



National Institute of Standards & Technology

Report of Investigation

Reference Material 8541

USGS24 Graphite

(Carbon Isotopes in Graphite)

This Reference Material (RM) is intended to provide a sample with a known isotope-amount ratio of carbon (C). The equivalent name for this RM, as used by the International Atomic Energy Agency (IAEA) and the U.S. Geological Survey (USGS), is USGS24 and is listed in column 2 of Table 1. A unit of RM 8541 consists of one bottle containing approximately 0.8 g of graphite.

Table 1. Reference Value and Expanded Uncertainty for the Relative C Isotope-Amount Ratio of RM 541

RM Number	Name	$\delta^{13}\text{C}_{\text{VPDB}}^{(a,b)} \times 10^3$
RM 8541	USGS24	$-16.05 \pm 0.07 \text{ ‰}$

- (a) The $\delta^{13}\text{C}$ values are expressed as a mean \pm an expanded uncertainty. The expanded uncertainty is equal to $U = ku_c$, where u_c is the combined standard uncertainty as defined by the ISO and NIST Guide [1] and k is the coverage factor. The value of the consensus mean and the associated combined standard uncertainty were calculated using a multivariate Bayesian approach [2]. The combined standard uncertainty is intended to represent, at the level of one standard deviation, the combined effects of Type A and B uncertainties on the reference value. Uncertainty in the bias of the methods is not included. The coverage factor k is 2 and provides an expanded uncertainty interval that has about a 95 % probability of encompassing the consensus mean.
- (b) Normalized to $\delta^{13}\text{C}_{\text{VPDB}}$ of RM 8545 (L-SVEC) = -46.6 ‰ .

Expiration of Value Assignment: The reference value of **RM 8541** is valid, within the measurement uncertainty specified, until **31 December 2020**, provided the RM is handled in accordance with instructions given in this Report of Investigation (see "Instructions for Use"). The reference value is nullified if the RM is damaged, contaminated, or otherwise modified.

Maintenance of RM Certification: NIST will monitor this RM over the period of its validity. If substantive technical changes occur that affect the value assignment before the expiration of this report, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The technical aspects involved in the issuance of this RM were coordinated through the NIST Analytical Chemistry Division by R.D. Vocke, Jr.

Reference Difference in Isotope-Amount Ratio Values: The differences in measured isotope-amount ratios of stable carbon isotopes $[n(^{13}\text{C})/n(^{12}\text{C})]$ are reported as $\delta^{13}\text{C}$ values, where $\delta^{13}\text{C} = ([n_{\text{sample}}(^{13}\text{C})/n_{\text{sample}}(^{12}\text{C})] - [n_{\text{VPDB}}(^{13}\text{C})/n_{\text{VPDB}}(^{12}\text{C})]) / [n_{\text{VPDB}}(^{13}\text{C})/n_{\text{VPDB}}(^{12}\text{C})]$. VPDB refers to the Vienna PDB scale, which is determined by assigning a $\delta^{13}\text{C}$ value of $+1.95 \text{ ‰}$ to RM 8544 (NBS 19) [3]. The reported $\delta^{13}\text{C}$ result for RM 8541 has been normalized to yield a consensus value of -46.6 ‰ for RM 8545.

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The reference value for $\delta^{13}\text{C}$ listed in Table 1 together with its expanded uncertainty are based on continuous flow elemental-analyzer isotope-ratio mass spectrometry [4] using the general method of Qi *et al.* [5]. Four expert laboratories (Centrum voor Isotopen Onderzoek, Rijksuniversiteit Groningen, Groningen, Netherlands; Max-Planck-Institute for Biogeochemistry, Jena, Germany; UFZ (Umweltforschungszentrum) Leipzig-Halle GmbH, Leipzig, Germany; U.S. Geological Survey, Reston, Va., USA) performed the analytical measurements and their results and the multivariate Bayesian approach for data reduction are described in detail in [2]. A reference value is a non-certified value that is the best estimate of the true value; however, the value may reflect only the measurement precision and may not include all sources of uncertainty.

Support aspects involved in the issuance of this RM were coordinated through the NIST Measurement Services Division.

INSTRUCTIONS FOR USE

Distribution: The distribution of RM 8541 (USGS24) is limited to one unit per three-year period of time.

Storage and Stability: Graphite is stable at normal room temperatures. This RM should be stored in the container in which it is supplied to the user.

REFERENCES

- [1] ISO; *Guide to the Expression of Uncertainty in Measurement*; ISBN 92-67-10188-9, 1st ed., International Organization for Standardization: Geneva, Switzerland (1993); see also 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://physics.nist.gov/Pubs/> (accessed May 2011).
- [2] Coplen, T.B.; Brand, W.A.; Gehre, M.; Gröning, M.; Meijer, H.A.J.; Toman, B.; Verkouteren, R.M.; *New Guidelines for $\delta^{13}\text{C}$ Measurements*: Anal. Chem., Vol. 78, pp. 2439–2441 (2006).
- [3] Hut, G.; *Consultants' Group Meeting on Stable Isotope Reference Samples for Geochemical and Hydrological Investigations*; IAEA, Vienna, Austria: 16-18 September, 1985 (1987).
- [4] Brenna, J.T.; Corso, T.N.; Tobias, H.J.; Caimi, R.J.; *High-Precision Continuous-Flow Isotope Ratio Mass Spectrometry*: Mass Spectrom. Rev., Vol. 16, pp. 227–258 (1997).
- [5] Qi, H.; Coplen, T.B.; Geilmann, H.; Brand, W.A.; Böhlke, J.K.; *Two New Organic Reference Materials for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ Measurements and a New Value for the $\delta^{13}\text{C}$ of NBS 22 Oil*; Rapid Comm. Mass Spectrom., Vol. 17, pp. 2483–2487 (2003).

Report Revision History: 04 May 2011 (Extension of the validity date); 01 November 2007 (This technical revision reports a change in the reference value and associated uncertainty as well as an update of expiration date); 22 June 1992 (Original certificate date).
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Users of this RM should ensure that the Report of Investigation in their possession is current. This can be accomplished by contacting the SRM Group: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at <http://www.nist.gov/srm>.