CHEMICAL IDENTIFICATION OF DUBNIUM AS A DECAY PRODUCT OF ELEMENT 115 PRODUCED IN THE REACTION ^{48}Ca+ ^{243}Am

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In experiments[1-6] performed during the past five years at the Flerov Laboratory of Nuclear Reactions, JINR, 17 isotopes of new chemical elements of the Periodic Table with atomic numbers 112-118 have been synthesized. The complete fusion reactions resulting from accelerated ^{48}Ca ions bombarding targets of ^{238}U, ^{242,244}Pu, ^{243}Am, ^{245,248}Cm, and ^{249}Cf were used for production of the above-mentioned superheavy elements (SHE). The nuclei of new elements appeared to mainly undergo α-decays (one or several) until the decay chain ends with a spontaneous fission (SF). The half-lives of the new nuclides range from 0.5 ms to 0.5 min, depending on the proton and neutron number of the synthesized nuclei. These results point to a considerable increase in the nuclear stability of isotopes of SHE with increasing neutron number. Essentially, they provide the first experimental confirmation of the theoretical predictions of the existence of an "Island of Stability" in the domain of hypothetical superheavy elements.

Chemical identification of isotopes in the observed decay chains could give us the identity of the atomic numbers of nuclei in the decay chain and provide independent evidence for the discovery of a new element (elements). Such an experiment was proposed[7] and performed[8] for element 115.

An isotope of element 115 with mass number 288 was synthesized[6] in the reaction ^{48}Ca+^{243}Am→^{288}115+3n. It undergoes five sequential α-decays ($115 \xrightarrow{\alpha} 113 \xrightarrow{\alpha} 111 \xrightarrow{\alpha} 109 \xrightarrow{\alpha} 107 \xrightarrow{\alpha} 105 \xrightarrow{SF}$) ending with the spontaneous fission of ^{268}Db. The total time of the first five α-transitions is about 20 seconds. The half-life of the spontaneously fissioning final nucleus ^{268}Db was estimated from the three observed events to be $T_{1/2}=16^{+19}_{-6}$ hours.

For chemical identification, the element should be separated according to its group properties. For this purpose, we developed a method of sorption extraction for the group 5 elements as anionic fluoride complexes. Bearing in mind that the Z=105 isotope of interest undergoes SF, we paid special attention to separating the group 5 elements from the actinides and, most importantly, from spontaneously fissioning isotopes of californium, ^{252}Cf ($T_{1/2}$=2.65 y, SF – 3.1%) and ^{254}Cf ($T_{1/2}$=60.5 d, SF – 99.7%).

In this report the results of the chemical identification of Db as the terminal isotope of the decay of element 115 produced via the ^{243}Am(^{48}Ca, 3*n*) ^{288}115 reaction are presented. The experiment was performed on the U-400 cyclotron of FLNR, JINR. The ^{243}Am target was bombarded with a beam dose of 3.4×10^{18} ^{48}Ca projectiles at energy of 247 MeV in the center of the target. The reaction products were collected in the surface of a copper catcher block, which was removed with a lathe and then dissolved in concentrated HNO_3. The group 5 elements were separated by sorption onto Dowex 50x8 cation-exchange resin with subsequent desorption using 1 M HF, which forms anionic fluoride complexes of group 5 elements. The eluant was evaporated onto a 0.4 μm thick polyethylene foils that were placed between a pair of semiconductor detectors surrounded by ^{3}He neutron counters for measurement of α-particles, fission fragments and neutrons. Over the course of the experiment, we

observed 15 spontaneous fission events (Table 1) with $T_{1/2}=32^{+11}_{-7}$ h which we

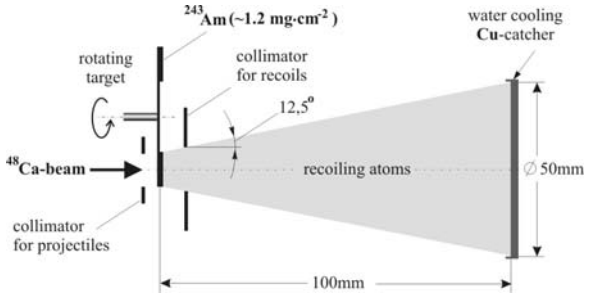

Figure 1. Scheme of the experiment.

attribute to ^{268}Db. The production cross section for the ^{243}Am + ^{48}Ca reaction was $4.2^{+1.6}_{-1.2}$ pb. These results agree with the original element 115 synthesis experiment where ^{268}Db was first observed as the terminal isotope following the five consecutive α-decays from the ^{288}115 parent nucleus in the Dubna gas-filled separator (Table 2).

The data from the present experiment give independent evidence for the synthesis of element 115 as well as element 113 via the ^{243}Am+^{48}Ca reaction.

Table 1. Conditions and results of the experiment

No	Time of irradi-ation /hours	^{48}Ca- ion beam dose	Energies of fission fragments E_1/E_2 (MeV)	Neutron multiplicity registered in every event of spontaneous fission	Time of regis-tration /hours
1	20	$2{,}5\cdot10^{17}$	120/126	2	20
2	22	$3{,}7\cdot10^{17}$	— /86	1	74
3	22	$3{,}4\cdot10^{17}$	131/124	1	15
			116/122	2	72
4	22	$2{,}9\cdot10^{17}$	104/120	1	22
			97/125	1	29
			100/128	1	51
5	38	$6{,}7\cdot10^{17}$	117/118	2	6
			108/107	3	9
			110/104	0	15
			-- /76	2	68
6	23	$3{,}9\cdot10^{17}$	120/114	2	39
7	22	$3{,}6\cdot10^{17}$	—	—	—
8	45	$7{,}4\cdot10^{17}$	119/110	2	5
			118/105	2	93
			65/58	3	174

Table 2. Results of physical and chemical experiments

	Physical experiment [6]	Chemical experiment
Separation method	Kinematic separator	Radiochemical separation
Separation efficiency	35%	80%
Detection method	Decay chains of nuclei with Z=115	SF of nuclei with Z=105
Energy of the ^{48} Ca-ion beam at the center of target layer	246 MeV	247 MeV
Total ^{48}Ca beam dose	$4.5\cdot10^{18}$	$3.4\cdot10^{18}$
Thickness of the ^{243}Am target	0.36 mg/cm^2	1.2 mg/cm^2
Number of detected spontaneous fission events	3	15
Formation cross section for the nuclei with Z= 115	$2.7^{+4.8}_{-1.6}$ pb	$4.2^{+1.6}_{-1.2}$ pb
Half-life	16^{+19}_{-6} hours	32^{+11}_{-7} hours
Total kinetic energy of spontaneous fission fragments	~ 225 MeV	~ 235 MeV
Average neutron multiplicity per fission act	--	4.2
Identification method of SF–decaying nuclei in the ^{48}Ca+^{243}Am	Method of excitation functions (Z=115)	Isolation of Group V elements (Z=105)

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