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NEW ISOTOPES OF BERKELIUM AND CALIFORNIUM

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In the course of work on transplutonium isotopes at Berkeley, it has been possible to prepare mixtures of Cm^{242}, Cm^{243}, and Cm^{244} by intensive neutron irradiation of samples[1,2] originally consisting of the isotope Am^{241}. The heaviest curium isotopes are useful sources for the preparation of berkelium and californium isotopes heavier than have been previously observed from helium ion and deuteron bombardments of the isotopes Am^{241} and Cm^{242}. The properties of such new isotopes are of intrinsic interest and also contribute to the extension of the systematics of radioactivity. This letter outlines some of the experimental work which has been done in this connection.

A target containing approximately 100 μg of Cm^{242}, ~5 μg Cm^{243}, and ~2 μg of Cm^{244}, was bombarded with 35 mev helium ions and 16 mev deuterons using the same target technique mentioned previously.[3] The resulting californium and berkelium isotopes were chemically separated from each other, from the target materials, and from fission products using the same combinations of precipitation and ion exchange methods as have been reported previously.[3] The final chemical separations were completed ~9 hours after the end of the bombardment.

Examination of the radiations associated with the decay of the berkelium isotopes in a windowless gas proportional counter showed the 4.6 hour Bk^{243} previously reported[3] and a considerably longer lived decay period corresponding to a 4.95 ± 0.1 day half-life. Some of this same radioactivity was examined in a differential alpha pulse analyzer,[4] which revealed alpha

particles of the following energies and abundances: 6.33 ± 0.05 mev (18%), 6.15 ± 0.05 mev (48%), and 5.90 ± 0.05 mev (34%). All three alpha particle groups were observed to decay with a 4.95 day half-life. Initially the three alpha particle groups belonging to the 4.6 hour Bk^{243} were also present. Consideration of the systematics of alpha radioactivity[5] suggests that the new 4.95 day isotope is most likely Bk^{245}. The new berkelium isotope must be of mass greater than 244 or it would have been observed in bombardments of Am^{241} with alpha particles. Furthermore, much longer half-lives than 4.95 days were predicted for Bk^{246} and Bk^{247} using methods of estimation which have been described previously.[6] Comparison of the counting rate of the 4.95 day radioactivity in the windowless counter to that in the alpha pulse analyzer allows calculation of ~0.1% alpha branching which corresponds to a 15 year partial alpha half-life. The alpha particle decay of this isotope appears to be hindered by a factor of ~100 (using the conventions of reference 5) and resembles the decay of the isotope Bk^{243} in this respect.

Following the decay of the berkelium isotopes, the curium daughters resulting from electron capture decay were examined in the alpha pulse analyzer and the characteristic alpha particles of Cm^{243} produced by the decay of 4.6 hour Bk^{243} were observed. The amount of alpha activity of energies expected for Cm^{245}, namely that in the range 5.4-5.8 mev, was such that the half-life of the latter isotope must be at least 500 years if the energy is as indicated by the alpha decay systematics.[5] This tentative conclusion is, of course, also based on the assumption that the mass assignment of the 4.95 day berkelium isotope is correct.

Examination of the californium fraction in the alpha pulse analyzer soon after irradiation showed only 6.75 mev alpha particles decaying with a 35 hour half-life (tentatively assigned previously to Cf^{246}).[7] The growth

of alpha particles of 6.08 mev energy was observed and the amount corresponded to a half-life of approximately 160 days. This daughter is undoubtedly Cm^{242} produced by the decay of Cf^{246}, and the assignment to Cf^{246} is now regarded as certain. The decay of the Cf^{246}, followed through a decay factor of approximately 50, gave a half-life of 35.7 ± 0.5 hours in agreement with previous measurements. The ratio of the counting rate in the windowless proportional counter to the alpha counting rate corresponded closely to that observed for a number of "pure" alpha emitters previously examined under similar conditions, so that Cf^{246} appears to be beta stable as expected. No radioactivity other than Cf^{246} and its daughter Cm^{242} was observed in the californium fraction. This result is somewhat surprising since it might have been expected that Cf^{247} and possibly Cf^{245} would have half-lives long enough to allow their observation.

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[1]Seaborg, James, and Morgan, National Nuclear Energy Series, Plutonium Project Record, Vol. 14B, "The Transuranium Elements: Research Papers," Paper No. 22.1 (McGraw-Hill Book Co., Inc., New York, 1949).

[2]Reynolds, Hulet, and Street, Phys. Rev. 80, 467 (1950).

[3]Thompson, Ghiorso, and Seaborg, Phys. Rev. 80, 781 (1950).

[4]Ghiorso, Jaffey, Robinson, and Weissbourd, National Nuclear Energy Series, Plutonium Project Record, Vol. 14B, "The Transuranium Elements: Research Papers," Paper No. 16.7 (McGraw-Hill Book Co., Inc., New York, 1949).

[5]Perlman, Ghiorso, and Seaborg, Phys. Rev. 77, 26 (1950).

[6]S. G. Thompson, Phys. Rev. 76, 319 (1949).

[7]Ghiorso, Thompson, Street, and Seaborg, Phys. Rev. 81, 154 (1951).