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The isotopic composition and atomic weight of ytterbium

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Abstract

The isotopic composition of ytterbium has been measured with high precision using a thermal ionization mass spectrometer, the linearity of which was verified by measuring the isotopically certified reference material for potassium (NIST 985), whose isotopes span a wide range of isotope ratios. The abundance sensitivity of the mass spectrometer in the vicinity of the measured ion beams has been examined to ensure the absence of tailing effects. Particular care was given in ensuring that potential isobaric interferences from erbium, lutetium and hafnium did not affect the measurement of the ytterbium isotopic composition. Gravimetric mixtures of two isotopically enriched isotopes ^{171}Yb and ^{176}Yb were used to calibrate the mass spectrometer, thus enabling the "absolute" isotopic composition of ytterbium to be determined. An accurate determination of the isotopic composition of ytterbium is required in order to calculate its atomic weight, the magnitude of which has remained unchanged since 1934, when it was determined by the Harvard chemical methodology. A number of mass spectrometric measurements of the isotopic composition of ytterbium have previously been undertaken, but none have taken into account linearity and isotope fractionation factors. The isotope abundances (in at.%) of ytterbium measured in this experiment are as follows: $^{168}\mathrm{Yb} = 0.1232 \pm 0.0004$; $^{170}\mathrm{Yb} = 2.982 \pm 0.006$; $^{171}\mathrm{Yb} = 14.086 \pm 0.020$; $^{172}\mathrm{Yb} = 21.686 \pm 0.019$; $^{173}\mathrm{Yb} = 16.103 \pm 0.009$; $^{174}\mathrm{Yb} = 32.025 \pm 0.012$; $^{176}\mathrm{Yb} = 12.995 \pm 0.0013$. These values enable an atomic weight $A_r(\mathrm{Yb}) = 173.054 \pm 0.001$ to be calculated as compared to the presently-accepted value of 173.04 ± 0.03, together with the solar system isotope abundances of Yb.

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1. Introduction

Ytterbium is named after the Swedish village of Ytterby where the mineral ytterbite was originally found. The Swiss chemist Jean-Charles Galissard de Marignac discovered ytterbium in 1878. Ytterbium comprises seven isotopes spanning a mass range from 168 to 176. The minor isotope ^{168}Yb is synthesised by the proton (p)-capture process of nucleosynthesis, ^{170}Yb by the s-only process, ^{171,172,173,174}Yb by a combination of the slow (s)- and rapid (r)-neutron capture processes, and ^{176}Yb by the r-only process [1].

The atomic weight of Yb has remained unchanged at a value of 173.04 since 1934. This chemically determined value was reconfirmed in the 1961 report of the Commission on Atomic Weights and Isotopic Abundances (CAWIA) [2], despite the fact that three mass spectrometric determinations of the isotopic composition of Yb had been made to that time [3–5]. These three mass spectrometric measurements gave atomic weights of 173.031 ± 0.06, 173.041 ± 0.006 and 173.024 ± 0.006, respectively, which were in good agreement with the chemically determined value, so that the commission had no reason to alter the existing value. In 1969, CAWIA assigned an uncertainty of 0.03 to the atomic weight [6], and $A_r(\mathrm{Yb}) = 173.04 \pm 0.03$ has remained unchanged to the present time [7]. CAWIA is a Commission of the International Union of Pure and Applied Chemistry (IUPAC). The name of the commission has recently been changed to the Commission on Isotopic Abundances and Atomic Weights (CIAAW).

The first "modern" mass spectrometric determination of the isotopic composition of Yb was carried out in 1950 [3]. The authors were not able to determine the extent of isotope fractionation or to establish the limitations on the linearity of the measurement system over the wide range of ion currents used, to better than 1%. Leland [4] employed thermionic Yb^+ ions from a sample of $\mathrm{Yb_2O_3}$ to determine the isotopic composition of Yb, but reported that the presence of isobaric impurities

