Coprecipitation behavior of element 102, nobelium, with barium sulfate

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The orbital electrons of heavy elements with $Z \geq 101$, synthesized by heavy-ion-induced nuclear reactions, are affected by significant relativistic effects. Therefore, the chemical properties of the heavy elements might be different from those expected from the periodicity of the homologues in the periodic table, and it is very interesting to investigate their chemical behavior.

We focus on element 102, nobelium (No). No is reported to exist as M^{2+} ion in aqueous solutions, whereas the other heavy actinides all form M^{3+}.[1,2] In the previous chemical experiments on No, the behavior of No was compared with those of divalent transition metal elements and the alkaline earth metal, barium (Ba). As a result, it has been reported that No behaves similarly to Ba. Thereafter, No was reported to have similar chemical behavior to those of calcium (Ca) and strontium (Sr), which have similar ionic radii to No, instead of other alkaline earth metal elements.[4] Recently, our research group focused on sulfate precipitates of alkaline earth metal elements and established the barium-sulfate-coprecipitation method which is applicable to No.[3] According to the results obtained in the preliminary experiments with Ca, Sr, Ba, and Ra, we found that the precipitation behavior in the present reaction system is sensitive to the ionic radii of the alkaline earth metal elements. In addition, it is expected that a difference in chemical bonding properties of No from those of alkaline earth metal elements will be observed. In this study, we applied the above method to No.

We produced ^{255}No ($T_{1/2}$ = 211 s) and ^{162}Yb ($T_{1/2}$ = 18.9 min) by the ^{248}Cm(^{12}C, $5n$)^{255}No and ^{nat}Gd(^{12}C, xn)^{162}Yb reactions, respectively, using the AVF cyclotron at RIKEN RIBF. The reaction products were transported by the He/KCl gas-jet system to the chemistry room and dissolved in a dilute HCl solution. When a precipitated sample is prepared, 20 μg of Ba and 2 mL of 0.1 M or 2.0 M ammonium sulfate were added into the dissolved solution in a 5-mL microtube, and the solution was stirred for 5 min at room temperature using a Vortex mixer. Then, the solution containing the precipitate was filtrated using the suction filtration apparatus controlled by PC. The precipitated sample was dried with He gas at 100°C. When determining the total amount of dissolved species (a standard sample is prepared), the reaction products were dissolved in dilute HCl solution, and the solution was put on a Ta plate. The sample was evaporated to dryness by He gas at 600°C and a halogen heat lamp. Finally, these dried precipitated and standard samples were subjected to alpha-particle measurement by the automated rapid alpha/SF detection system. After the alpha-particle measurement, gamma-ray activities of ^{162}Yb in the samples were measured with a Ge detector to monitor the chemical yields and coprecipitation behavior of Yb.

We successfully prepared 17 coprecipitated samples and 41 standard samples. Alpha-particle spectrum for the standard samples is shown in Fig. 1. Based on the alpha counts, we estimated the coprecipitation yields of ^{255}No and ^{162}Yb, considering various corrections such as the differences in the cooling times before the measurements and detection efficiency. As a result, a high coprecipitation yield of around 80% was obtained for ^{255}No in the case of adding 2.0 M ammonium sulfate. A detailed analysis is underway. We plan to discuss the sulfate complexation properties of ^{255}No based on the comparison with those of alkaline earth metal elements. In addition, we will compare the results with those obtained by quantum chemical calculations which were previously performed[4] to discuss the chemical bonding properties of No.

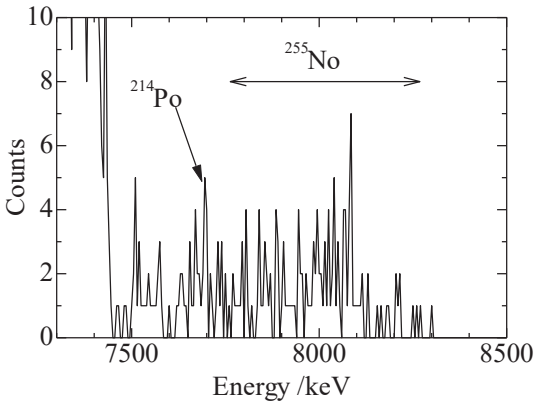

Fig. 1. Alpha-particle spectrum for the ^{255}No standard sample.

References
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