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Performance Assessment of Automatic Continuous Separating System for radiochemical analysis

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1. Introduction

Kori-1 and Wolsong-1, which had been commercially operated over 40 years and permanently shutdown in 2017 and 2019, respectively, are about to be decommissioning. It is expected that the radioactive waste (hereinafter RW) generated from the decommissioning is properly characterized and the radioactivity analysis of those waste is necessary for it. Thus, the demand for the analysis of RW will be increased as the decommissioning is progressed. Additionally, as the regulation rules is stricter, the request for the radio-characterization of RW will grow more than expected.

According to the NSSC 2020-11, some radionuclides requiring the chemical separation, such as Fe-55, Ni-59/63, Sr-90, and Tc-99, should be analyzed. In terms of the analysis, the chemical separation is challenging because it is time consuming and labor-intensive work. So, the automated separation system gets more attraction.

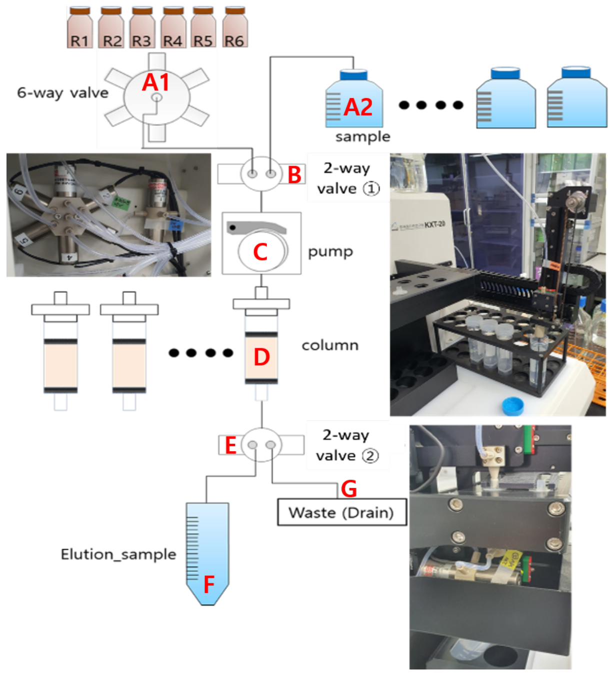
This study presents the home-made automated separation system, called with KXT-20 (Kaeri eXtraction Technology-20), which is modified from KXT [1]. KXT-20 is able to handle maximum twenty samples in a single run with the same analytical protocol. We evaluated the applicability of it for the separation of strontium-90 using Sr-resin.

2. Method and Results

2.1. Evaluation of the dead volume

Fig. 1. Appearance of KXT-20

KXT-20 has sample parts, column parts, and elution parts (Fig 1) and controlled by C# based operation software. KXT-20 uses many of tubes between valves, column, and pump, so that it has the volume for each part of tubes that does not need to be considered in the gravity method. It is called the dead volume. Characterization of the dead volume of automated separation system is essential to develop proper separation protocol. It is estimated using deionized water and the results are described in Fig 2.



Path in → out	Volume (mL)	Path in → out	Volume (mL)
A1 → B	1.5	E → F	1.3
A2 → B	7.7	R(1~6) → A1	6.9
B → C → D → E	15.0		

Fig. 2. Pathways to evaluate dead volume and the results

2.2 Set separation protocol

We developed the separation protocol for Sr resin referring to previously reported article [2]. Aside from KXT, which commercialized for automated nuclide separation, auto-sampler is equipped in KXT-20. So every sample requires the cleaning protocol to avoid the memory effect owing to potentially remained samples in the loading-tubing after the individual separation. The results are presented in Table 1.

	Reagent	Path in → out	KXT-20	
			Flow rate (mL/min)	R/V+D/V* (mL)
Conditioning	8M HNO_3	A1 → G	4	20
Loading	Sample	A2 → G	2	14
Rinsing	8M HNO_3	A1 → G	2	38
Elution	DIW	A1 → F	2	12
Cleaning	Cleaning DIW	Cleaning DIW → F	13.5	27

*R/V : Reagent Volume, D/V : Dead Volume

Table 1. Sr separation protocol of KXT-20

2.3 Comparison of performance between KXT-20 and Gravity method

We prepared 10 samples containing Sr, Ba, Ca and Y mixed standard solution (Accustandard) and applied them for KXT-20 to purify Sr from the sample using Sr resin (Eichrom, 50-100 μm) and estimated the recovery . Including cleaning steps, total elapsed time for 10 samples was about 6.7 hours and the average of Sr recovery was 91.6 ± 1.8 %.

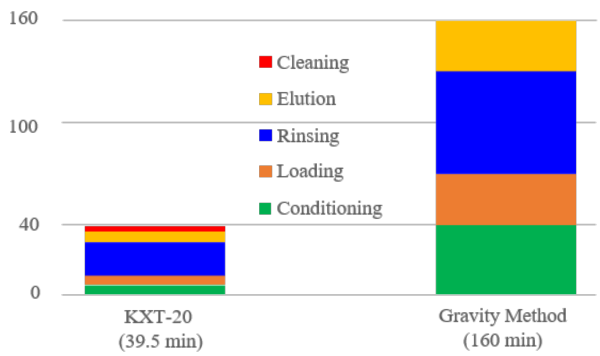


Fig. 3. Comparison of elapsed time per sample between KXT-20 and gravity method.

So as we can see in Fig.3, the separation time of KXT-20 is 4 times shorter than the gravity method. However, KXT-20 is able to handle samples one by one, so the total elapsed time for the separation is proportional to the number of sample. While KXT-20 was running, analyst did not have to pay attention to the equipment at all. KXT-20 is definitely a less-labor approach and has the strong point of securing the safety of the analyst during the separation. KXT-20 produces radioactive wastes very rarely because it does not require funnels, pipette tips or larger columns that used by gravity method. The gravity method has advantages to handle several samples, but it is most labor-extensive work.

3. Conclusion

The new automated separation system is presented and it is applied for the continuously separation of the radionuclide from a number of samples in a single run. It does require less labor compared with the gravity method, so is very effective way to handle lots of samples.

REFERENCES

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