# SI-traceable $n(^{13}C)/n(^{12}C)$ isotope amount ratio measurements by IRMS and MC-ICPMS

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## Comparability of $^{13}C/^{12}C$ isotope ratios

Variations in $^{13}C/^{12}C$ isotope ratios are commonly reported as delta values (in ‰) on the international scale VPDB-LSVEC:

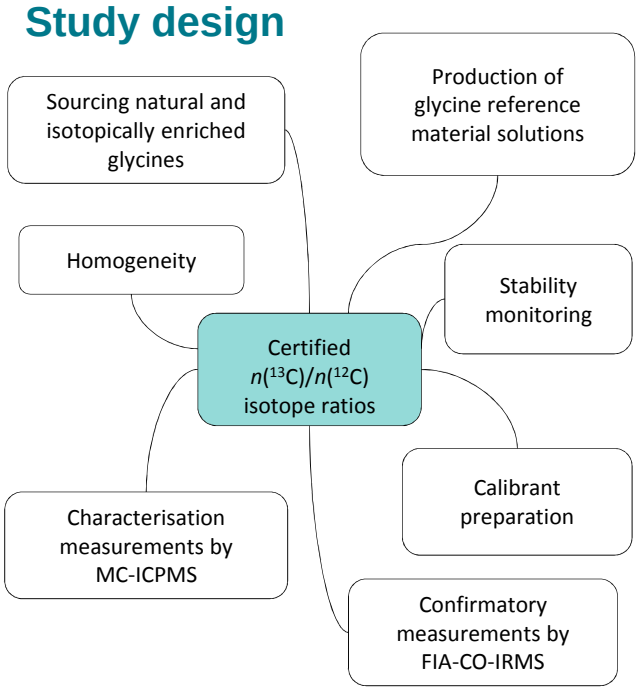
$$\delta^{13}C_{VPDB} = \frac{^{13}R_{sample}}{^{13}R_{VPDB}} - 1$$

Concerns about comparability of $\delta(^{13}C)$ values have been raised due to replacement of one primary reference material by another and drifting of $\delta(^{13}C)$ values of the second primary reference material (LSVEC) during storage.

Establishing traceability to the International System of Units (SI) is a sustainable solution ensuring accuracy and metrological traceability of measurement results.

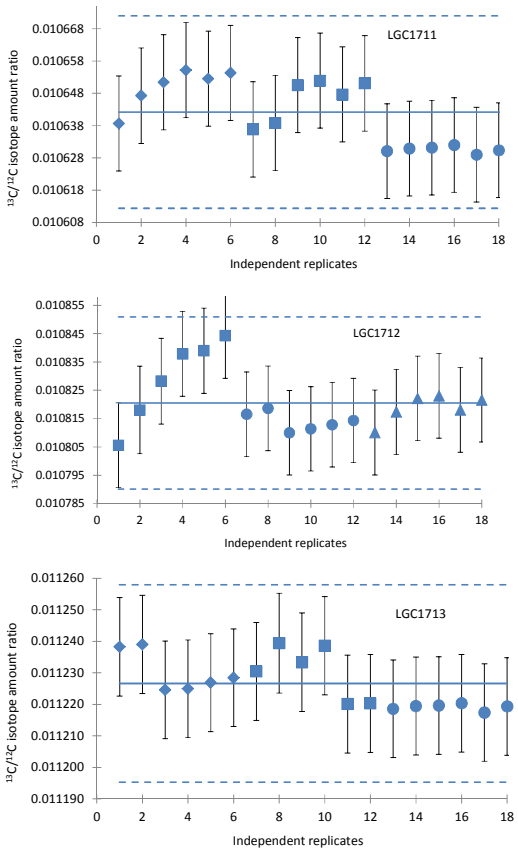
To enable traceability to SI, new and improved methods of $n(^{13}C)/n(^{12}C)$ measurements by gas source isotope ratio mass spectrometry (IRMS) and multicollector inductively coupled plasma mass spectrometry (MC-ICPMS) have been developed at LGC.

## Study design




## Measurement results

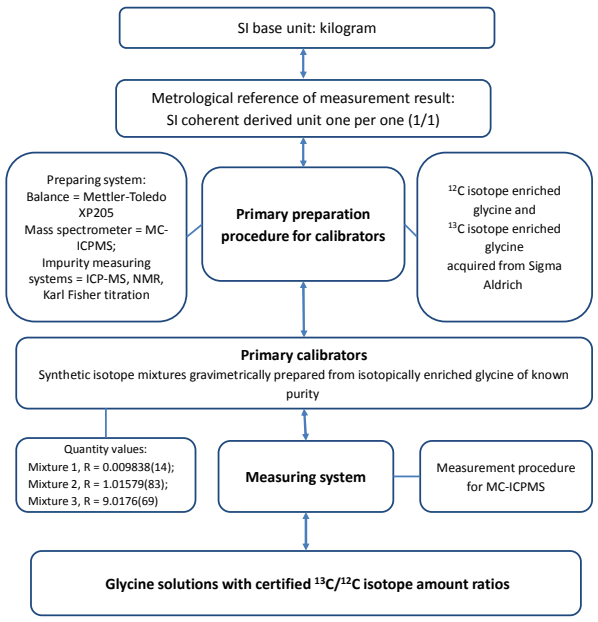
$n(^{13}C)/n(^{12}C)$ isotope ratios determined for the glycine CRM LGC171-KT in characterisation study. Uncertainty bars are $U_c$ ($k$=1); solid and dotted lines are mean values and $U_{exp}$ ($k$=2), respectively.