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necessitated the correction of ^{168}Yb by approximately 14% and ^{170}Yb by approximately 0.4%. Collins et al. [5] reported the presence of trace impurities of rare earth elements in their measurements of the isotopic composition of Yb, but were able to place upper limits on the presence of other possible naturally occurring isotopes other than ^{168,170,171,172,173,174,176}Yb. Two further mass spectrometric measurements of Yb were carried out by McCulloch et al. [8] and Holliger and Devillers [9]. The atomic weights derived from the isotopic composition of Yb from these two measurements were 173.0327 ± 0.0003 and 173.038 ± 0.003, respectively, but because neither was a calibrated determination CAWIA again saw no reason to change the standard atomic weight from $A_r(\text{Yb}) = 173.04 \pm 0.03$. McCulloch et al. [8] showed that the isotopic composition of eight meteorites and four terrestrial samples were identical within experimental uncertainties to a laboratory standard, but Holliger and Devillers [9] showed that anomalous Yb occurred in samples from the Oklo natural reactor U deposit in Gabon, Southwest Africa.

The isotope abundances of Yb given in the most recent Table of the Isotopic Composition of the Elements 2001 [10], as the "best" measurement from a single terrestrial source are those of Holliger and Devillers [9]. However, a "best" measurement does not necessarily imply a "good" mass spectrometric measurement [7], as no details of linearity, abundance sensitivity or isotope fractionation correction procedures were given in this paper [9]. This is understandable in that the primary objective of the experiment was to determine the isotopic composition of Lu in a number of U-rich samples from the Oklo natural reactor, in order to calculate the average equilibrium temperature of the neutrons involved in the nuclear reactions [9]. Thus the symbol "N" is appended to the "best" measurement for Yb in the table of isotopic composition of the elements [10], which implies that the isotope abundances are based on a non-calibrated measurement.

The present project has measured the isotopic composition of Yb using a VG 354 thermal ionization mass spectrometer (TIMS), for which the linearity and abundance sensitivity have been confirmed, and the absence of isobaric interferences demonstrated. A crucial parameter in determining an accurate value for the atomic weight is the evaluation of the isotope fractionation of Yb. The "absolute" isotopic composition of Yb in this experiment was determined by calibrating the TIMS with isotopically enriched isotopes of ^{171}Yb and ^{176}Yb. A rigorous assessment of the experimental uncertainties of the measurements has been made, so that an accurate value for the atomic weight of Yb can be determined. At present the atomic weight of Yb is one of the least accurately known of all the elements, the magnitude of the atomic weight having remained unchanged since 1934 [7].

2. Experimental

2.1. Laboratory standard

A laboratory standard solution of Yb was prepared by dissolving spectroscopically pure Yb_2O_3 sample of 99.999% purity from Electronic Space Products International (ESPI) CAS number 1314-37-0, in ultrapure 1 M HCl. Samples of $YbCl_3$ were mounted on the two side filaments of a triple Re filament assembly. A total load of approximately 1 μg of $YbCl_3$ enabled a $^{174}Yb^+$ ion beam of approximately 5×10^{-11} A to be maintained for several hours at a central filament temperature of approximately 1800 °C, with low temperatures on the two side (sample) filaments. A VG 354 TIMS, fitted with a Faraday cup collector system, was used for the isotope measurements of Yb, in which the seven Yb ion beams were collected simultaneously. A number of replicate analyses of the laboratory standard were measured under as near to identical mass spectrometric conditions as possible. The Yb isotope ratios were also measured using the peak-switching mode of data collection to give an identical result to the mean ratios obtained by Faraday cup collection. However, the measurement methodology adopted in this paper lays open the possibility that a systematic bias may occur due to factors other than isotope fractionation. We have taken account of this possibility in our assessment of experimental uncertainties.

2.2. Linearity

In order to measure the isotopic composition of Yb with high accuracy, it is essential to establish the linearity of the mass spectrometer detector system at least over a range commensurate with the magnitude of the ratio of the largest and smallest ion beams of Yb, which for $^{174}\text{Yb}/^{168}\text{Yb}$, is approximately 245 [10]. Isotopically certified reference material (ICRM) NIST 985 for K was obtained to check the linearity of the TIMS used in this experiment. This ICRM comprises highly purified KCl whose absolute isotope abundance ratios have been measured on two mass spectrometers, both of which were calibrated using synthetic mixtures prepared from nearly isotopically pure separated ^{39}K and ^{41}K isotopes [11]. The absolute isotope data for NIST 985 are listed in Table 1.

