DEVELOPMENT OF SEALED RADIATION SOURCE BASED ON CADMIUM-109 RADIONUCLIDE

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The x-ray fluorescent analysis is based on fact that the x-rays emitted from an ionized atom have energies that are characteristic of the element involved. The x-ray intensity is proportional to both the elemental concentration and the strength of the ionizing source. Photon ionization, which
is achieved using radioisotopes ($^{55}$Fe, $^{57}$Co, $^{109}$Cd, $^{241}$Am) is most convenient to nondestructive assay of various materials. Among them the $^{109}$Cd radionuclide has found widespread use as a photon source in x-ray fluorescence analysis devices employed in industry for numerous applications such as the direct determination of gold in ores, the analysis of metals and identification of steels.

Cadmium-109 has a half-life of 461.9 days and decays by electron capture to $^{109}$Ag with the emission of a $\gamma$-ray of 88 keV (3.79%) along with the characteristic X-ray from the K level of Ag, with energy of 22.5 keV. There are several methods for the production of $^{109}$Cd in literature: 1) Bombardment of silver cyclotron target via $^{109}$Ag(d,2n)$^{109}$Cd reaction with 16 MeV deuterons. 2) Bombardment of natural silver target via $^{109}$Ag(p,n)$^{109}$Cd reaction with 14 MeV protons. 3) Proton bombardment of natural indium target with 96 MeV protons. 4) Irradiation of enriched $^{107}$Ag target in high-flux nuclear reactor at neutron flux $2 \times 10^{15}$ n·cm$^{-2}$·s$^{-1}$ via $^{107}$Ag(n,$\gamma$)$^{108}$Ag$\rightarrow^{108}$Cd (n,$\gamma$) $^{109}$Cd reaction. 5) Irradiation of enriched $^{108}$Cd target in nuclear reactor at neutron flux $1\times10^{14}$ n·cm$^{-2}$·s$^{-1}$ via $^{108}$Cd (n,$\gamma$) $^{109}$Cd reaction.

In the present work we developed both a method for separation and purification of $^{109}$Cd from cyclotron silver target and a method for preparation of sealed source based on cadmium-109.

The purification method is based on the selective adsorption of silver on column containing 0.5 g of polyethenemonosulphide (PEMS or trade name TR-1) from nitric acid solutions of Ag, Cu, Zn and Cd. This sorbent has high adsorptive capacity to silver, its adsorptive capacity reaches to 1920 mg/g from 1.5 M nitric acid solutions. After adsorption of silver the solution obtained evaporated to dryness and the solid residue is dissolved in 0.5 M nitric acid containing 0.1 M hydrobromic acid. Then the solution obtained is percolated through the column, containing 5 ml of Dowex1×8 resin. The copper(II) and zinc are completely eluted with 70 ml of 0.5 M HNO$_3$ + 0.1 M HBr. The cadmium-109 is eluted with 50 ml of 3 M nitric acid. The obtained solution is evaporated to dryness and the dry residue is treated by evaporation with 2 ml of 12 M hydrochloric acid. After treatment the damp residue is dissolved in 0.1 M hydrochloric acid. The yield of cadmium-109 is higher than 90% and the radiochemical purity was more than 99.9%.

The $^{109}$Cd radionuclide obtained is incorporated in ceramic matrix and sealed in an argon welded titanium capsule. The activity of active part with dimensions 4×2 mm was 740 MBq. The window thickness is 0.25 mm. The testing for leakage of the experimental source sample with $^{109}$Cd radionuclide showed that the activity removed is less 185 MBq.

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