## Specific Activity of Potassium

WILLIAM R. FAUST
*Nucleonics Division, Naval Research Laboratory, Washington, D. C.*
April 12, 1950

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: $31.2\pm3.0$ beta-rays/sec.-g K, and $3.6\pm0.4$ 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 $3.4\pm0.2$ gamma-rays/sec.-g K, while the specific beta-ray activity is $31.8\pm1.0$. These averages include the estimates of Ahrens and Evans.

The author is indebted to Drs. M. H. Johnson and F. N. D. Kurie for many helpful suggestions and to G. E. Halloway and C. C. Porter for aid in performing the experimental work.

[1] W. R. Faust and M. H. Johnson, Phys. Rev. **75**, 467 (1949).
[2] D. E. Alburger, Phys. Rev. **75**, 1442 (1949).
[3] To be published elsewhere.
[4] R. W. Stout, Phys. Rev. **75**, 1107 (1949).
[5] F. W. Spiers, Nature **165**, 356 (1950).
[6] L. H. Ahrens and R. D. Evans, Phys. Rev. **74**, 279 (1948).
[7] E. Gleditsch and T. Graf, Phys. Rev. **72**, 641 (1947).
[8] G. A. Sawyer and M. L. Wiedenbeck, Phys. Rev. **76**, 1535 (1949).

## A Long-Lived Zirconium Activity in Fission

E. P. STEINBERG AND L. E. GLENDENIN
*Argonne National Laboratory, Chicago, Illinois*
April 10, 1950

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 $2.1\times10^6$ yr. and 0.21 Mev, respectively. In the present investigation, we have isolated from uranium fission a zirconium activity of $\sim5\times10^6$-yr. half-life, emitting beta-rays of $60\pm5$ 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/cm²) 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/cm² 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/cm², 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 $60\pm5$ 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.

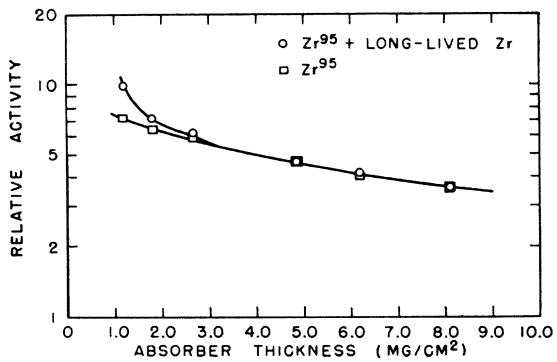


FIG. 1. Proportional counter absorption curves of fission zirconium sample ($Zr^{95}$+long-lived Zr) and $Zr^{95}$ tracer.