2.3. Abundance sensitivity

Another important consideration in ensuring an accurate isotope ratio measurement is to demonstrate that the mass spectrometer has sufficient mass resolution to ensure that two adjacent ion beams can be measured without "tailing" effects. This is especially important for elements of high mass number *A*, particularly if an abundant isotope of higher mass is adjacent to a less abundant isotope. Fig. 1 is a mass scan from $167 \leq A \leq 177$ at the filament current and vacuum conditions at which the Yb^+ ion

Table 1

Calibrated K absolute isotope abundance ratios for NIST 985, together with the isotope ratios measured in this project

	$^{39}\text{K}/^{41}\text{K}$	$^{40}\text{K}/^{41}\text{K}$
Calibrated NIST ratios	13.8566 ± 0.0063	0.0017343 ± 0.0000060
Measured ratios	14.1018 ± 0.0012	0.001745 ± 0.000005
Corrected ratios	13.8566	0.00173 ± 0.00005

Uncertainties of the measured ratios are at the 95% confidence level, based on the repeatability of four replicate analyses of NIST 985.

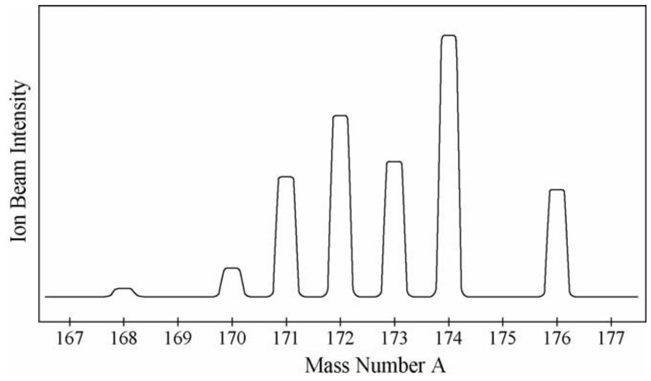

Fig. 1. The mass spectrum of Yb^+ generated by the VG 354 TIMS in the mass region $167 \leq A \leq 177$, generated under operating conditions of data collection.

beams were measured. Before any data was collected, a high sensitivity measurement of the mass spectrum in the vicinity of Yb was carried out to demonstrate the absence of interfering isotopes, and to ensure the absence of tailing effects in the Yb mass spectrum. Typical vacuum conditions in the ion source and mass analyser were approximately 5×10^{-8} Torr and $\leq 10^{-9}$ Torr, respectively, during data collection.

2.4. Isobaric isotopes

It is also essential to account for any isobaric isotopes which may be present when the Yb isotope data are being measured. This is particularly relevant when analysing the rare earth elements, which are sometimes difficult to obtain in sufficient purity to exclude the absence of other rare earth elements, all of which are relatively easily ionised by TIMS. Thus special attention was given in this experiment to the possibility of isobaric interferences with the Yb ion beams.

Fig. 2 illustrates the situation of the Yb isotopic composition with respect to the isobaric isotopes ^{168,170}Er, ^{174,176}Hf and ^{176}Lu. Of these potential interferences, ^{174,176}Hf are unlikely to cause any difficulties in measuring ^{174,176}Yb, because Hf is not a rare earth element, has a high ionization potential, and ^{174,176}Hf are minor isotopes of Hf. The presence of Hf was monitored by examining the ^{177}Hf mass position. Although Lu is a rare earth element, ^{176}Lu is the minor isotope of Lu, and its presence can easily be monitored by observing the presence of ^{175}Lu, since no Yb isotope exists at this mass number. No evidence of ^{177}Hf or ^{175}Lu were ever observed at the operating conditions used to measure the Yb isotopes. The most important potential isobaric interference is that of Er, because ^{168,170}Er are relatively abundant isotopes, whilst ^{168,170}Yb are the minor isotopes of Yb. The mass spectrum in Fig. 1 does not reveal the presence of ^{166,167}Er, ^{175}Lu or ^{177}Hf under the operating conditions of the mass spectrometer during data collection for Yb. However, extreme care was taken to ensure the absence of Er by monitoring the abundant ^{166,167}Er isotopes during the analysis of the ESPI laboratory standard.

