Specific Activity of Potassium

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ABSOLUTE beta- and gamma-ray disintegration rates of potassium have been measured by immersing suitable counters in a large tank of water (53 in. deep and 48 in. diameter) containing 4.55 kg of KCl in solution. Geometrical conditions of the experiment were such that the source could be considered as homogeneously distributed in an infinite medium. By utilizing previous results,[1] on multiple Compton scattering under such conditions, the absolute disintegration rate of the 1.50-Mev gamma-ray was deduced. The specific beta-ray activity was found from the observed beta-ray counting rate by a calculation involving the counter geometry, and the mean range of the beta-rays in water. The results of Alburger[2] were used to compute the mean beta-ray range. A calculated correction of about 15 percent was also made for the Compton electrons. It is estimated that the error in these determinations is less than 10 percent.

The method has been tested[3] by determining specific beta- and gamma-ray disintegration rates of Na^{24} under the same conditions. A Na^{24} source (Na_2CO_3) was calibrated by three methods (coincidence counting, comparison with a known source in an ionization chamber and by means of a calibrated gamma-ray counter) which gave results differing by less than three percent from each other. After dissolving this source in a known volume of water, the specific activity determined by the methods described above differed from that calculated from the measured source strength and amount of solute by less than five percent for both beta- and gamma-rays.

Results obtained for the specific disintegration rate of potassium are: 31.2±3.0 beta-rays/sec.-g K, and 3.6±0.4 gamma-rays/sec.-g K. The beta-ray activity is in agreement with results of Stout,[4] Spiers,[5] and Ahrens and Evans.[6] The gamma-ray activity reported here is in agreement with recent observations[6-8], but is considerably higher than the results of Spiers. The mean gamma-ray activity of all recent measurements is 3.4±0.2 gamma-rays/sec.-g K, while the specific beta-ray activity is 31.8±1.0. These averages include the estimates of Ahrens and Evans.

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A Long-Lived Zirconium Activity in Fission

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ALTHOUGH much information has been obtained regarding the fission products,[1] the decay characteristics of those of very short or very long half-lives have not yet been fully investigated. Several of these "missing" activities (Se^{79}, Zr^{93}, Pd^{107}, I^{129}, Cs^{135}) have been predicted for some time to have low decay energies and probably very long half-lives. Recently Sugarman[2] has isolated Cs^{135} from uranium fission and established its half-life and beta-energy as 2.1×10^6 yr. and 0.21 Mev, respectively. In the present investigation, we have isolated from uranium fission a zirconium activity of $\sim 5\times 10^6$-yr. half-life, emitting beta-rays of 60±5 kev maximum energy, which is probably Zr^{93}.

The zirconium activity was isolated by a carrier-free method from uranium which had been irradiated for 10 months in a pile. The separation was carried out four years after the end of the irradiation, at which time the activity of 65-day Zr^{95} had decayed to a sufficiently low intensity that the observation of a very long-lived isotope was possible. The chemical procedure involved the carrying of zirconium on MnO_2 precipitated from a $1N$ HNO_3 solution of a fission product concentrate of the irradiated uranium. Niobium activity was removed by carrying on MnO_2 precipitated from $10N$ HNO_3, and final purification of the zirconium was achieved by repeated extractions of the cupferron complex into $CHCl_3$. These operations permit the isolation of zirconium activity in high radiochemical purity without the presence of an isotopic carrier.[3]

Observations of the radiations of the zirconium activity were made with a thin (0.85 mg/cm^2) end-window proportional counter and an internal Geiger counter ("*Q*-gas counter"[4]). Figure 1 shows a comparison of the zirconium activity isolated in these experiments with that of pure 65-day Zr^{95} tracer using the proportional counter. Points not shown in Fig. 1 indicated that the two absorption curves were identical over the region of heavier absorbers. A soft component is seen in the fission zirconium curve, but not in the pure Zr^{95} curve. In successive separations of zirconium, the abundance of the soft component was found to increase over a period of two months relative to that of the Zr^{95} by an amount consistent with the 65-day half-life of Zr^{95}. This observation is evidence that the soft activity is due to a zirconium isotope, since the two activities were not fractionated by the chemical operations. Examination in a methane-flow alpha-proportional counter eliminated alpha-contamination as a possible source of the soft activity.

