



# Certificate of Analysis

## Certified Reference Material

### ALED-1

#### Lead-206 and lead-207 double spike isotopic standard

ALED-1 is a high purity isotopic lead Certified Reference Material (CRM). A unit of ALED-1 consists of 1 mL lead solution at 250 mg/kg in 2 % nitric acid that was prepared by mixing separated lead isotope materials to obtain approximately 4:1 ratio of lead-206 and lead-207. This material is intended as an isotopic standard of lead. Certified values for the isotopic composition and the atomic weight of lead have been established for this CRM. These values are listed in the Table 1. Certified values are based on measurements carried out at the National Research Council Canada (NRC). The expanded uncertainty ( $U_{\text{CRM}}$ ) in the certified values is equal to  $ku_c$  where  $u_c$  is the combined standard uncertainty calculated according to the JCGM Guides [1] and protocols [2] and  $k$  is the coverage factor. A coverage factor of two (2) was applied which corresponds to approx. 95 % confidence.

**Table 1: Certified quantity values and expanded uncertainties ( $k=2$ ) of atomic weight, isotopic abundances, and isotope ratios of lead in ALED-1**

Quantity	Value	Expanded uncertainty	Unit
Atomic weight of lead, $A_r(\text{Pb})$	206.182 88	0.000 08	1
Isotopic abundance, $x(^{204}\text{Pb})$	0.000 039	0.000 013	mol/mol
Isotopic abundance, $x(^{206}\text{Pb})$	0.801 461	0.000 051	mol/mol
Isotopic abundance, $x(^{207}\text{Pb})$	0.188 794	0.000 047	mol/mol
Isotopic abundance, $x(^{208}\text{Pb})$	0.009 706	0.000 027	mol/mol
Isotope ratio, $n(^{204}\text{Pb})/n(^{206}\text{Pb})$	0.000 05	0.000 02	mol/mol
Isotope ratio, $n(^{207}\text{Pb})/n(^{206}\text{Pb})$	0.235 56	0.000 07	mol/mol
Isotope ratio, $n(^{208}\text{Pb})/n(^{206}\text{Pb})$	0.012 11	0.000 03	mol/mol
Isotope ratio, $n(^{204}\text{Pb})/n(^{207}\text{Pb})$	0.000 21	0.000 07	mol/mol
Isotope ratio, $n(^{206}\text{Pb})/n(^{207}\text{Pb})$	4.245 16	0.001 30	mol/mol
Isotope ratio, $n(^{208}\text{Pb})/n(^{207}\text{Pb})$	0.051 41	0.000 15	mol/mol

Isotopic composition of lead (Table 1) was determined by multi-collector inductively-coupled plasma mass spectrometry (MC-ICPMS) using two independent methods of calibration: (1) the gravimetric isotope mixture method based on the use of four high-purity isotopes of lead and (2) the regression method with NIST SRM 997 thallium isotopic standard as the calibrator. Both calibration methods provide consistent results [3].

Atomic masses of lead isotopes are taken from 2016 Atomic Mass Evaluation [4]. The molar mass,  $M(\text{Pb})$ , and the atomic weight of lead,  $A_r(\text{Pb})$ , are related as  $M(\text{Pb}) = A_r(\text{Pb})M_u$ , where  $M_u$  is the molar mass constant,  $M_u = 1 \text{ g/mol}$  with negligible uncertainty.

### **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 to be used as the isotopic standard of lead with special focus on the lead isotope analysis using the double spike technique.

### **Storage**

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

### **Preparation of material**

The reference material was prepared from separated lead isotopes in metallic form. The chemical purity of the lead-206 material was determined by glow discharge mass spectrometry (GDMS) at the NRC [5] whereas the purity of other isotopes was determined by high-resolution ICPMS giving the following chemical purity (mass fraction of lead): 0.999 95 kg/kg (lead-206) and 0.999 54 kg/kg (lead-207) [3]. Afterward, the lead isotopes were cleaned with 5 %  $\text{HNO}_3$ , rinsed with water, and dried in a class 10 fume hood before their quantitative dissolution in 30 %  $\text{HNO}_3$ . Appropriate aliquots of stock solutions were then weighed and mixed to obtain approximately 4:1 ratio of lead-206 and lead-207 in the final solution. The solutions were bottled in 4 mL acid pre-cleaned plastic bottles. Each vial contains 1 mL solution with mass fraction lead approx. at 250 mg/kg in 2 %  $\text{HNO}_3$ .

### **Stability**

Potential instabilities due to long-term storage and transport 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 lead.

### **Uncertainty**

The overall combined uncertainty estimate includes the uncertainties in the batch characterization which include the primary standards, calibration model, and measurement repeatability.

## Metrological traceability

Isotopic composition results presented in this certificate are traceable to the SI through two independent calibration methods. The gravimetric mixture method involves the purity assessment of four lead isotope materials available in metallic form and gravimetrically preparing 1:1 mixtures of them in pairs [3,5]. These isotope mixtures serve to calibrate the MC-ICPMS response. Independently, the regression method with NIST SRM 997 thallium isotopic standard [6,7] was also used to calibrate the MC-ICPMS response [8]. As such, ALED-1 serves as a suitable reference material 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/](http://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

Users should ensure that the certificate they have is current. Our website at [www.nrc.gc.ca/crm](http://www.nrc.gc.ca/crm) will contain any new information.

## References

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8. Yang L, Tong S, Zhou L, Zhaochu H, Mester Z, Meija J (2018) A critical review on isotopic fractionation correction methods for accurate isotope amount ratio measurements by MC-ICP-MS. *J. Anal. At. Spectrom.* 33: 1849-1861

## Cited by

A list of scientific publications citing ALED-1 can be found at [doi.org/10.4224/crm.2021.aled-1](https://doi.org/10.4224/crm.2021.aled-1).

**Authorship**

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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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