APMP comparison of the activity measurements of Ce-139

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Abstract

International comparisons on radioactivity measurements of ^{139}Ce was carried out within the framework of the Asia-Pacific Metrology Programme (APMP). One ampoule source was also sent to the SIR/BIPM in order to link this regional comparison to the BIPM key comparison reference values (KCRV). In total, 9 laboratories took part in this comparison, and 6 laboratories undertook absolute measurement.

1. Introduction

The regional key comparison of ^{139}Ce was planned in the 3rd meeting of APMP/TCRI in Singapore, and started as the official RMO key comparison as APMP-RI(II)-K3-04. The coordinating laboratory was the NMIJ/AIST, and in total, 9 institutes took part in the comparison. The radioactive sources were delivered in February 2004 to all participants and also to the BIPM/SIR. Finally, 6 institutes performed measurement with their own methods and reported to the coordinating laboratory. These 6 results have been agreed within the uncertainties, and are expected to be linked to the BIPM/SIR.

2. Source preparation

The original solution of ^{139}Ce was provided from Cyclotron Co. Ltd, Obninsk of Russia, with the chemical form of $CeCl_2$, and about 70MBq/g of specific activity. After rough measurement and impurity check, this original solution was diluted by 0.1N HCl with 100μg/g of $CeCl_2$ carrier to be about 0.5MBq/g. Then diluted solution was transferred to the NMIJ standard 5ml type ampoules and also to the BIPM/NIST type ampoule. The NMIJ type ampoules were delivered to all participants, and BIPM/NIST type was sent to the SIR. All these ampoules were measured by ionization chamber before shipping, and the standard deviation of specific output current (pA/g) was within 0.03%.

3. Participants and standardization methods

Table 1 shows the list of participating laboratories. Six laboratories from three different RMOs took part in this comparison. Most laboratories selected 4π(pc)e,X-γ-coincidence method, while one laboratory used 4π (LS)e,X-γ-coincidence counting, and one laboratory tried to use very thin NaI(Tl) to detect K-X rays as the EC event trigger counter.

Table 1. List of the participants in the APMP-RI(II)-K3-04

NMI	Full name	Country	Regional metrology organization
NMIJ/AIST	National Metrology Institute of Japan / National Institute of Advanced Industrial Science and Technology	Japan	APMP
KRISS	Korea Research Institute of Standards and Science	Korea	APMP
NIM	National Institute of Metrology	China	APMP
INER	Institute of Nuclear Energy Research	Chinese Taipei	APMP
CSIR-NML	CSIR National Metrology Laboratory	South Africa	SADCMET
VNIIM	D. I. Mendeleyev Institute for Metrology	Russia	COOMET

4. Result and Conclusion

Table 2 shows the standardization methods and their results with uncertainties and E_n evaluation values. Figure 1 shows the present results listed in the table 2. As shown in the figure 1 and table 2, all present results passed the E_n evaluation to the present mean and its deviation. These results will be re-evaluated comparing with the KCRV of BIPM/SIR. The detailed uncertainties of each participant were listed in the table 3.

In the present average value, the test results of VNIIM was not included because we selected only one value from one laboratory. This new coincidence technique used very thin NaI(Tl) detector (0.1mm of thickness and 20mm diameter with Be window) for "β-channnel" instead of conventional beta counter, measuring only K-X-rays from Ce-139. Most of gamma radiation pass through this thin NaI(Tl), and detected by the main NaI(Tl) This system can arrange the γ-counter just close to the trigger detector, and works excellent for electron capture radionuclide with relatively high γ-energy and low emission rate radionuclide such as ^{51}Cr. In the present measurement, 166keV γ-rays from ^{139}Ce were not estimated 100% pass through the trigger counter, so that uncertainty was increased somehow, but the result was in good agreement as shown in the table 2.

The CSIR-NML tried to use a small LS vial for β-counter, and made coincidence measurements with a 3" by 3" NaI(Tl) counter. They measured 8 samples and averaged value was 312.9 with standard deviation of 0.09%. Finally taking into many other uncertainty factors, total uncertainty became 0.53%(1σ). These detailed uncertainty evaluation was listed in the table 3.

