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A Cesium-137—Barium-137*m* Isotope Generator

The 30-yr $^{137}Cs \rightarrow$ 2.6-min ^{137m}Ba pair can be effectively used in the classroom or laboratory to demonstrate the concept of the simple "cow" or generator system, where a relatively long-lived parent activity decays to a relatively short-lived radioactive daughter. An earlier article in THIS JOURNAL[1] covers the same pair of isotopes in an experiment involving precipitation with carrier. The ^{137}Cs parent activity can be readily obtained[2] as a fission product in 1 *M* HCl solution and, at 50¢/curie or fraction thereof, is one of the least expensive of all radioisotopes.

The general equations relating to the activities of radioactive parent-daughter systems are well known[3] and can be expressed mathematically as:

$$\lambda_B N_B = \lambda_A N_A \frac{\lambda_B}{\lambda_B - \lambda_A} [1 - e^{-(\lambda_B - \lambda_A)t}] \qquad (1)$$

where N_A is the number of parent atoms, A, present at time, *t;* and λ_A is the decay of the parent. The activity of N_A is then $\lambda_A N_A$, and similarly the activity of the daughter, B, is $\lambda_B N_B$. When the long-lived parent does not decay appreciably during the course of the experiment (i.e., λ_A is negligible compared to λ_B), eqn. (1) becomes

$$\lambda_B N_B = \lambda_A N_A (1 - e^{-\lambda_B t}) \qquad (2)$$

and after a steady state is reached $\lambda_B N_B = \lambda_A N_A$. In the case of the $^{137}Cs \rightarrow ^{137m}Ba$ system, it should be noted that since about 5% of the β decay is to the ground state, at equilibrium $\lambda_B N_B = 0.95\ \lambda_A N_A$. A simplified version of the decay scheme of ^{137}Cs is

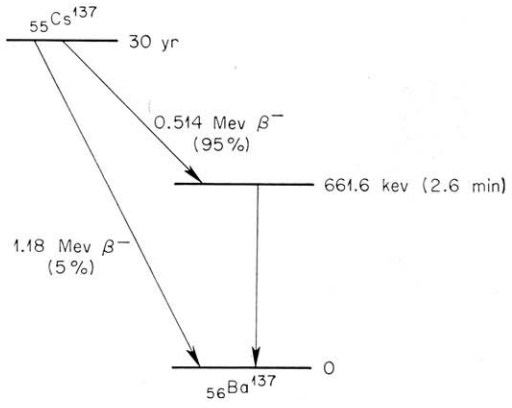

Figure 1. Simple decay scheme of ^{137}Cesium.

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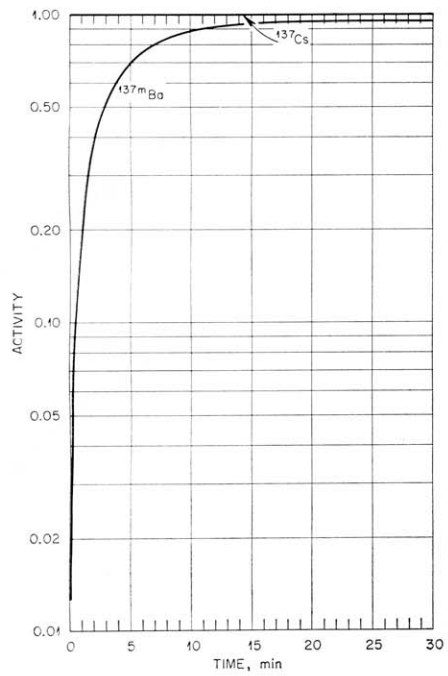
[1] CHOPPIN, G. R., AND NEALY, C. L., J. CHEM. ED., **41**, 598 (1964).

[2] Isotopes Sales Department, Isotopes Development Center, Oak Ridge National Laboratory, Oak Ridge, Tennesee.

[3] PINAJIAN, J. J., *Isotopes and Radiation Technology*, **1**, 340 (1964); and CHOPPIN, G. R., AND NEALY, C. L., J. CHEM. ED., **41**, 598 (1964).



Time, minutes	Activity of ^{137m}Ba
.00	.00
1.00	.223
2.00	.393
3.00	.523
4.00	.623
5.00	.699
6.00	.758
7.00	.803
8.00	.837
9.00	.864
10.00	.884
11.00	.899
12.00	.911
13.00	.920
14.00	.927
15.00	.933
16.00	.937
17.00	.940
18.00	.942
19.00	.944
20.00	.945
25.00	.949
30.00	.950
35.00	.950

Figure 2. The growth and decay curves of ^{137m}Ba and ^{137}Cs, respectively.

shown in Figure 1. The growth and decay curves are shown in Figure 2.