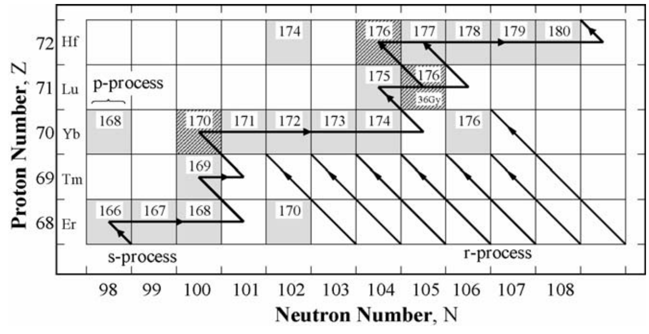

Fig. 2. A schematic diagram of the mass region $166 \leq A \leq 180$ showing the s-process path, the r-process decay chains and the p-process produced nuclides. The s-only process nuclide ^{170}Yb is shielded from the r-process by ^{170}Er. The p-only produced nuclide ^{168}Yb is located on the neutron poor region of the valley of nuclear stability.

2.5. Isotope fractionation

A TIMS isotope analysis invariably introduces time-dependent mass fractionation, with a lighter isotope's ion beam being enhanced with respect to the heavier isotopes under the usual data collection regime. An accurate assessment of the isotopic composition and atomic weight of an element must involve a correction for isotope fractionation, which will have the effect of decreasing the magnitude of the lighter isotopes with respect to the heavier isotopes, and therefore slightly increase the atomic weight. The magnitude of the isotope fractionation can be determined by calibrating the mass spectrometer, provided two enriched isotopes of Yb are available in sufficient quantity and purity to prepare gravimetric spikes of the two enriched isotopes. Approximately 51 mg of ^{171}Yb and ^{176}Yb were obtained from the Oak Ridge National Laboratory (ORNL) in the metallic form. The metal was used rather than the oxide because it minimizes the risk of possible stoichiometric effects. The purity of the enriched ^{171}Yb and ^{176}Yb spikes was determined by a spark source mass spectrographic analysis of each isotope by ORNL.

3. Results and discussion

3.1. Linearity

A sample of NIST 985 for K was dissolved in ultrapure 1 M HCl and loaded on the two side filaments of a triple Re filament assembly in the VG 354 TIMS. The mean of the measured isotope ratios of four replicate analyses of NIST 985 are given in Table 1 together with the calibrated values. The isotope fractionation of the measured ^{39}K/^{41}K ratio has been evaluated with respect to the calibrated value of 13.8566 using an exponential isotope fractionation correction factor. This isotope fractionation has been applied to the measured ^{40}K/^{41}K ratio to give a value of 0.0017297 ± 0.0000050, which is in agreement with the calibrated value within experimental uncertainties. The assumption has been made that the measured ^{39}K/^{41}K value is not affected by non-linearity effects, since the magnitude of this isotope ratio is 13.8566, and the same VG 354 is routinely used to measure NIST ICRMs for Sr and Pb with similar isotope ratio magnitudes, without difficulty. Thus the linearity of the VG 354

Table 2
Details of primary solutions A (^{171}Yb) and B (^{176}Yb)

Sample	A	B
Form	Yb metal	Yb metal
Purity (%)	99.99 ± 0.01	99.88 ± 0.02
Weight (mg)	50.81 ± 0.01	50.90 ± 0.01
Weight of solution (g)	19.60740 ± 0.00001	20.31317 ± 0.00001
Concentration of Yb in solution (μg/g)	2591.11 ± 0.77	2502.76 ± 0.77

Table 3
The mean of four replicate analyses of the measured isotope ratios of the two enriched isotopes ^{171}Yb and ^{176}Yb (samples A and B), respectively

