

## Separation of Sr nuclide from nuclide mixture generated from salt waste

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### 1. Introduction

Strontium-90 is utilized in various fields, such as a source for radioisotope thermoelectric generator (RTG), beta particle source and radiation therapy, due to its pure beta emission and high energy generation during nuclide decay [1-7]. Sr nuclides are generated in the form of salt waste through the pyrochemical process or nuclide management process under study at the Korea Atomic Energy Research Institute and could be separated through reactive distillation [8-10]. During the reactive distillation process, Ba nuclides are also separated due to their chemical similarity [10], and Sr-90 decays to Zr-90 during storage, so Sr nuclides exist as a mixture with Ba and Zr nuclides. To utilize Sr nuclide, Sr nuclide should be recovered with high purity from nuclide mixture. In this study, a process for separating and purifying Sr nuclides from a mixture of three nuclides (Sr, Ba and Zr) was established.

### 2. Methods and Results

In this study, a two-step precipitation reaction was used to separate Sr nuclides from impurity nuclides. The first reaction is separation of Ba/Zr nuclides through chromate precipitation with pH control, and the other reaction is separation of Sr nuclides in the filtrate using carbonate precipitation into SrCO<sub>3</sub>. The recovered SrCO<sub>3</sub> was dissolved in a hydrochloric acid solution, and then a carbonate precipitation reaction was repeated for the purification process. The established process is shown in Figure 1.

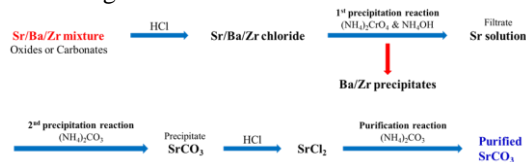


Figure 1. Schematic diagram of separation and purification process.

#### 2.1 Separation and purification study

The initial surrogate solution was assumed to have the same molar ratio of Sr, Ba and Zr in consideration of the storage period after the separation of Sr nuclides,

and the initial composition and precipitation conditions of each separation process are shown in Table 1.

Table 1. Composition of surrogates and precipitation conditions in each separation process.

		T1	T2	T3	T4	T5	
Aqueous solution of surrogates (Sr/Ba/Zr)	DI water	300 mL					
	SrCl <sub>2</sub>	2.00 g					
	BaCl <sub>2</sub>	2.62 g					
	ZrCl <sub>4</sub>	2.94 g					
First precipitation process	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>	Equivalents to Ba moles	1.1	1.25	1.6	2.2	4
		(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> (g)	2.11	2.40	3.07	4.22	7.67
	NH <sub>4</sub> OH	pH	4.7	4.7	4.7	4.7	4.7
Second precipitation and purification process	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>	Equivalents to Sr moles	6	6	6	6	6
		(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> (g)	7.24	7.24	7.24	7.24	7.24

#### 2.1.1 Chromate precipitation results

In chromate precipitation reaction, (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub> was added to initial surrogate solution using 1.1, 1.25, 1.6, 2.2 and 4 equivalents relative to the initial Ba moles. The composition analysis of each precipitate was performed using XRF, and the results are shown in Figure 2. As the amount of chromate increased, the precipitation ratio of Ba increased while the co-precipitation of Sr increased. This result was also confirmed through XRD analysis (Figure 3). The XRD peak pattern shifted to the right as the co-precipitation of the smaller Sr increased.

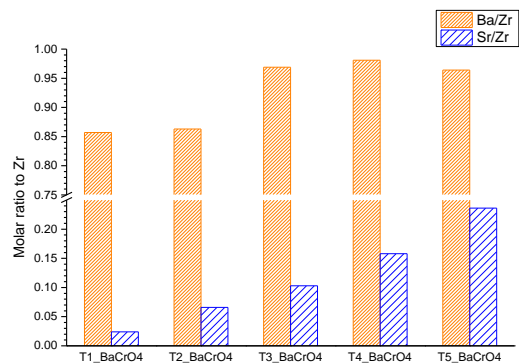


Figure 3. Molar ratio of chromate precipitates.

