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The Need for Performance Evaluation prior to Direct Use of Commercial Resin

Jung Bo Yoo, Hyo Jin An
Radioactive Waste Chemical Analysis Center, Korea Atomic Energy Research Institute (KAERI)
yoojungbo@kaeri.re.kr

1. Introduction

When low-and intermediate-level radioactive wastes are transferred to a permanent disposal site, it is essentia l to follow the transportation regulations provided by th e Nuclear Safety Commission for the safe storage of rad ioactive waste. According to the Announcement No. 20 21-26 of the Nuclear Safety Commission, it requires identifying the radiation levels of 13 radionuclides inclu ding ^{3}H, ^{14}C, ^{55}Fe, ^{58}Co, ^{60}Co, ^{59}Ni, ^{63}Ni, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, and ^{144}Ce, as well as transuranic radionucli des. Among these radionuclides, ^{55}Fe, ^{59}Ni, ^{63}Ni, ^{90}Sr, a nd ^{94}Nb are radioactive materials generated from nuclea r fission and material during the investigation process, e mitting low-energy X-rays and beta rays. Therefore, each radionuclide must be separated and purified individually for quantitative analysis. Especially for the ^{90}Sr radionuclide, expensive resins sold by companies such as Eichrom are commonly used for radionuclide analysis. The resin used for ^{90}Sr radionuclide analysis contains 1-octanol and 4,4'(4')-di-t-butylcyclohexano 18-crown-6 (crown ether) in an inert polymer support. Although the substance is composed of stable compounds, it has a very complex structure. Therefore, if small variables occur during the synthesis process, the performance of resin may be compromised.

In this study, a performance evaluation was conducted on Eichrom company`s Sr-resin used in ^{90}Sr radionuclide analysis prior to its use. Performance evaluation prior to the use of commercial resins was performed using non-radioactive Sr standards, and the recovery rates of radionuclides were confirmed by ICP-OES. To perform radionuclide analysis efficiently, performance evaluation prior to the use of commercial resins must be conducted, and this can lead to effects such as reduction of secondary analysis waste, increase in worker efficiency, and reduction of reanalysis rates.

2. Experimental Section

All chemicals used in the experiment were not subjected to any additional purification process, and distilled water was obtained by passing deionized water through Milli-Q plus Ultra-Pure Water System (Millipore). For measuring the separation and recovery efficiency of ^{90}Sr radionuclide, chemical-grade reagents for chemical transportation were used, which were Accustandard's ICP-OES standard solution (10,000 mg/mL), and 3 mg of Sr was added. Sr resin was purchased from Eichrom Technologies, LLC. For quantitative and qualitative analysis of metal ions in this experiment, an inductively coupled plasma optical emission spectrometer (ICP-OES, SPECTRO ACROSS) capable of simultaneous analysis of several elements was used.

3. Results and Discussion

(1) Manufacture of Sr radionuclide separation column

Fill a 4 mL separation column with 700 mg (B.H.: approximately 34 mm) of Sr-Resin and place a Frit on top. Run the interlocked pump in reverse at a rate of approximately 0.35 mL/min (pump speed: 1.0) to allow the resin to flow until it is submerged in distilled water and remove air. Pass 3 mL of 8 M HNO_3 through the column.

(2) Determination of Sr chemical yields

Dissolve 3 mg of Sr standard substance in 5 mL of 8 M HNO_3. Place a 100 mL plastic beaker under the Sr-Resin separation column prepared in (1) and pass the solution through it. Continue to pass 15 mL of 8 M HNO_3 and discard it. Place a vial (20 mL) under the separation column and elute Sr by passing 10 mL of 0.05 M HNO_3. After closing the lid and shaking well, mix 0.1 mL of the eluent with 10 mL of 0.05 M HNO_3 in a vial (20 mL), shake well, and quantify Sr by ICP-OES.

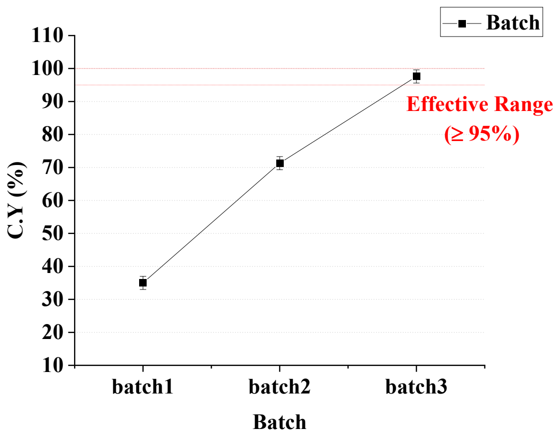

Fig 1. Comparison of the chemical recovery of each Sr resin for efficiency performance.

As the analysis results show, it was confirmed that the recovery rate performance of the Sr resin in batch 1 was at a level of about 40% without undergoing any separate chemical treatment. Since it is not possible to confirm the performance deterioration of the Sr resin manufacturing process, the exact cause of the performance degradation cannot be identified. However, it is assumed that batch 1 indirectly affected the Sr resin during storage as it was not stored in a desiccator after opening. Batch 2 and 3 were opened for performance testing despite being unopened, and batch 2 fell short of the target recovery rate at an average of about 70%. The average recovery rate of batch 3 was confirmed to be at a level of about 100%, which is within the normal range. This research result is not intended to raise general issues about the quality of commercial resins but is based on experience in specific cases only.

In brief, this study presents an evaluation of the performance of Sr resin before use across a total of three batches. The first batch was subjected to exposure for a certain duration under conditions where constant temperature and humidity were not maintained, resulting in a resin performance level below 40%. The second batch consisted of unopened resin stored under conditions where constant temperature and humidity were not maintained, with the resin demonstrating a performance level of around 70%. Finally, the third batch comprised unopened resin stored under conditions where constant temperature and humidity were maintained by storing in a desiccator, with the resin demonstrating a performance level of 100%. This highlights the influence of storage conditions on resin performance. Hence, it is strongly advised to conduct prior performance evaluation tests and utilize commercial resin only when the results confirm a minimum of 95% efficacy, before embarking on experimental procedures.

4. Conclusion

In order to verify the reliability of the performance of commercial resins, we conducted a performance evaluation of Sr resin prior to its use. From the standpoint of having purchased and used Sr resin for several years, the results presented in this study are highly specific cases. However, it cannot be guaranteed that the performance of all resins produced and sold is excellent. Therefore, researchers performing radiochemical analysis tasks are strongly recommended to conduct a performance evaluation of commercial resins before using them. Further study will aim to evaluate resin performance according to storage period and method, providing valuable information for researchers in this field.

5. Acknowledgement

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REFERENCES

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [1]. It is recommended that the number of references does not exceed five.

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