LONGTERM ANIMAL STUDIES ON THE EFFECT OF INCORPORATED RADIOACTIVE AND NONRADIOACTIVE PARTICLES AND THEIR SYNERGISM - RADIOCHEMICAL PREPARATION OF TISSUE SAMPLES AND ALPHA-SPECTROSCOPY

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Introduction

When evaluating longterm effects of incorporated collodial ThO_2 (Thorotrast) from a radiobiophysical view of quantifying the radiation risk, the nonradiation effect of the foreign body must be considered. There are well-founded indications that in the induction of tumors the late detrimental effects observed originate not only from radiation but apparently also from physico-chemical stimulus of a foreign body in the sense of a synergism. In search of clarifying the participation of the nonradiation effect in the genesis of tumors after the incorporation of Thorotrast, a comparison is made on hand of animal experiments - within the scope of a combined research project - between the longterm effects of Thorotrast, Th-230 enriched colloidal ThO_2 and radioactive as well as nonradioactive colloids of identical physicochemical characteristics (We 83, Ri 83). The latter part of the project deals with colloidal zirconium dioxide injected into rats as nonradioactive zirconotrast or as a radiocolloid (radiozirconotrast) labelled with Th-230 and Th-228.

It was the objective of this study to develop methods for the radiochemical preparation of samples along with physical measuring and evaluating techniques for calculating tissue doses on the basis of results from the thorium isotopes Th-230 and Th-232 (with daughter products) in tissue samples of animals after administration of normal and enriched Thorotrast.

1. Radiochemical preparation of samples

A method was developed that allows a complete radiochemical work-up of tissue samples containing Thorotrast. For the subsequent electrodeposition, the method described by Schieferdecker, inter alia, (Sch 68, HA 77) was used as a starting point. A procedure was developed that resulted in a nearly mass-free (self-absorption, energy resolution) preparation of samples for alpha-spectroscopy.
The radiochemical sample preparation consists of five steps:

1. Th-229 added as internal standard
2. Wet ashing of Thorotrast tissue with concentrated nitric acid using a reflux condenser

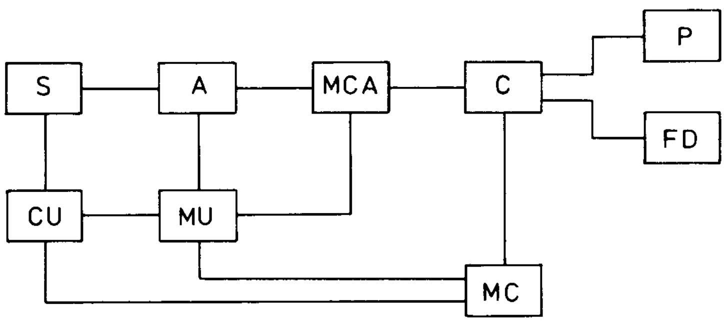
3. Separation of thorium from other elements by anion-exchange

4. Removal of an aliquot for the radiochemical work-up by electrodeposition

5. Electrodeposition of thorium from solution in sulfuric acid.

2. Design and function of the alpha-spectroscopy measurement system

For assessing thorium activity from different tissue samples, an alpha-spectroscopy measurement system was designed with a 500 mm^2 Si-surface barrier detector. Since the counting times are longer than 1000 min and a large number of samples from long-term tests had to be measured and evaluated, it was necessary to automate the system for routine measurements (Figure 1).



S Sample changer
A Amplifier
MCA Multichannelanalyzer
C Main computer
P Printer
FD Floppy disk

CU Control unit
MU Monitoring unit
MC Monitoring computer

Fig. 1: Block diagram of automated alpha-spectroscopy measurement system

System guidance and control is performed by the main computer C (Apple II Europlus). In order to use this computer also for other functions, e.g. spectrum analysis, a monitoring computer was installed for continuous system guidance and control (sample changer S, amplifier A, multichannel analyzer MCA and control unit CU). The spectrum fed into the multichannel analyzer automatically goes into the main computer and, with appropriate sample classification, is put out by printer P as hardcopy and/or stored on a floppy disk FD, as needed. The control unit CU continuously controls the functional parameters of the highly sensitive semiconductor, e.g. vacuum and detector bias. In case of malfunction or error, indicated by the control unit, the monitoring computer gives a highest priority interrupt signal to the main computer. The main computer interrupts its program and registers the error. Depending on a pre-programed command, the main computer will again start the measurement program or signal its discontinuance.

Computer assistance is provided for evaluating the alpha-radiation spectra.

3. Results

3.1 Radiochemical sample preparation

For determining the activity of the thorium isotopes Th-232 Th-230 and Th-228, Th-229 is added to the tissue samples as a tracer prior to work-up. This procedure permits an individual determination of recovery for each single tissue sample. With good reproducibility the yield from organ samples containing Thorotrast is about 80 %.

Due to the extremely inhomogenous activity distribution in organs, one each complete organ sample is worked up and the mean activity derived.

3.2 Alpha-spectroscopy

The efficiency yielded via an Am-241 reference source is about 25 %. The energy resolution of the semiconductor is reported to be 25 keV FWHM; in practice, however, the energy resolution of single peaks for electrodeposition from physically pure standard solutions of thorium ranges from 50 to 60 keV FWHM, and from 60 to 80 keV FWHM for the electrodeposition of worked up Thorotrast tissue samples (Figure 2).

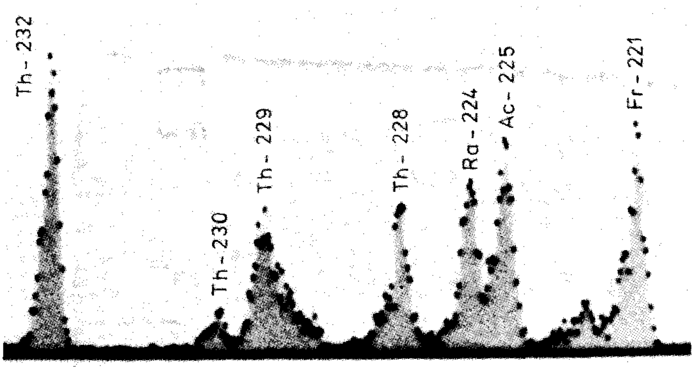


Fig. 2: Typical thorium spectrum following electrodeposition of a Thorotrast sample

Due to the low activity in tissue samples (approx. 1 pCi), counting times range from 1000 to 1700 min, depending on the sample, whereby the mean background rates are as follows:

Th-232	0.028 cpm
Th-230	0.025 cpm
Th-228	0.138 cpm.

The higher background rate in the Th-228 range can be attributed to detector contamination by recoil atoms.

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