Table 2. Standardization methods of the participants and their results

NMI	Method used	Activity (kBq/g)*	Relative uncertainty (k=2)	E_n value***	Date of measurement
NMIJ/AIST	4P-PC-MX-NA-GR-CO	311.8	0.37%	-0.18	2004/03/16
KRISS	4P-PP-MX-NA-GR-CO	309.8	0.72%	-0.57	2004/06/13
NIM	4P-PC-MX-NA-GR-CO	316.5	1.04%	0.71	2004/06/20
INER	4P-PC-MX-NA-GR-CO	312.1	0.63%	-0.10	2004/06/01
CSIR-NML	4P-LS-MX-NA-GR-CO	312.9	1.06%	0.05	2004/03/31
VNIIM	4P-PC-MX-NA-GR-CO (4P-NA-KX-NA-GR-CO)	312.5 (309.8)	0.24% (0.90%)	-0.02	2004/04/28
Average		312.6**	1.4%**		

* reference date = 0:00 h UTC of 1st March 2004
** without test trial (4P-NA-KX-NA-GR-CO) of VNIIM
***E_n=(Result-Average)/SQRT(U_{res}**2+U_{ave}**2)

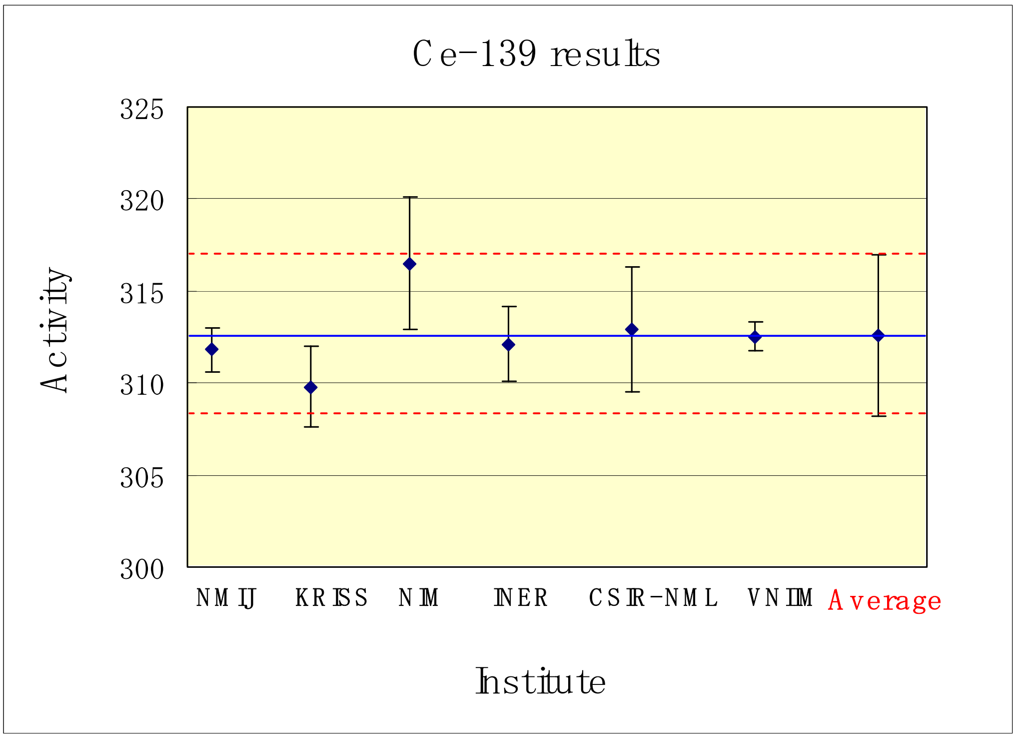

Figure 1. Results of APMP-RI(II)-K3-04

Table 3. Uncertainty components and estimated values.

Item No.	Function	NMIJ/ AIST	KRISS	NIM	INER	CSIR- NML	VNIIM
1	counting statistics	0.05*	0.23	0.25	0.1	0.09	0.06
2	weighing	0.02*	0.10	0.10	0.01	0.015	0.01
3	dead time	0.01	0.10	0.03	0.01	0.05	0.04
4	background	0.01	0.05	0.02	0.01	0.01	0.006
5	resolving time	0.03	0.05	0.05	0.01	<0.01	0.003
6	Gandy effect	<0.01	--	--	--	--	--
7	counting time	0.01	0.01	--	0.01	--	--
8	adsorption	--	0.02	0.03	--	0.002	--
9	impurities	--	--	--	--	--	0.0015
10	decay-scheme parameters	--	--	--	0.05	--	--
11	half life $T_{1/2}$ =137.64	0.01	0.002	0.02	0.01	0.002	0.005
12	self absorption	--	--	--	--	--	--
13	extrapolation of efficiency curve	0.17	0.22	0.43	0.29	0.42	0.09
14	other effects	--	--	0.08**	--	0.30***	--
combined uncertainty (1σ)		0.18	0.36	0.52	0.32	0.53	0.12

*Random components of counting and weighing are included in the extrapolation of efficiency.
**Evaluate the repeatability of results of measurements.
***Satellite pulses.

In conclusion, the APMP key comparison of APMP-RI(II)-K3-04 for ^{139}Ce radioactivity was successfully done. In total, 6 national laboratories from 3 different regions undertook absolute measurements, and all the results agreed within their uncertainties. The present results will be linked to the BIPM KCRV through the NMIJ/AIST value submitted to the BIPM/SIR.

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