Figure 2 shows the absorption curves of the fission Zr and Zr^{95} tracer obtained with a *Q*-gas counter. The curves have been normalized so that the Zr^{95} curve can be subtracted from the observed data to give the absorption curve of the soft beta-radiation from the long-lived isotope. A half-thickness in aluminum of 0.35 mg/cm^2 is observed. In order to establish the maximum energy of the beta-radiation from its observed half-thickness, a curve of half-thickness *vs.* energy is desirable. Two points on such a curve were established using Ru^{106} and Sm^{151}. The half-thicknesses of the beta-radiations from these nuclides were determined to be 0.20 and 0.50 mg/cm^2, respectively; maximum energies of 40.1 and 76.6 kev, respectively, were available from beta-ray spectrometer measurements.[5] Linear interpolation gives a value of 60±5 kev for the maximum beta-energy of the long-lived zirconium.

Previous attempts to find any zirconium activity assignable to mass 93, both from neutron irradiation of zirconium[6] and from uranium fission in the half-life range from 3 min. to 100 yr.,[7] have been unsuccessful. Also, a very low decay energy is predicted for Zr^{93} from the mass formula of Bohr and Wheeler.[8] From these considerations it is probable that the new long-lived zirconium fission product is Zr^{93}. It is planned to make a positive mass assignment by examination in the mass spectrometer.

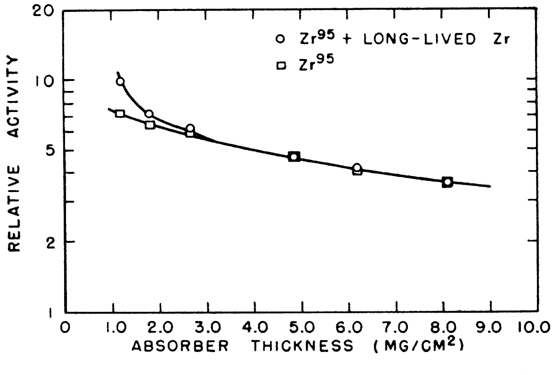

Fig. 1. Proportional counter absorption curves of fission zirconium sample (Zr^{95}+long-lived Zr) and Zr^{95} tracer.

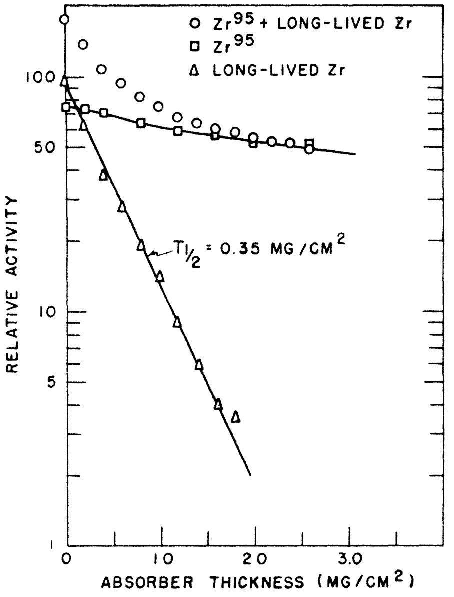

FIG. 2. Absorption curve of long-lived Zr as determined in an internal Geiger counter ("*Q*-gas counter").

Assuming this long-lived fission product is Zr^{93}, whose fission yield in uranium may be obtained from the smooth yield-mass curve,[1] the ratio of its activity to that of Zr^{95} at a given time after a known period of irradiation permits an estimation of its half-life. The ratio of activities observed at 4.2 yr. after an irradiation of 0.83 yr. was 1.4. This value gives a half-life for Zr^{93} of 5.2×10^6 yr. A possible error in the value of the half-life of the order of a factor of two is estimated from the uncertainty in the half-life of Zr^{95} (65 ± 2 days). Another possible source of error lies in self-absorption by the source, which consisted of ~10 μg of solid material deposited over a small area. This effect should lower the calculated half-life by no more than a factor of two. Thus, the true half-life of Zr^{93} should lie in the range 1.5 to 8.5×10^6 yr. Further work is in progress to eliminate these sources of possible error and to establish the half-life with greater accuracy.

