002 036	0.000 008	mol/mol
Isotopic abundance, $x(^{154}\text{Gd})$	0.021 844	0.000 060	mol/mol
Isotopic abundance, $x(^{155}\text{Gd})$	0.148 173	0.000 280	mol/mol
Isotopic abundance, $x(^{156}\text{Gd})$	0.204 848	0.000 240	mol/mol
Isotopic abundance, $x(^{157}\text{Gd})$	0.156 564	0.000 120	mol/mol
Isotopic abundance, $x(^{158}\text{Gd})$	0.248 276	0.000 130	mol/mol
Isotopic abundance, $x(^{160}\text{Gd})$	0.218 259	0.000 260	mol/mol
Isotope ratio, $n(^{152}\text{Gd})/n(^{158}\text{Gd})$	0.008 20	0.000 04	mol/mol
Isotope ratio, $n(^{154}\text{Gd})/n(^{158}\text{Gd})$	0.087 98	0.000 24	mol/mol
Isotope ratio, $n(^{155}\text{Gd})/n(^{158}\text{Gd})$	0.596 81	0.001 26	mol/mol
Isotope ratio, $n(^{156}\text{Gd})/n(^{158}\text{Gd})$	0.825 08	0.001 14	mol/mol
Isotope ratio, $n(^{157}\text{Gd})/n(^{158}\text{Gd})$	0.630 60	0.000 44	mol/mol
Isotope ratio, $n(^{160}\text{Gd})/n(^{158}\text{Gd})$	0.879 10	0.001 20	mol/mol

Isotopic composition of gadolinium was determined by multi-collector ICPMS using the regression method [3, 4] with NRC HALF-1 isotopic CRM of natural hafnium as the calibrator [5,6].

Atomic masses of gadolinium isotopes are taken from 2016 Atomic Mass Evaluation [7]. The molar mass, $M(\text{Gd})$, and the atomic weight of gadolinium, $A_r(\text{Gd})$, are related as $M(\text{Gd}) = A_r(\text{Gd})M_u$,

where M_u is the molar mass constant, $M_u = 1$ g/mol with negligible uncertainty. By convention, atomic weight is a dimensionless quantity with unit 1.

Certified values

Certified values are considered to be those for which the NRC has the highest confidence in accuracy and that all known and suspected sources of bias have been taken into account and are reflected in the stated expanded uncertainties. Certified values are the best estimate of the true value and uncertainty.

Intended use

This certified reference material is intended for the calibration of instruments and evaluation of analysis methods for the determination of isotope ratios of gadolinium.

Storage

It is recommended that the material is stored at room temperature and the ampoule opened immediately prior to use in a clean area with precautions taken against contamination.

Preparation of material

The reference material was prepared from a commercial gadolinium standard solution of 10 g L⁻¹ in 5 % HNO₃. The material was diluted 10-fold in 2 % HNO₃, bottled and flame sealed in cleaned amber glass ampoules containing approximately 1 mL aliquots at 1000 mg kg⁻¹ mass fraction of gadolinium.

Stability

Potential instabilities due to long-term storage and transportation were considered, and such effects deemed to be negligible on the isotopic composition of the material. The material is deemed stable with respect to the certified values for ten years.

Homogeneity

The material is deemed to be homogeneous with respect to the isotopic composition of gadolinium.

Uncertainty

The overall combined uncertainty estimate includes the uncertainties from the primary standard, calibration model, and measurement repeatability.

Metrological traceability

Results presented in this certificate are traceable to International System of Units (SI) through NRC HALF-1 isotopic CRM of natural hafnium [5, 6]. As such, GADS-1 serves as a suitable reference materials for laboratory quality assurance programs, as outlined in ISO/IEC 17025.

Quality Management System (ISO 17034, ISO/IEC 17025)

This material was produced in compliance with the NRC Metrology Quality Management System, which conforms to the requirements of ISO 17034 and ISO/IEC 17025. The Metrology Quality Management System supporting NRC Calibration and Measurement Capabilities, as listed in the Bureau international des poids et mesures (BIPM) Key Comparison Database (kcdb.bipm.org/),

has been reviewed and approved under the authority of the Inter-American Metrology System (SIM) and found to be in compliance with the expectations of the Comité international des poids et mesures (CIPM) Mutual Recognition Arrangement. The SIM approval is available upon request.

Updates

For updates please refer to doi.org/10.4224/crm.2021.gads-1.

References

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Cited by

A list of scientific publications citing GADS-1 can be found at doi.org/10.4224/crm.2021.gads-1.

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Acknowledgments

The contribution of Ovi Mihai and Inorganic Chemical Metrology staff (NRC) are acknowledged.

Citation

Meija J, He J, Grinberg P, Mester Z, and Yang L. GADS-1: Isotopic Certified Reference Material of Natural Gadolinium. Ottawa: National Research Council Canada; 2021.

Available from: doi.org/10.4224/crm.2021.gads-1.

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Date of issue: October 2021

Date of expiry: October 2031

Approved by:



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This Certificate is only valid if the corresponding material was obtained directly from the NRC or an Authorized Reseller.

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