Rapid Screening and Analysis of Uranium Particles in Safeguards by using an UV/Vis spectrophotometer

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1. Introduction

IAEA required each State to develop a verification method of nuclear material presented in the State's accounts. Depending on the safeguards objectives, Korea Institute of Nuclear Nonproliferation and Control (KINAC) currently focuses on how to effectively and quickly analyze various samples such as concrete, graphite and aluminum via DA (Destructive Analysis) techniques [1, 2].

Alpha spectrometry or ICP-MS are typically applied to assess uranium particle concentration but they suffer from long measurement time, high cost and etc.

UV/Vis spectrophotometry is a comparatively easy substitute method and generally used in chemistry since it is featured by its good accuracy and lower cost compared with other methods [3].

Therefore, with the purpose of safeguards, UV/Vis spectrophotometry was applied to determine uranium concentration in a concrete sample, produced through nuclear fuel fabrication.

2. Experimental

2.1. Sample

A concrete sample is mixed with some liquid added in nuclear fuel fabrication process. The final form of the sample is similar to sludge like Fig. 1.

Fig. 1. Concrete sample mixed with processed liquid waste

The sample used in this study was provided by Korea Electric Power Corporation-Nuclear Fuel (KEPCO-NF).

2.2. Apparatus and Reagents

A LAMBDA 365 photometer (PerkinElmer) using 1.0 cm quartz cell was employed for spectrophotometric analysis. Its measuring wavelength range was 400 to 800 nm and scanning speed was 600 nm/min.

Total 350 μl of ^{235}U standard solution (IRMM) was used as a standard sample in order to compare with the concrete sample, quantitatively.

Arsenazo Ⅲ solution; Arsenazo Ⅲ (Kanto) 0.25 *g* and 0.5 N NaOH 1 *ml* were added into a 100 *ml* volumetric flask with deionized water.

2.5 % DTPA solution; Diethylenetriaminepenta-acetic acid (DTPA) (Kanto) 2.5 *g* in 100 *ml* deionized water and dropwise addition of 0.5 N NaOH 10 *ml*. It used to supernatant liquid.

10 % tartaric acid; Tartaric acid (Daejung) 10 *g* in 100 *ml* deionized water.

HNO_3 (pH 2.0); HNO_3 (Merck) 1 *ml* in 400 *ml* deionized water and adjusted to pH 2.0 with 0.5 N NaOH.

2.3 Procedure

1) HNO_3 10 *ml* is added to 1 *g* of a concrete sample. The mixture is heated, filtered, poured into a 100 *ml* volumetric flask, and diluted by deionized water.
2) The solution for UV/Vis spectrophotometer contains of arsenazo Ⅲ 0.2 *ml*, 2.5 % DTPA 0.4 *ml*, and 10 % tartaric acid 0.2 *ml*. The solution is poured into a 10 *ml* volumetric flask.
3) Sample preparation
   3-1) Blank: No uranium solution.
   3-2) Standard Group: ^{235}U standard solution (0.05 *ml*, 0.1 *ml*, and 0.2 *ml*)
   3-3) Sample Group: A concrete sample solution (0.1 *ml*, 0.2 *ml*, 0.3 *ml*, 0.4 *ml* and 0.5 *ml*)
   ※ Above solutions are diluted by HNO_3 (pH 2.0).
4) After stabilizing (5 min), the absorbance of the uranium-arsenazo Ⅲ complex is determined against a HNO_3 (pH 2.0).

3. Results and Discussion

3.1 Color Characteristics

The color of the UV/Vis spectrophotometer solution was changed immediately when ^{235}U standard or concrete sample were added to arsenazo Ⅲ solution. Besides, different color can be appeared depending on concentration of uranium. The experimental results are shown in Table 1 and Fig. 2.

Table. 1. Color characteristics per sample

Sample	Type	Volume (*ml*)	Color
A	Nothing	0	Pink
B	^{235}U standard	0.05	Dark violet
C		0.1	Navy
D		0.2	Bluish green
E	Concrete sample	0.1	Pink-violet
F		0.2	Light violet
G		0.3	Violet
H		0.4	Dark violet
I		0.5	Dark violet

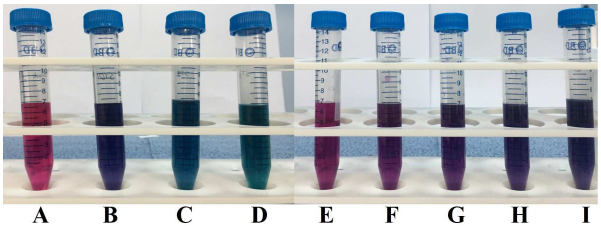

Fig. 2. The solution for UV/Vis spectrophotometer

These color characteristics can be a tracer to visually decide uranium concentration.

3.2 Spectrum Characteristics

Fig. 3 and Fig.4 show the relationship between blank and containing of uranium. They show that spectrum peaks shift to longer wavelength (Redshift) when uranium is existed in the solution. In addition, the absorbance of arsenazo Ⅲ oppositely decreases if the concentration of uranium ions increases.

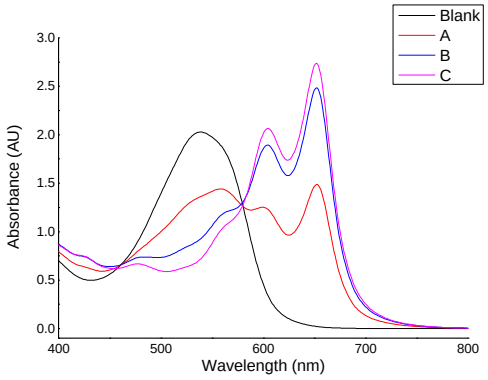

Fig. 3. Absorption spectra of ^{235}U standard solution

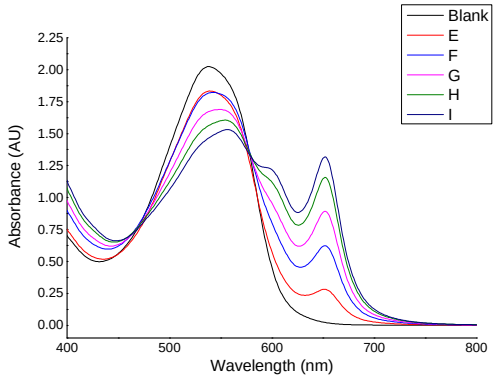

Fig. 4. Absorption spectra of concrete sample solution

4. Conclusions

This study was conducted how to quickly decide uranium concentration based on the color and spectrum characteristics using UV/Vis spectrophotometry.

The experimental results showed the possibility that this UV/Vis spectrophotometry can be used to effectively and quickly analyze uranium concentration. Further step will repeat measurement with different types of samples such as graphite and aluminum, optimize the experimental procedure, and apply this technique for safeguards inspection.

REFERENCES

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[3] Golmohammadi H, Rashidi A, Safdari S. J, “Simple and rapid spectrophotometric method for determination of uranium (Ⅵ) in low grade uranium ores using arsenazo (Ⅲ)”, Chemistry & Chemical technology, Vol. 6, No.3, 2012