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Optical Absorption Edge for BaO as Determined by the Method of Ives and Briggs

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TYLER[1] has located the optical absorption edge of evaporated films of BaO at $h\nu \cong 3.8$ ev. We have confirmed his result by measuring the photoelectric emission from very thin metallic films deposited on the surface of BaO layers. This method, originated by Ives and Briggs[2] in their investigation of Na films on Ag, has not been applied in the case of ionic substrates. (It is interesting to note that the narrow transmission band of Ag has almost the same location as the absorption edge of BaO.) Figure 1 shows the spectral distribution of the photoelectric yield from thin films of Ba metal deposited on BaO layers formed by thermal decomposition of BaCO$_3$. The thinnest Ba films were invisible. They had only a small effect on the incident ultraviolet radiation. However, they suppressed almost entirely the photoelectric emission from the BaO itself. Thus, loosely speaking, one may say that they behaved like metallic photo-emitters with the optical constants of the layer of ionic crystals. The photoelectric yield drops by several-fold between 3.7 and 3.9 ev, in good agreement with the absorption edge found by Tyler. As the films become thicker, the effect becomes less pronounced and finally disappears. The surface then has the properties of bulk Ba metal. We have obtained analogous results with films of Mg on BaO, and with Ag and Pb on KI.

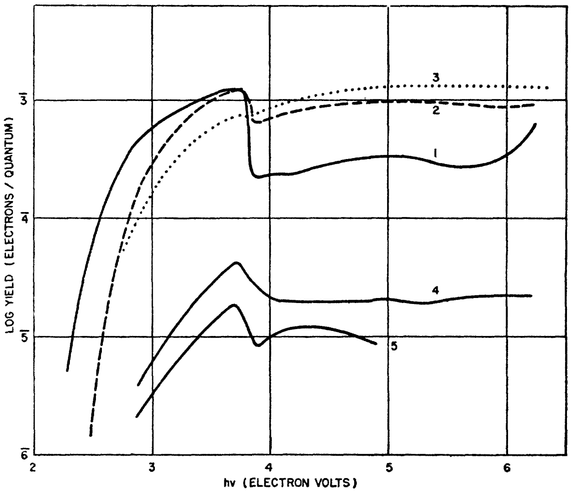

FIG. 1. Photoelectric yield of Ba films on BaO layer; curves 1, 2, and 3 are in order of increasing thickness of Ba. Curves 4 and 5 are results for Na on Ag taken in this laboratory and by Ives and Briggs respectively—the absolute magnitude of the yields being displaced arbitrarily. Note that the characteristics of the logarithms are negative.

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X-Ray Determination of Hg Arc Temperature

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THE absorption of a beam of x-rays passing along the axis of a carbon arc in air was used by von Engel and Steenbeck[1] to determine the gas density and thence the arc temperature. The method has been applied to the Hg arc by the writers,[2] by Fischer[3] at about the same time, and more recently by Koch.[4] This letter outlines the writers' work as extended in early 1942 and terminated by the war.

The apparatus is shown in Fig. 1. Here an x-ray beam from a 30-kv Mo anode tube passes through a ZrO$_2$ filter, to render it more monochromatic, through a defining diaphragm, thence along the axis of the arc, entering and leaving the quartz tube through thin inblown windows and passing through hollow electrodes, and finally into an argon-filled ionization chamber where its strength is measured by a string electrometer. Because of the mounting of the x-ray tube, the arc is run horizontally. A special magnet confines the arc well in the axial position except near the cathode, where ordinarily the arc bows upward more strongly. This is corrected by using three cathodes operating in parallel with separate ballasts. The Hg pressure is controlled by the temperature of the furnace F_1, and measured to ~0.3 percent