Isotope ratio	A	B
^{168}Yb/^{174}Yb	0.00383 ± 0.00001	0.00058 ± 0.00011
^{170}Yb/^{174}Yb	0.4316 ± 0.0002	0.03147 ± 0.00012
^{171}Yb/^{174}Yb	64.750 ± 0.047	0.1598 ± 0.0002
^{172}Yb/^{174}Yb	3.939 ± 0.006	0.2569 ± 0.0002
^{173}Yb/^{174}Yb	0.7985 ± 0.0007	0.2691 ± 0.0003
^{176}Yb/^{174}Yb	0.2254 ± 0.0005	49.222 ± 0.051

The uncertainties are at the 95% confidence level and are based on the repeatability of the four replicate analyses of A and B.

Table 4
Isotopic compositions of samples A and B (in at.%), determined from the isotope ratios in Table 3

Isotope	A (%)	B (%)
^{168}Yb	0.00538 ± 0.00001	0.0011 ± 0.0002
^{170}Yb	0.6066 ± 0.0005	0.0618 ± 0.0002
^{171}Yb	91.007 ± 0.010	0.3137 ± 0.0005
^{172}Yb	5.536 ± 0.009	0.5043 ± 0.0006
^{173}Yb	1.1223 ± 0.0012	0.5283 ± 0.0008
^{174}Yb	1.4055 ± 0.0009	1.963 ± 0.002
^{176}Yb	0.3168 ± 0.0007	96.628 ± 0.004
Total	100.0	100.0

The uncertainties are at the 95% confidence level.

detecting system has been demonstrated with respect to three ICRMs–NIST 985, 987 and 981, over at least a magnitude of 577, which is in excess of the largest Yb isotope abundance differential of approximately 245 [10].

3.2. Determination of isotope fractionation

Approximately 51 mg of ^{171}Yb and ^{176}Yb in the metallic form, were accurately weighed, and then dissolved in ultrapure 1 M HCl in two precleaned containers marked primary solutions A and B, respectively. Details of the two primary solutions are given in Table 2.

Aliquots of the two primary solutions A and B were then measured in the VG 354 TIMS in an identical manner as for the laboratory standard. The means of the isotopic composition of four replicate analyses of A and B are listed in Table 3, the uncertainties of the means being at the 95% confidence level. The isotope abundances of the ^{171}Yb and ^{176}Yb primary solutions were calculated from the isotope ratios as listed in Table 4.

Four aliquots of the primary solutions A and B were accurately weighed and thoroughly mixed to produce a number of mixed solutions AB 1–4 to give a spread in the ^{171}Yb/^{176}Yb ratio. The ^{171}Yb/^{176}Yb ratios could be calculated from the weighed amounts of the primary solutions, W_A and W_B knowing the concentrations of the primary solutions and the isotopic composition of the enriched isotopes ^{171}Yb and ^{176}Yb. The relevant data are given in Table 5. The isotopic composition of each of the four mixed solutions AB, were measured on four separate occasions using the same mass spectrometric procedures as before, and the means of the ^{171}Yb/^{176}Yb ratios are given in Table 6, together with the uncertainties at the 95% confidence level. The measured ^{171}Yb/^{176}Yb ratios for each of the four mixed solutions AB could then be compared with the calculated

Table 5
Details of the sample weights of primary solutions A (^{171}Yb) and B (^{176}Yb) for four mixtures AB, together with their gravimetrically calculated and experimentally measured ^{171}Yb/^{176}Yb ratios, and the permil deviations δ, for each mixture

Mixture	W_A (g)	W_B (g)	(^{171}Yb/^{176}Yb)$_{meas}$	(^{171}Yb/^{176}Yb)$_{calc}$	δ (‰)
AB 1	2.2752 ± 0.0001	1.8036 ± 0.0001	1.2602 ± 0.0030	1.2280 ± 0.0014	5.24 ± 0.02
AB 2	0.5112 ± 0.0001	0.9939 ± 0.0001	0.5168 ± 0.0010	0.5041 ± 0.0013	5.14 ± 0.02
AB 3	1.0280 ± 0.0001	0.9951 ± 0.0001	1.0326 ± 0.0022	1.0070 ± 0.0013	5.08 ± 0.02
AB 4	1.0276 ± 0.0001	0.9926 ± 0.0001	1.0357 ± 0.0027	1.0091 ± 0.0014	5.25 ± 0.02

The uncertainties are at the 95% confidence level.