Certified values of absolute carbon isotope ratios and indicative $\delta^{13}C_{VPDB\text{-}LSVEC}$ values of LGC171-KT. Uncertainties in parentheses are $U_{exp}$ ($k$=2).

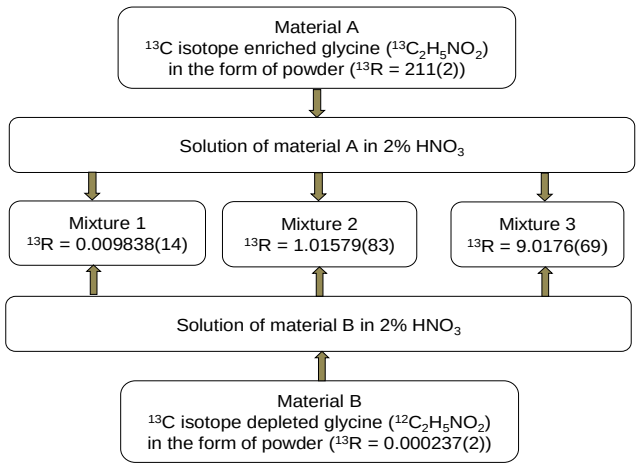
| Solution | $n(^{13}C)/n(^{12}C)$ ratio | $\delta^{13}C_{VPDB\text{-}LSVEC}$ values, ‰ |
|---|---|---|
| LGC1711 | 0.010642(30) | -42.22(0.34) |
| LGC1712 | 0.010821(30) | -24.66(0.24) |
| LGC1713 | 0.011227(32) | +12.55(0.22) |

## Traceability to SI units

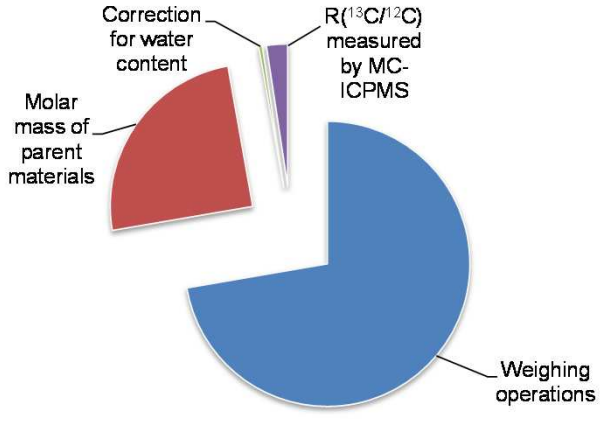



## Preparation procedure for calibrators of $R(^{13}C/^{12}C)$

Parent isotopically enriched glycines were weighed and brought into solution and then mixed with each other in different proportions.

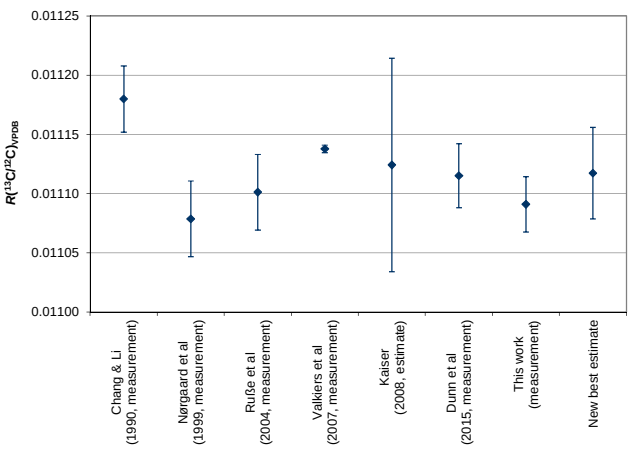



## Uncertainty budget




- Conservative uncertainty was assigned to molar mass values of parent glycines to account for potential presence of non-glycine forms of carbon.
- Homogeneity testing showed that both within and between bottle inhomogeneity are negligible.

## Re-determination of $R(^{13}C/^{12}C)_{VPDB}$




Comparison of $R(^{13}C/^{12}C)_{VPDB}$ values previously reported in the literature together with a new best estimate. Error bars show the expanded uncertainties.

## Conclusions

The developed methodology has been successfully applied to characterization of a new glycine reference material. Three glycine solutions of the CRM LGC171-KT produced in this study are intended for use in the calibration of instruments for the determination of absolute carbon isotope ratios.

Certified $R(^{13}C/^{12}C)$ values are traceable to the SI base units in the most direct way through calibration of the mass spectrometer with calibrators prepared from well characterised isotopically enriched glycines.

Improved measurement capabilities for isotope amount ratios $n(^{13}C)/n(^{12}C)$ have enabled provision of a new estimate of $R(^{13}C/^{12}C)$ value of the zero-point of the VPDB isotope delta scale and a more reliable link between the relative carbon isotope delta scale and the SI.

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