DECAY CHARACTERISTICS OF ELECTROSTATICALLY COLLECTED SAMPLES OF RADON DAUGHTERS

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Dedicated to Dr Karel Mach on the occasion of his 60th birthday.

Samples of radon daughters collected electrostatically from the air in various conditions were analyzed by measuring their decay curves (both integral and for the spectrometrically resolved components). The results are helpful for establishing electrostatic collection as a sampling method in radon daughters measurements.

Key words: Radon daughters; Radon measurements; Electrostatic collection.

When assessing the risk associated with the inhalation of air containing radon it is necessary to know not only the concentration of radon itself but, in particlular, also the concentrations of radon decay products which deposit in the lung and thus are directly responsible for the detriment. The concentrations of radon daughters are determined by collecting samples from a given volume of air and measuring their activity. Various collection methods are available, among which electrostatic collection is an attractive and as yet not fully exploited option. This method is based on the fact that nuclides emerging from alpha decay are mostly positively charged and can be collected on a negatively charged electrode, where their activity is conveniently determined. In fact, only that fraction of radon daughter activity (particularly of RaA, *i.e.* ^{218}Po, and RaB, *i.e.* ^{214}Pb formed by alpha decay) which is in the form of positive ions (or is attached to charged clusters) having a sufficient mobility in the applied electric field can be efficiently collected in this way. Hence, the activity detected in samples collected from free air cannot be interpreted in terms of the equivalent volume activity of radon. Electrostatic collection, however, has been used in measurements of radon activity in large

chambers[1,2]. The purpose of the present study was to acquire information on the decay of electrostatically collected short-lived daughters of radon (^{222}Rn) and thoron (^{220}Rn).

EXPERIMENTAL

Two types of decay kinetics measurements were made. In the first set, the collection proceeded from free air on the surface of an electrode (12 mm in diameter) embedded in a plexiglas cylinder (see Fig. 1) and held at –500 V with respect to the ground (metallic support) by means of a small battery-operated high voltage source. The distance of the electrode surface from the support was 12 cm. After completing the collection for various periods of time, the electrode was transferred into the measuring position of a portable alpha counting set[3], where its total alpha activity was measured for up to 24 h. In such measurements, samples were collected from ambient air indoors and outdoors at

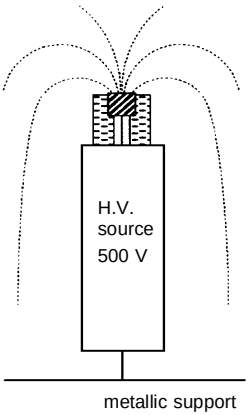

FIG. 1
Experimental arrangement used for collection of radon daughters from ambient air

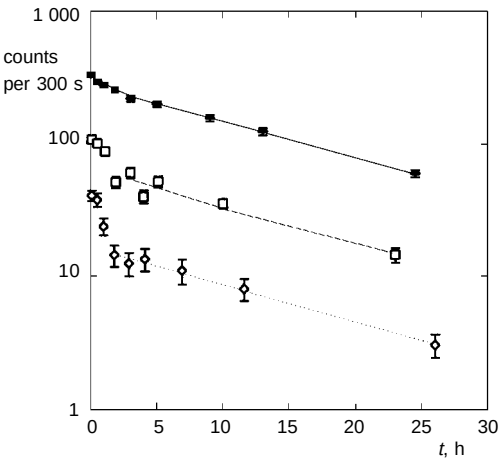

FIG. 2
Decay curves of samples of radon and thoron daughters collected electrostatically for various collection times: ✧ 0.5 h, ❒ 2 h, – 10 h; - - - -, – – – –, ——— linear fits. The evaluated half-lives are in a good agreement with the ThB (^{212}Pb) value of 10.64 h

various places, particularly in a ground level cellar where the equivalent radon concentration was about 20 Bq/m^3, as determined by the grab sampling filtration technique[4].

High-activity radon daughter samples for spectrometric analysis were collected electrostatically on a disc-shaped electrode from air present in a metallic cylindrical vessel containing crushed uranium ore. Here the decay kinetics of the individual alpha-activity components (RaA and RaC′, *i.e.* ^{218}Po and ^{214}Po) was recorded using a multichannel analyzer[5], where the spectra from measurements in successive 1 min and 10 min intervals, respectively, were accumulated and stored.

RESULTS AND DISCUSSION

Typical integral decay curves obtained with samples collected from air in the cellar are shown in Fig. 2. The contributions of both radon and thoron daughters to the total counts could be determined. While the activity of the collected ^{222}Rn daughters saturated roughly in 3 h of collection, the activity of the collected ^{220}Rn products continued to increase and only saturated in several days of collection.