Table 6
The measured isotope ratios of Yb for the four mixtures AB produced by mixing known amounts of solutions A (^{171}Yb) and B (^{176}Yb), details of which are given in Table 5

Mixture	^{168}Yb/^{174}Yb	^{170}Yb/^{174}Yb	^{171}Yb/^{174}Yb	^{172}Yb/^{174}Yb	^{173}Yb/^{174}Yb	^{176}Yb/^{174}Yb
AB 1	0.00216 ± 0.00082	0.2283 ± 0.0008	31.719 ± 0.048	2.0644 ± 0.0012	0.5290 ± 0.0008	25.170 ± 0.022
AB 2	0.00142 ± 0.00031	0.1426 ± 0.0012	18.290 ± 0.021	1.2953 ± 0.0008	0.4184 ± 0.0002	35.388 ± 0.032
AB 3	0.00193 ± 0.00056	0.2076 ± 0.0003	28.510 ± 0.043	1.8797 ± 0.0009	0.5024 ± 0.0003	27.610 ± 0.020
AB 4	0.00193 ± 0.00029	0.2079 ± 0.0005	28.558 ± 0.045	1.8828 ± 0.0005	0.5030 ± 0.0005	27.574 ± 0.028

The uncertainties are at the 95% confidence level.

Table 7
Replicate analyses of the isotope abundance ratios of the Yb laboratory standard (ESPI) as measured with the VG 354 TIMS

	^{168}Yb/^{174}Yb	^{170}Yb/^{174}Yb	^{171}Yb/^{174}Yb	^{172}Yb/^{174}Yb	^{173}Yb/^{174}Yb	^{176}Yb/^{174}Yb
Yb #1	0.003982	0.09521	0.4472	0.6847	0.50560	0.4013
Yb #2	0.003982	0.09525	0.4474	0.6848	0.50565	0.4012
Yb #3	0.003983	0.09526	0.4474	0.6849	0.50566	0.4012
Yb #4	0.003969	0.09520	0.4472	0.6846	0.50557	0.4014
Yb #5	0.003981	0.09519	0.4472	0.6846	0.50556	0.4014
Yb #6	0.003980	0.09528	0.4475	0.6849	0.50568	0.4012
Yb #7	0.003977	0.09509	0.4468	0.6842	0.50543	0.4016
Yb #8	0.003961	0.09501	0.4465	0.6840	0.50533	0.4018
Yb #9	0.003963	0.09494	0.4463	0.6837	0.50526	0.4019
Yb #11	0.003970	0.09502	0.4466	0.6840	0.50536	0.4017
Yb #13	0.003960	0.09492	0.4462	0.6836	0.50521	0.4019
Yb #14	0.003962	0.09490	0.4462	0.6836	0.50518	0.4020
Yb #15	0.003967	0.09497	0.4464	0.6838	0.50528	0.4018
Yb #16	0.003962	0.09495	0.4463	0.6838	0.50526	0.4019
Yb #17	0.003968	0.09520	0.4472	0.6847	0.50558	0.4014
Mean	0.003971	0.09509	0.4468	0.6843	0.50544	0.4016
	0.000004	0.00007	0.0002	0.0002	0.00009	0.0002
Fractionated corrected	0.00385 ± 0.00003	0.0931 ± 0.0004	0.4398 ± 0.0016	0.6771 ± 0.0016	0.5028 ± 0.0006	0.4058 ± 0.0009

The uncertainties of the means of the isotope ratios of the 17 analyses are at the 95% confidence level, as are the uncertainties of the isotope fractionation-corrected ratios.

