3 - 27 Preparation of the Ac-225 and Ac-227 Alpha Radioactive Sources by Electrodeposition Method

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In the latest research project of our group, a Gas-filled spectrometer detector has been set up for studying the chemical properties of superheavy elements.The feasibility of the detector before the on line experiments is need to be verified. Hence, the two 100% alpha nuclides of Actinium, ^{225}Ac and ^{227}Ac, are considered in our research. With a very suitable half-life ($T_{1/2}$ = 10.0 d), ^{225}Ac is a parent nuclide for ^{221}Fr ($T_{1/2}$= 4.9 min) and ^{213}Bi ($T_{1/2}$= 45.7 min). It is noteworthy that ^{221}Fr decays with 218 keV of characteristic gamma rays and ^{213}Bi decays with 440 keV, respectively. So the double nuclides are suitable for coupling calculation in the detector testing experiment. Besides, ^{227}Ac ($T_{1/2}$= 27.7 y) is very suitable for α-particle emission probabilities and chemical properties research in the long periods of decades.

The production process of ^{225}Ac has been implemented by our group in two years ago through the irradiation of thorium targets by high-energy proton beams. Table 1 showed the radioactive purity can arrive at 94.7% after the initial separation technology, which can meet the results of products from the TRUMF in Canada [1]. After analysis of the activity ratios with high-purity Germanium detector, the 6 kBq ^{225}Ac product is used for prepared alpha radioactive sources firstly.

Table 1 The activity ratios of different nuclides in the four batches of Ac-225 products.

Nuclides	**$T_{1/2}$**	**Activity ratios**			
		Initial products of IMP	**Products of Canada[1]**	**6 kBq products of Russia**	**3 MBq products of Russia**
Ac-225	**10.0 d**	**94.7%**	**93.04%**	**98.8%**	**99.9%**
Ac-227	**21.7 y**	**0.133%**	**0.16%**	—	—
Ce-141	32.5 d	1.777%	<0.03%	<0.008%	<0.001%
La-140	1.68 d	1.407%	2.29%	<0.011%	<0.001%
Ru-103	39.2 d	<0.04%	0.25%	<0.012%	<0.001%
Sr-85	64.8 d	<0.04%	0.14%	0.0319%	<0.006%
I-131	8.02 d	0.004%	—	<0.0014%	<0.001%
Ra-226	1600 y	—	<0.01%	<0.002%	<0.001%
Ra-224	3.66 d	<0.006%	<0.07%	0.4488%	<0.0005%
Ra-223	11.4 d	<0.0002%	<0.04%	<0.104%	<0.001%
Ba-140	12.8 d	<0.0002%	<0.01%	<0.028%	<0.001%
Th-227	18.7 d	0.638%	<0.04%	<0.025%	<0.001%

The electrochemical cell used in the experiments was the electrodeposition instrument of EDP 9002 in Figure 1. The cathode was a cylinder insulated with a Teflon mantle, and the metal disc was used for Actinium electrodeposition. The stable platinum was only chosen to be the electrodeposition material, which is dissolved in a small amount in the hot acid solution. The electrolyte was a ^{225}Ac acid aqueous solution at different pH values adjusted with HNO_3 or NH_4OH. It was noted that the liquid cannot be leaked from he electrolytic cell. Then the cathode was rotated at different controlled velocities with the cleaned metal disk parallel to a platinum disk anode.

The optimum condition is pH=1.0∼2.0 for the 6∼10 mL electrolyte, 60∼120 rpm for velocities and 0.15∼0.35 A for electric current. After rotating with four to six hour, the 15 mm diameter alpha radioactive source of Ac-225 was prepared as the left picture in Fig. 2. It can be seen that there was scarcely other impurities on the film of platinum disk. Then, the alpha radioactive source of Ac-227 was also prepared at the same condition with the initial separated product after Ac-225 decayed completely. the initial separated product after the Ac-225 decayed into oblivion. However, there were some gray mineral salts on the platinum disk for Ac-227 source. According to the original composition and the analysis of ICP-OES and high-purity Germanium detector, the gray mineral salts mainly contained carbonate of Ca, Mg, Pb and so on.

Fig. 1 (color online) The electrodeposition instrument of EDP 9002

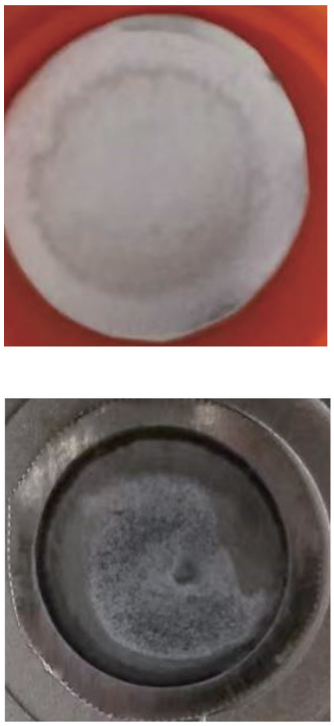

Fig. 2 (color online) The alpha radioactive sources of Ac-225 (left) and Ac-227(right)

Unfortunately, the electrodeposition efficiency was only 40%∼60% because of the low concentration of Ac solution and the uncertainty of voltage for the equipment. In general, these radioactive sources are all special suitable for spectroscopic, α-particle emission probabilities and isotopic ratio studies[2]. The further study of the preparation of alpha radioactive sources is still performed to increase the electrodeposition efficiency in our laboratory.

References

[1] A. Robertson, B. L. Mcneil, H. Yang, et al., Inorganic Chemistry, 5917(2020)12156.

[2] A, Becerril-Vilchis, Nucl. Instrum. and Meth A, 369, (2-3)(1996)613.