For our experiment we chose zirconium phosphate as the exchanger on the basis of the work of Kraus, *et al.*,[4] on the ion-exchange properties of hydrous oxides; they indicated that Cs^+ is strongly held by zirconium phosphate, while Ba^{2+} is practically unadsorbed. A column can be conveniently prepared from a disposable Pasteur-type pipet or a short length of 5-mm id glass tubing drawn to a capillary tip. A plug of glass wool at the bottom is used to retain the inorganic exchanger. The column is filled to a height of about 10 mm with Bio-Rad ZP-1, 100–200 mesh zirconium phosphate, previously equilibrated with 1 *M* HCl. Figure 3 shows the simple apparatus. From 10 μcurie to 1 mcurie of ^{137}Cs stock solution is charged directly onto the column without any treatment. (The lower quantity can be purchased without license and can be handled with no special shielding precautions.) The column is allowed to run dry. From activity measurements on the eluate it was concluded that >99.99% of the ^{137}Cs activity was adsorbed on the column.

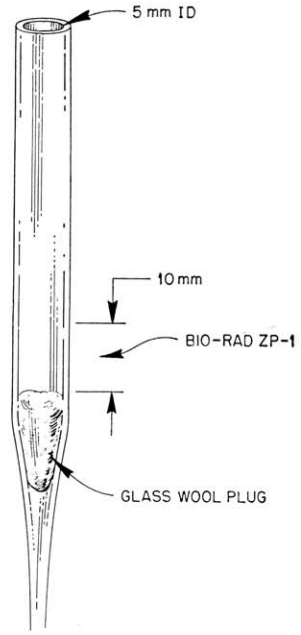


Figure 3. The radioisotope generator.

Elution was made by passing about 1 ml of 1 *M* HCl through the column and collecting the individual drops in separate 10 × 75-mm test tubes. The 661.6-kev photon was measured in the γ-spectrometric analyzer using a 3 × 3-in. NaI(Tl) crystal. Since the half-life of ^{137m}Ba is only 2.6 min, and the time required for counting, summing the peak, and having the data typed out was nearly 10 min for the 20 samples, the time of each 6-sec count was recorded and decay corrections were made on the counting rate. No correction was made for the growth of ^{137m}Ba during the 1–1$^1/_2$ min milking time. Figure 4 shows a typical elution curve. The tailing effect is, of course, the result of the growth of ^{137m}Ba during the elution.

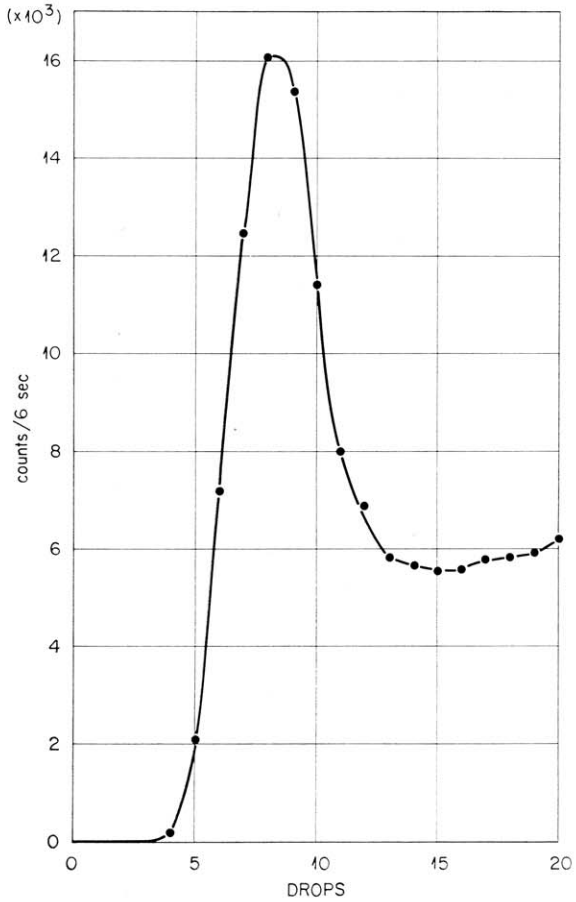


Figure 4. Elution of 2.6-min ^{137m}Ba from 30-yr ^{137}Cs with 1 *M* HCl. (Bio-Rad ZP-1, 100–200 mesh; flow rate: free flow.)

By analyzing a 1.0-ml eluate 1 hr after elution (to reduce the ^{137m}Ba activity to a negligible level) and comparing this activity with the original activity at the time of elution, a limit of $<2 \times 10^{-5}$% is obtained for the ^{137}Cs contamination. The yield of ^{137m}Ba is ~20% of the theoretical value. This, however, is adequate for the purpose.

The entire experiment should not take more than 1 hr, and the cost of the materials, excluding the γ-spectrometer or G-M counter, is quite nominal.

The author is most grateful to A. P. Callahan for performing these experiments.

[4] Kraus, K. A., Phillips, H. O., Carlson, T. A., and Johnson, J. S., "Second United Nations Conference on Peaceful Uses of Atomic Energy, Geneva," paper 1832, 1958.