Electronic Supplementary Material (ESI) for Journal of Analytical Atomic Spectrometry.
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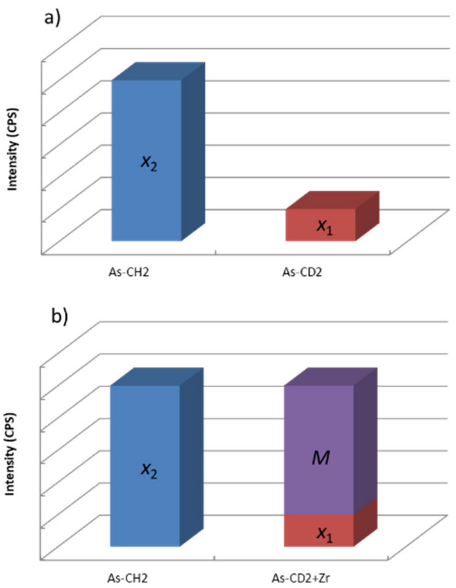
Supplementary Information

S1 The basic theory of the universal ID method.



The intensities of production ions, which are produced from the reaction between an analyte of a monoisotopic element and a labelled reaction gas in the DRC of ICP–MS, are measured with and without a third element in the universal ID method, although the different isotopes are measured in the conventional ID method.
The typical measurement results are shown in the left figure, where the upper is measured without a third element and the below with a third element. In the case of As determination, As^+CH_2, As^+CD_2 and As^+CD_2 + Zr^+ are measured, so the signal intensities are expressed as [As^+CH_2], [As^+CD_2] and [As^+CD_2 + Zr^+]. It is assumed that the amount of As in a sample is X, the amount of As contained in As^+CD_2 is x_1, the amount of As in As^+CH_2 is x_2, and the amount of Zr is M. The conversion efficiency of As to As^+CH_2 and As^+CD_2 is a constant under the constant conditions. Therefore, the intensity ratios measured are expressed by the equation (i) and (ii). Similarly, the intensity ratios between the x_1 and x_2 (Figure a)) and the x_1+M and x_2 (Figure b)) are expressed by equation (iii) and (iv).

$[\mathrm{As}]\!:\![\mathrm{As^{+}CD_2}] = X\!:\!x_1$ ···equation (i)

$\frac{[\mathrm{As^{+}}]}{[\mathrm{As^{+}CD_2}]} = \frac{X}{x_1} = R_x$ ···equation (ii)

$\frac{[\mathrm{As^{+}CH_2}]}{[\mathrm{As^{+}CD_2}]} = \frac{x_2}{x_1} = R'$ ···equation (iii)

$\frac{[\mathrm{As^{+}CH_2}]}{[\mathrm{As^{+}CD_2} + \mathrm{Zr^{+}}]} = \frac{x_2}{x_1+M} = R$ ···equation (iv)

Then, the As concentration, X, is derived as follows;

$\frac{R' x_1}{x_1+M} = R$ ···equation (v) (from equation (iii) and (iv))

$x_1 = \frac{R}{R'-R}M$ ···equation (vi)

$\therefore \frac{X}{R_x} = \frac{R}{R'-R}M$ ···equation (vii) (from equation (ii))

Finally, X is calculated from equation (viii)

$X = \frac{RR_x}{R'-R}M$ ···equation (ix)