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Modern methods for studying "hot" particles of various origin

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"Hot" particles have formed as a result of nuclear weapon testing, accidental releases at nuclear facilities, etc. In studying them much attention is paid to the analysis of transuranic elements (TUE) because they are long-lived alpha-emitting radionuclides, especially ^{238,239,240}Pu and ^{241}Am. The current accumulation and increase of the TUE content in the environment require to develop prompt methods for reliable monitoring of these isotopes in environmental objects, biological materials, and other samples.

We have developed a method for determining the activity of α-emitting plutonium isotopes using x-ray and γ-spectra spectroscopy. It allows you to quickly, reliably and with sufficiently high accuracy to carry out mass studies of samples without radiochemical separation of elements. This method is reducing the cost of analysis of one sample by almost two hundred times.

The essence of the method is as follows. As a result of alpha decay of plutonium isotopes, a series of low-energy states of the corresponding uranium isotopes with an energy lower than the K-electron binding energy are excited with a probability of about 25%. The decay of these states occurs through the internal conversion of gamma rays, followed by the emission of characteristic x-ray radiation with a 13-23 keV range energy. Thus, we obtain data about the plutonium content in the sample by measuring the intensity of x-ray radiation using semiconductor spectrometers. The accuracy of the proposed method in environmental samples is 10-15% for activities over 100 Bq and 20-30% for activities less than 100 Bq.

The developed method has been used to study the isotopic composition of "hot" particles of various origins: from an atomic and thermonuclear explosion, accidental origin from the 4^{th} Chernobyl nuclear power unit.

The results of spectrometric studies are confirmed by the data of traditional, radiochemical studies. To isolate actinides from the particles, the Eirchrom ACW03-21 extraction chromatographic method was used with UTEVA + TRU resins (TrisKem Int). Radiography with Imaging Plates, alpha-track radiography, SEM-EDX, micro-XRF, and XAFS have used to search, isolate and non-destructive analysis of "hot" particles. The obtained results are discussed. The reported study was funded by RFBR, project number 19-05-50095.

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