Evaluation of Uncertainty in the Analysis of Uranium Powder Using Alpha Spectrometry with ^{232}U Tracer

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1. Introduction

Destructive analysis is used to verify that protracted diversion of safeguard nuclear materials has not occurred [1]. Uranium isotope an be analysed using alpha spectrometry, in some experimental groups[2]. Furthermore to obtain meaningful and sufficiently accurate results using alpha spectrometry, it is necessary to demonstrate uncertainty for each steps[3]. The aim of this paper is focused on the evaluation of uncertainty for each procedures in the analysis of uranium isotope using alpha spectrometry[5,6].

2. Methods and Results

2.1 Sample preparation

Uranium Powder were provided by Korea Electric Power Corporation-Nuclear Fuel (KEPCO-NF). The powder samples were weighed out accurately about 1mg using micro balance (XP2U, Mettler-Toledo, Inc.) and then charged into the teflon vessel with 8M HNO_3. Microwave digestion system(START D, Milestone, Inc.) with the Teflon vessels was used to dissolve uranium powder under 400 W at 110℃ for 2 hours as soon as putting ^{232}U tracer into teflon vessels. After digestion procedure, the samples in the teflon vessels were taken 1~2 mℓ. The pH was adjusted to 1.7 and controlled with NH_4OH(base) and (1:9) H_2SO_4 (acid) with the litmus paper. For preparation of SUS disk for alpha spectrometry, the solution was put in the electrodeposition cell which was made of teflon. The anode was a platinum wire and operation condition was maintained by 1A for 2hours. The disks were heat by fire until hot after electro- deposition[4].

2.2 Determination of the activity concentration

The activity concentration are determined as follows:

$$A(U_i) = \frac{C(U_i)}{C(^{232}U) \times S(g, amount)} \times A(Bq, ^{232}U) \quad (1)$$

Where, A is activity concentration of uranium isotope, C is net counts of uranium isotope, S is amounts of sample and U_i is isotope uranium(^{234}U,^{235}U,^{238}U respectively). The alpha spectrometry has a great affect on the factor of C in the equation and the measurement of mass and volume also have influence with S and A(^{232}U tracer) respectively. The schematic fish born including schematic diagrams of analysis procedure using alpha spectrometry is shown in Fig. 1.

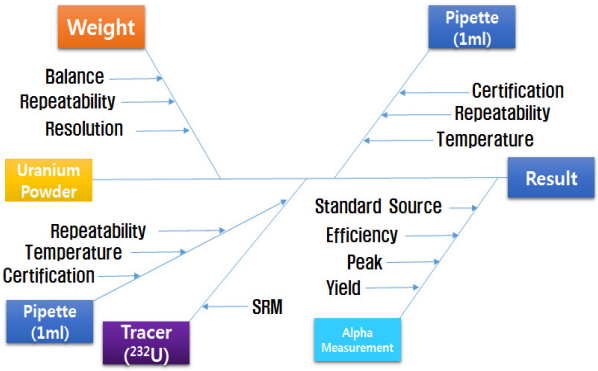

Fig. 1. The schematic fish-born of analysis procedure.

2.3 Evaluation of measurement uncertainty

All of uncertainty factor is shown in Table. 1.

Table 1. The type of uncertainty and value

Group		Uncertainty type		Expression	Value	Reference
1	Weigh(Balance)	B type	Certification	u_{weigh}	0.00018	certificated by Mettler-Toledo
2	Tracer NPL	B type	Certification	u_{NPL}	0.005	certificated by NPL
	Tracer Pipette	B type	Certification	u_{pip}	0.0005	certificated by eppendorf
		B type	Temperature	u_{temp}	0.00031	·
3	Volume (Pipette)	B type	Certification	u_{pip}	0.0005	certificated by eppendorf
		B type	Temperature	u_{temp}	0.00031	·
4	Instrument (Alpha spectrometry)	B type	Standard source	u_{ss}	0.018	certificated by Eckert&Ziegler
		A type	Efficiency	u_{eff}	0.016	·
		A type	Yield	u_{yield}	0.11	·
		A type	Peak(^{234,235,238}U)	$u_{234peak}$	0.004	·
				$u_{235peak}$	0.044	·
				$u_{238peak}$	0.99	·

In the case of temperature factor in pipette, our lab is reasonable to assume that the temperature does not differ from 20℃ by more than 4 degrees.

2.4 Calculation of uranium enrichment from concen -tration of isotope uranium

$$C(U_i, \mu g/g) = \frac{A(U_i, Bq/g)}{\gamma_i(Bq/\mu g)} \qquad (2)$$

where, γ_i = Specific activity of uranium isotope

- $^{234}\gamma = 2.30 \times 10^{14}$ Bq/μg
- $^{235}\gamma = 8.0 \times 10^{10}$ Bq/μg
- $^{238}\gamma = 1.24 \times 10^{10}$ Bq/μg

U_i = **I**sotope uranium

A = Activity concentration of uranium isotope

C = Mass of uranium isotope

3. Conclusions

The main resource of uncertainty were identified as uncertainties associated with the measurement using alpha spectrometry which are difficult to reduce.

4. References

[1] SAFEGUARDS TECHNIQUES AND EQUIPMENT: 2011 EDITION, INTERNATIONAL NUCLEAR VERIFICATION SERIES No. 1 (ReV. 2), IAEA, 2011.

[2] M.P Rubio, Montero, A. Martin Sanchez, A.M Carrasco Lourtau "Isotopic uranium and plutonium analysis by alpha-particle spectrometry" Nuclear Instruments and methods in Physics Research B 213 (2004) 429-433.

[3] Dr. ASHRAF E. M. KHATER "RECENT DEVELOPMENT IN RADIOCHEMICAL ANALYSIS FOR SAFEGUARDS PURPOSES" Nuclear Safeguards and Physical Protection Department National Center for Nuclear Safety and Radiation Control Atomic Energy Authority Cairo-Egypt, 2005.

[4] Jong-Ho Yoon etc "The Capability of isotopic uranium analysis in nuclear material at KINAC" Transactionso of the korean Nuclear Society Spring Meeting Jeju, Korea, May 7-8, 2015.

[5] ISO Guide for "the expression of uncertainty in measurement(GUM)" (1998).

[6] The IAEA Guide on Quantifying uncertainty in nuclear analytical measurement" (1999).