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Abstract

A description is given of the properties of the nuclides included in the "active deposit" of thoron. A method is presented for obtaining a quantitative measurement of the activity of the transient-equilibrium mixture.

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In an atmosphere to which is exposed natural thorium, mesothorium, thorium-228, or uranium-232 (often a contaminant of U-233), the gas thoron (Em-220) and its radioactive daughters are usually present. The daughters of 51.5-sec thoron are listed in Table I. If a portion of such an atmosphere is passed through a filter, trap, or precipitator, part of the daughter activity is retained, and is termed the "active deposit." Other information on the thorium series has been reported.^(1,2)

Neglecting Po-216 because of its short half-life, and assuming for simplicity that pure Pb-212 is deposited, data for the curves of Fig. 1 are obtained. A sample does not show as much growth as indicated, because the daughters of Pb-212 grow to some degree before counting is begun. Actually the alpha and beta activities may grow slightly, remain about constant for a time, or decay from the beginning of counting with the 10.6-hour half-life characteristic of the transient-equilibrium mixture. The alpha spectrum is simple, consisting of ~ 6.05- and 8.8-Mev peaks. The gamma spectrum is shown in Fig. 2.

In order to give a quantitative measurement of the active deposit, one may report the total disintegration rate of the four nuclides, Pb-212 (A_8), Bi-212 (A_9), Po-212 (A_{10}), and Tl-208 (A_{11}). In equilibrium - at most a few hours after a sample is received - the following relationships hold:

$$A_9 = \frac{T_8}{T_8 - T_9} A_8 = 1.105 A_8$$

$$A_{10} = 0.65 A_9$$

$$A_{11} = 0.35 A_9$$

$$\frac{A_8 + A_9 + A_{10} + A_{11}}{A_{11}} = 8.3$$

Fig. 1. - Growth of α and β Activity in Pb-212

The activity of Tl-208 may be measured simply by integrating its 2.6-Mev peak in the gamma spectrum (Fig. 2.) by the usual spectrometric technique.⁽³⁾ Multiplying this value by 8.3 gives the disintegration rate of the four activities, referred to as "thoron daughters," abbreviated "Th d."

Table I
Daughters of Thoron

Nuclide	Series No. ^a	Half-Life	Energies and Intensities ^b		
			Alpha	Beta	Gamma
Po-216 (ThA)	7	0.16 sec.	6.77 (1)	--	--
Pb-212 (ThB)	8	10.6 hr.	--	0.35 (0.9) 0.59 (0.1)	0.24 (0.4) 0.30 (0.03)
Bi-212 (ThC)	9	60.5 min.	6.05 (0.25) 6.09 (0.10)	2.2 (0.64)	0.73 (0.05) 0.83 (0.04) 1.03 (0.04) 1.6 (0.04)
Po-212 (ThC')	10	0.3 μ sec.	8.8 (1)	--	--
Tl-208 (ThC'')	11	3.1 min.	--	1.3 (0.3) 1.5 (0.2) 1.8 (0.4)	0.51 (0.3) 0.58 (0.8) 0.86 (0.1) 2.6 (1)

^aSequence number in Th series (Th-232 is No. 1).

^bEnergies of important radiations in Mev. In parentheses, particles or photons per disintegration.⁽²⁾

Fig. 2 - Gamma Spectrum of Thoron Daughters (3 x 3" crystal, 1.2 g/cm² Be, h = 5.5 cm)

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