The alpha spectrum of sample collected from the ^{222}Rn enriched atmosphere in a short time exposure (*i.e.* 5 min) exhibited first the RaA (6.00 MeV) peak only (see Fig. 3a). The peak corresponding to RaC′ (7.69 MeV) developed in parallel with the accumulation and decay of RaC (^{214}Bi) proceeding due to the decay of RaA as well as RaB which may have collected directly from the air in this form (see Figs 3b and 3c). The

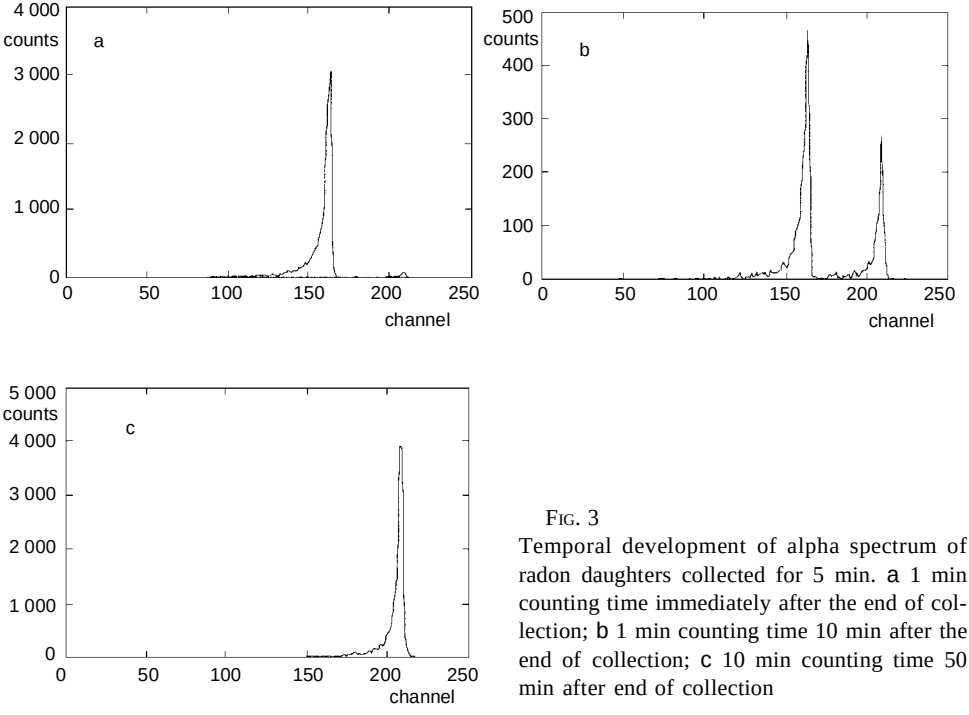

FIG. 3
Temporal development of alpha spectrum of radon daughters collected for 5 min. a 1 min counting time immediately after the end of collection; b 1 min counting time 10 min after the end of collection; c 10 min counting time 50 min after end of collection

temporal development of these spectral components in the samples collected for 5 and 30 min are shown in Figs 4 and 5, respectively. The somewhat larger values of the RaA half-life derived from these data are due to the contribution of some RaC′ counts to the RaA channel region.

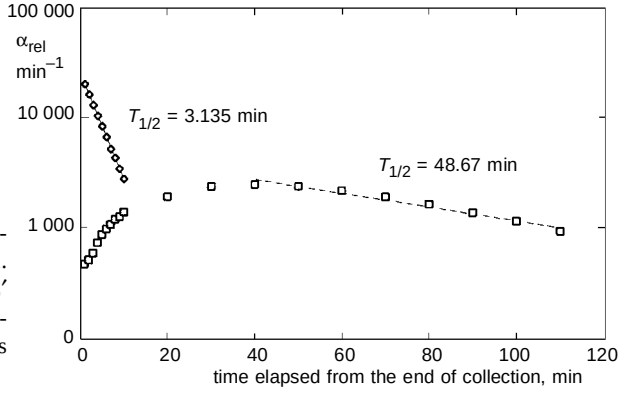

FIG. 4
Decay of Rn daughters accumulated electrostatically for 5 min. Contributions of RaA (✧) and RaC′ (❒) were separated spectrometrically; ———, - - - - linear fits. α_{rel} is the relative alpha activity

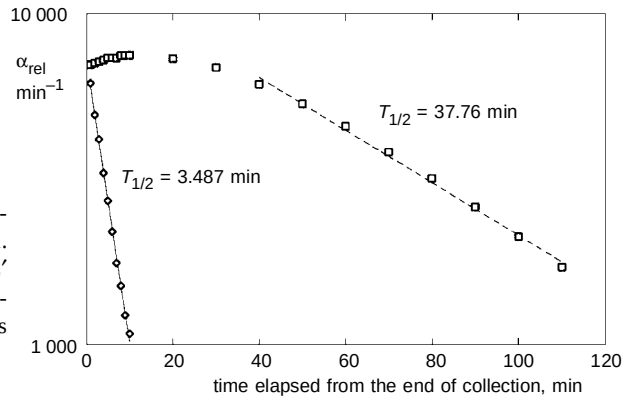

FIG. 5
Decay of Rn daughters accumulated electrostatically for 30 min. Contributions of RaA (✧) and RaC′ (❒) were separated spectrometrically; ———, - - - - linear fits. α_{rel} is the relative alpha activity

The fitted effective half-life of RaB + RaC was found to be dependent on the collection time. The contribution of RaB collected directly was larger for the 30 min collection time than for the case of shorter collection times, thus affecting the effective half-life.

It is noteworthy that the integrated RaA activity is only about one-half with respect to the integrated RaC′ activity. This indicates that in this experiment a substantial part of RaB was collected directly from the air rather than produced by decay of the already collected RaA.

These facts should be borne in mind when designing radon daughter collection procedures and interpreting measured data.

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