

DETERMINATION OF TRANSURANIUM ELEMENTS IN NUCLEAR POWER PLANT WASTES

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During the operation of nuclear reactors, various α -emitting isotopes and activation products, coming from the surface contamination of fuel elements or from the fuel itself due to leaking through possible cracks or damage of the enclosure, may appear in nuclear power plant wastes.

It is known that in the case of uranium-based fuel elements, isotopes of uranium, neptunium and plutonium constitute the greater part, while those of americium and curium the smaller part of the α -emitting isotopes occurring in the wastes. These also appear in the regeneration wastes of primary coolant purifiers in concentrations depending on their amounts originally present and their solubilities, the latter being determined by the chemical nature of the radionuclides.

Several papers have been published on the analysis of radioactive nuclear power plant wastes for transuranium elements. In these articles different individual techniques are described for measuring α -emitting radionuclides used at various nuclear reactors.^{1–3} It is quite understandable that different analytical procedures are needed in the case of different types of reactors for the selective detection of α -emitters.

In this paper a new technique is described in detail, which was developed for the analysis of α -emitting radionuclides in low-activity liquid wastes of VVER-440 type (PWR) reactors. The main feature of the procedure is its suitability for treating solutions saturated with respect to boric acid and also containing several organic and inorganic compounds.

Experimental

The procedure involves a separation step for sample preparation and an analysis step by using α -spectrometry.

Sample preparation consists of the following steps:

- separation from borate ions,
- precipitation of metal ions with organic complexing agents,
- oxidative decomposition of organic complexes,
- preparation of a thin-layer sample by electrolysis or drop technique.

The α -emitting radionuclides and their activity concentrations were determined by means of an α -spectrometer equipped with a PIPS semiconductor detector.

Samples analyzed: The samples were liquid radioactive wastes (evaporation residues) from nuclear power plant. The evaporation residues consisted of two phases: (1) solid-phase sediment and (2) solution saturated for borate. Sample preparation methods have been developed for both phases to precede α -spectrometric analysis.

Instrumentation: Alpha particles were detected by a silicon semiconductor detector (PIPS of Canberra) which was situated in a vacuum chamber, as usual in α -spectrometry. Some characteristic data of the detector are as follows:

Type:	A-900-19-AM
Active surface:	900 mm ²
Thickness of active layer:	300 μ m
Resolution (FWHM):	< 19 keV (under standard conditions)
Typical background	
(in the energy region 3–9 MeV)	12 counts/day

The charge pulse appearing at the output of the detector is transformed into a voltage pulse by a charge-sensitive two-stage pre-amplifier. The first stage is a FET incorporated in the detector housing, and the second stage is a voltage amplifier to provide a five-fold amplification. Further signal processing was done by an amplifier (Canberra), A/D converter and a multi-channel analyzer (Canberra System 100).

Data processing was aided by display, spectrum evaluation and documentation programs running under WINDOWS, which were part of Canberra System 100. The software searches peaks and assigns them to the previously loaded energy scale, and, following marking of peak limits, calculates peak areas.

Sample preparation: A large number of samples were analyzed. In the following sections the procedure will be presented for one sample to represent the sample preparation and spectrum analysis methods developed.

The volume of the sample which also contained same sediment, was 900 cm³. The sediment was removed by vacuum-filtration with a G1-Whatman1 combination filter. The precipitate was washed with 2 \times 50 ml double-distilled water (temperature 0–4 °C).