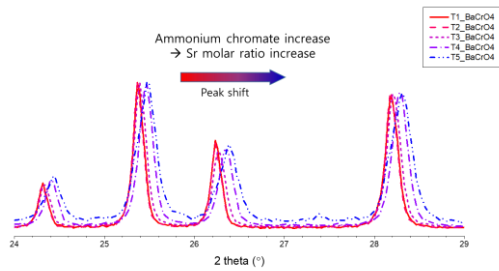


Figure 3. Peak shift of PXRD patterns of chromate precipitate.

### 2.1.2 Carbonate precipitation and purification results

After the chromate precipitation reaction, to recover the Sr nuclides remaining in the filtrate, 6 equivalents of  $(\text{NH}_4)_2\text{CO}_3$  relative to Sr sufficient for complete precipitation was added to recover Sr nuclides in the form of  $\text{SrCO}_3$ . The recovered  $\text{SrCO}_3$  was dissolved in hydrochloric acid solution for purification, and then carbonate precipitation was repeated. XRD pattern analysis (Figure 4) was performed to analyze the crystal phase of the finally produced carbonate precipitate, and as a result, it was confirmed that all of them had the same structure as  $\text{SrCO}_3$ . ICP analysis was performed to measure the composition of the final product, and the results are shown in Figure 5, and the yield and purity of the final product are tabulated in Table 2. As the amount of added chromate increased, the purity of  $\text{SrCO}_3$  also increased. In T3 to T5, in which chromate was added more than 1.6 equivalents relative to Ba nuclide, the purity of  $\text{SrCO}_3$  over 99.9%. On the other hand, as the amount of chromate increased, the yield of Sr gradually decreased. Therefore, when chromate was added in 1.6 equivalents relative to Ba nuclide,  $\text{SrCO}_3$  achieved high purity over 99.9% and high yield of 84.3%.

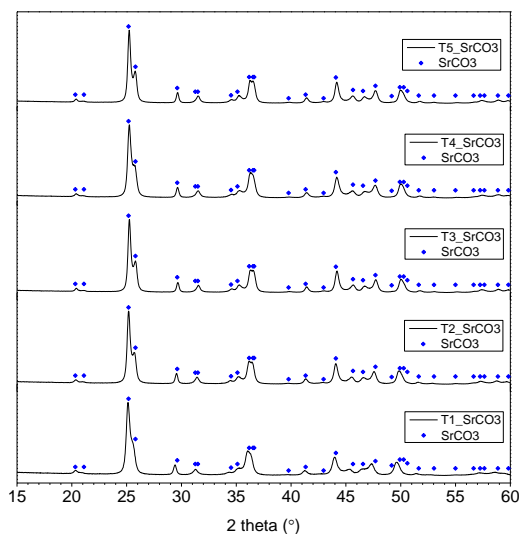


Figure 4. PXRD patterns of final products.

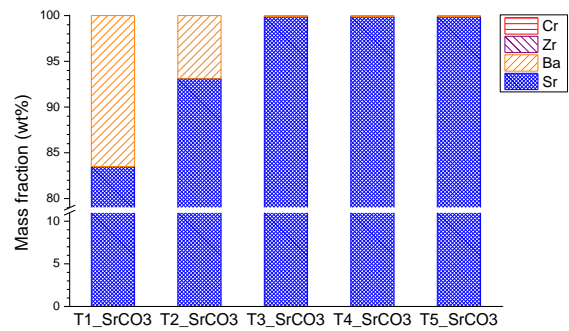


Figure 5. Mass fractions of each element in purified final product obtained from ICP-OES results.

Table 2. Mass, purity, and yield of final products.

	T1	T2	T3	T4	T5
Mass (g)	2.02	1.79	1.57	1.45	1.31
Yield (%)	108.5	96.1	84.3	77.9	70.3
Purity (%)	83.5	93.1	99.9	99.9	99.9

### 3. Conclusions

To separate Sr nuclide from the mixture of nuclides generated from salt waste, separation/purification process including chromate/carbonate precipitation established. Through optimization study, addition of 1.6 equivalents of chromate relative to Ba nuclide was found to achieve a high purity (99.9%) and yield (84.3%) for  $\text{SrCO}_3$ .

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