^{171}Yb/^{176}Yb ratios, to give an isotope fractionation δ expressed as permil per mass unit, such that

$$\delta = \frac{(^{171}\mathrm{Yb}/^{176}\mathrm{Yb})_{\mathrm{measured}} - (^{171}\mathrm{Yb}/^{176}\mathrm{Yb})_{\mathrm{calculated}}}{5 \times (^{171}\mathrm{Yb}/^{176}\mathrm{Yb})_{\mathrm{calculated}}}$$

The mean of the four such deviations δ, is 5.18 ± 0.05 permil per mass unit.

The laboratory standard (ESPI) Yb was measured on a number of occasions on the VG 354 mass spectrometer under as identical mass spectrometric conditions as possible. Seventeen replicate analyses of this ESPI sample are listed in Table 7. Each replicate analysis comprised at least 100 ratios for each isotope. The grand mean of the 17 Yb isotope analyses has been calculated and listed in Table 7. The uncertainties of the mean of each isotope ratio is at the 95% confidence level. The isotope fractionation of 5.18 ± 0.05 permil per mass unit, determined by calibrating the VG 354 TIMS with the ^{171}Yb and ^{176}Yb enriched isotopes, has then been applied to the measured isotope ratios, to give a fractionation-corrected set of isotope ratios for Yb which are also listed in Table 7. The uncertainties associated with the fractionation-corrected isotope ratios have been derived by applying the uncertainty of $\delta = \pm 0.05$ permil, to the mean of the uncorrected ratios, taking into account the uncertainties of the means of the measured ratios.

If the relative atomic masses of Audi et al. [12] are used together with the corrected isotope abundances of Yb, an atomic weight of 173.054 ± 0.001 can be calculated. The atomic weight of Yb determined in this experiment, is in agreement with the presently-accepted standard atomic weight A_r(Yb) = 173.04 ± 0.03 [7], but with a much smaller uncertainty.

4. Conclusions

The “absolute” isotopic composition of Yb has been determined using a VG 354 TIMS whose linearity has been demonstrated over nearly four orders of magnitude using the K ICRM NIST 985, together with good abundance sensitivity in the mass region $167 \leq A \leq 177$. Special attention was paid to monitor potential isotope interferences of ^{168,170}Er, ^{176}Lu and ^{174,176}Hf. Two enriched isotopes ^{171}Yb and ^{176}Yb were used to calibrate the mass spectrometer used in this experiment, which enabled the isotope fractionation of the Yb isotopes to be determined as 5.18 ± 0.05 permil per mass unit.

The isotope fractionation correction factor for ^{171}Yb/^{176}Yb was then applied to all the other measured isotope ratios to give a final isotopic composition in which the isotope abundances are as follows: ^{168}Yb = 0.1232 ± 0.0004%; ^{170}Yb = 2.982 ± 0.006%; ^{171}Yb = 14.086 ± 0.020%; ^{172}Yb = 21.686 ± 0.019%; ^{173}Yb = 16.103 ± 0.009.%; ^{174}Yb = 32.025 ± 0.012%; ^{176}Yb = 12.995 ± 0.0013%. If the solar system abundance of Anders and Grevesse [13] of 0.2479 (with respect to Si = 10^6 atoms) is adopted, the solar abundances of the seven Yb isotopes are as follows: ^{168}Yb = 0.000305; ^{170}Yb = 0.00739; ^{171}Yb = 0.0349; ^{172}Yb = 0.0538; ^{173}Yb = 0.0399; ^{174}Yb = 0.0794; ^{176}Yb = 0.0322. The solar abundances for the p-only process nuclide ^{168}Yb of 0.000305 ± 0.000001 and the s-only process nuclide ^{170}Yb of 0.00739 ± 0.00001 (with respect to Si = 10^6 atoms) are of importance in astrophysics (e.g., [14]), and should be adopted in future nucleosynthetic calculations. The atomic weight calculated from these isotope fractionation-corrected abundances give a value of A_r(Yb) = 173.054 ± 0.001, which will enable the present standard atomic weight of A_r(Yb) = 173.04 ± 0.03 to be reevaluated by CIAAW. The “best” measurement of the isotopic composition of Yb from a single terrestrial source, needs to be re-examined by CIAAW as a result of the data reported in this paper.

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