Study on the flow rate of Column in Uranium Separation and Extraction

Uk-Ryang Park, Seunghoon Park, Heejun Chung, Aeri Lee, Sung-Woo Kwak *
Korea Institute of Nuclear Non-proliferation and Control, Yuseong-daero, Yuseong-gu, Daejeon, Korea 305-348
**Corresponding author: swkwak@kinac.re.kr*

1. Introduction

The technology for analysis of environmental samples is a very useful for monitoring and tracking of declared and undeclared nuclear activities. Korea Institute of Nuclear Nonproliferation and Control (KINAC) developed the technology and equipment which can be used to detect uranium on facility sites in order to detect both declared and undeclared nuclear activities. In particular, among various environmental samples, the measurement of uranium in the air is an important activity which can be used to verify the use of authorized nuclear materials in nuclear facilities. In order to measure uranium in the air, it is required an air-sampling process, pre-conditioning processes, processes of separating and extracting uranium, processes of fabricating the standard source and measurements [1, 2]. However, radioactive chemical processes are mainly carried out in the laboratory for precise analyses. The methods have a lot of problems on sites. The column chromatography for separation of uranium from the mixture of environment sample is a complex and long process.

In this study, in the stage of separating and extracting uranium during the radioactive chemical processing, the injection flow rate of column chromatography was controlled in order to reduce the process time comparing the recovery rate of uranium.

2. Experimental Methods & Results

2.1 Experimental Materials

The ion exchange resin used for the separation and extraction of uranium is the UTEVA resin (Eichrom) [3]. In order to calculate the recovery rate of uranium, ^{232}U Tracer (Isotope Products Lab, USA) was used. By using the special reagent for analyses (Merck) and the column for separation and extraction (20ml, Eichrom), pure uranium was separated.

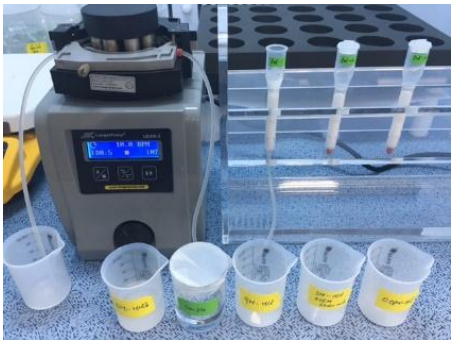

Fig. 1. LEAD2- Flow rate peristaltic tubing pump.

Regarding the change of the injection flow rate of the column, the LEAD2- Floerate peristaltic tubing pump (Longerpump), which could provide the precise control of 0.005 to 75 ml/min based on the size of the tube, was used (Fig 1). For the fabrication and analysis of the uranium standard source, the electrodeposition equipment and the alpha-particle spectrometer were used.

2.2 Experimental Method

For the separation and extraction of uranium, the experimental device was set up. For the control of the injection flow rate of the column, the teflon tube (1.6 mmID × 1.6 mmWT) was directly connected to the end of the column. By pushing the tube through the LEAD2- Flow rate peristaltic tubing pump, the injection flow rate can be controlled. In the process of injecting samples and reagents for the separation and extraction of uranium, the previous method was applied. However, the flow rate for the injection of samples and the extraction of uranium within the column was fixed as 1 ml/min. When other reagents were injected, the experiment was carried out by changing the flow rate. The injection flow rate were set to be 1, 3, 5 and 7 ml/min. In order to minimize the experimental errors, 3 samples were applied for each injection flow rate. With the average value, the recovery rate of uranium was analyzed.

2.3 Results

Prior to this experiment, the injection flow rate test was carried out by using the pre-set device in order to evaluate the reproducibility of the injection flow rates of 1, 3, 5 and 7 ml/min, which were the conditions of the experiment. As a result, it was confirmed that injection flow rate of the column were 1, 3, 5 and 7 ml/min in case of the rotating speeds of the device being 2, 6, 10 and 14 rpm. The experiment was carried out by setting each rpm.

The pre-conditioned samples for the separation and extraction of uranium were input the column at different flow rates in order to get pure uranium. After measurement of each sample by alpha-particle spectrometer, the average recovery rate of uranium was calculated respectively. Consequently, it was able to obtain the results of 1 ml/min: 102.7 %, 3 ml/min: 90.2 %, 5 ml/min: 99.0 %, and 7 ml/min: 99.3 %. As shown in Fig. 2, the recovery rate of uranium for each injection flow rate was found to be relatively similar regardless of the injection flow rates. Therefore, when uranium was separated and extracted under the condition of the flow rate of 1 ml/min for the injection of samples and the separation of pure uranium, 7 ml/min, which is the maximum injection flow rate of the column among the

experimental conditions of the column, was found to have negligible influences on the recovery rate of uranium compared to the injection flow rate of 1 ml/min.

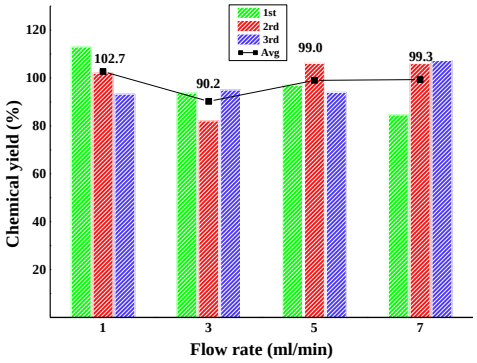

Fig. 2. The uranium recovery rate by the flow rate of the column.

3. Conclusion

Among the previous radioactive chemical processing methods, the column chromatography shows the limitation of the average flow rate of the column being about 1 ml/min in case of the separation and extraction of uranium. Therefore, in order to obtain pure uranium through the separation and extraction, the process time of more than 150 min is required. In this study, with the purpose of reinforcing safeguards and rapid investigation of declared and undeclared nuclear activities on facility sites, the process time have to reduce as increasing the injection flow rate in the stage of separating and extracting uranium as a part of the radioactive chemical processes for samples in the air. Also, in order to analyze uranium quickly, the injection flow rate of the column was changed in comparison with the recovery rate of uranium. As a result, when the flow rate for the injection of samples and the last extraction of pure uranium were set to be 1 ml/min, it was possible to have a similar recovery rate of uranium regardless of the injection flow rate. At the injection flow rate of 7 ml/min which is the maximum injection flow rate, the process time was about 75 min. Compared to the previous method, it was confirmed that the process time was able to reduce by about 50%.

In order to obtain the optimal injection flow rate for the separation and extraction of uranium in the future, it is necessary to carry out further experiments after re-establishing the injection flow rate condition of the column.

REFERENCES

[1] H. Kang, H. Chung, S. Park, J. Shin, S. KWAK, A Comparative Study on Radiochemical Pre-treatment Methods for Airborne Uranium-Isotropic Analysis, Journal of Radiation Protection and Research, Vol. 40, No. 2, p. 101-109, 2015.

[2] I. Riekkinen, T. Jaakkola, S. Pulli, S. Salminen, S. Ristonmaa, R. Rosenberg, R. Zilliacus, Analytical methods for wide area environmental sampling (WAES) for air filters, STUK-YTO-TR report No 184, 2002.

[3] E. P. Horwitz, M. L. Dietz, R. Chiarizia and H. Diamond, Separation and preconcentration of uranium from acidic media by extraction chromatography, Analytica Chimica Acta, Vol. 266, p. 25-37, 1992.