PHOTON SPECTRA OF ^{125}I AND ^{129}I

There is a widely held misconception about the energy of the photon output of ^{125}I and since this nuclide is so widely used in radioimmune assay, it seems worthwhile to discuss the subject.

Iodine-125 decays by electron capture to ^{125}Te. In its isomeric transition from the nuclear activated state, the daughter emits a 35-keV gamma ray and this gamma is widely cited as the photon output of ^{125}I. This is misleading since the photon output of ^{125}I is almost entirely (95%) composed of characteristic x-rays of the daughter element tellurium. The photon output of ^{125}I is (*1*): gamma, 6.8%–35 keV; and x-rays, K_{α_1} 73.8%–27.5 keV; K_{α_2} 37.8%–27.2 keV; K_{β_1} 19.9%–31 keV; and K_{β_2} 4.1%–31.8 keV. Thus, the 35-keV gamma actually constitutes only 5.1% of the total photon output.

Once in flight, these x-rays originating from the electron shells are indistinguishable (except for their slightly different energies) from gamma rays of nuclear origin. The widely cited gamma ray at 35 keV is strongly overshadowed by the largely unrecognized but much more common x-rays mostly between 27 and 28 keV.

The sodium iodide crystal ordinarily used to count ^{125}I is incapable of resolving the several 27–32 keV x-rays from the relatively uncommon 35-keV gammas and all are lumped under one broad spectral peak. The top of this peak is at about 28–30 keV.

Because ^{125}I has a $T_{1/2}$ of only 60 days, it is inconvenient to use as a calibration standard and ^{129}I commonly is used as a long-lived (1.7×10^7 years) mock ^{125}I. Its photon output usually is stated as being

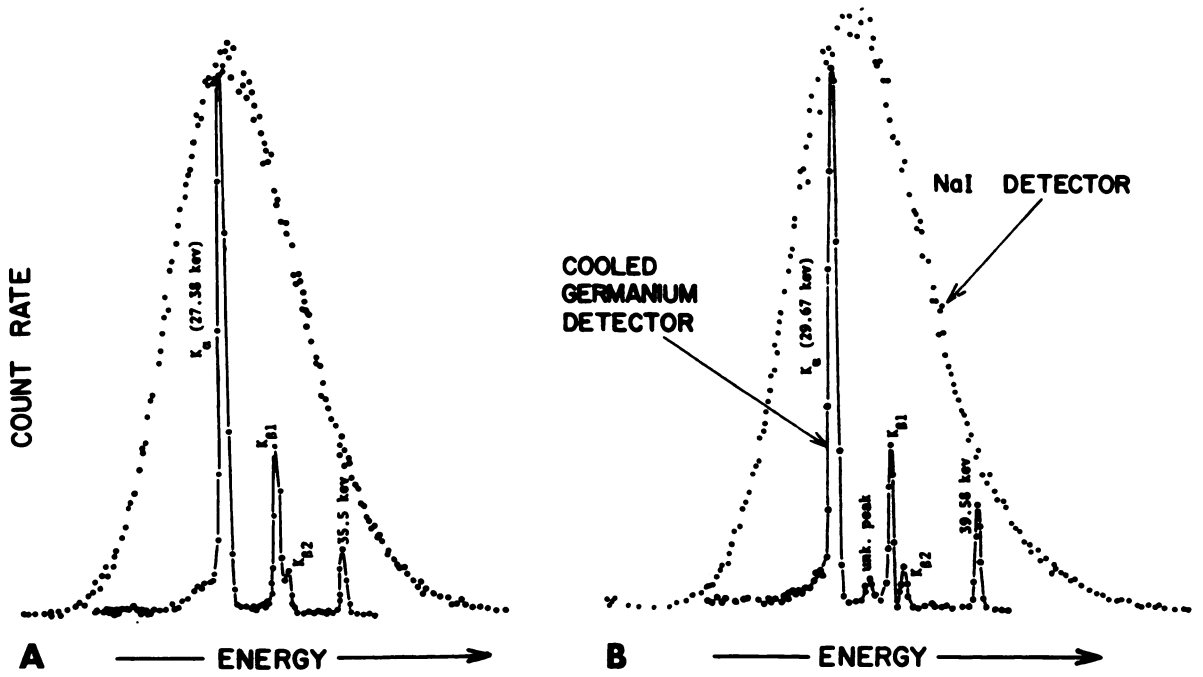

FIG. 1. (A) Spectra obtained from ^{125}I source using sodium iodide detector (upper curve) and high-resolution solid state detector (lower curve). Gamma (35 keV) is seen to be minor component (5%) of much greater numbers of lower-energy daughter tellurium x-rays. Sodium iodide detector lumps them all together and its peak is at substantially lower energy than gamma energy. (B) Similar spectra for ^{129}I. Gammas (39.5 keV) constitute about 12% of total photon output and are overshadowed by daughter xenon x-rays largely at 29–31 keV. The K_{β_1} x-ray energy is 33.6 keV and K_{β_2} is 34.4 keV.

a gamma of 39.5 keV. However, as with ^{125}I, this gamma is greatly overshadowed by daughter xenon x-rays of about 7% higher energy than ^{125}I-Te x-rays. It is actually these x-rays for the most part that are counted in a sodium iodide crystal detector. If the 39.5-keV gammas of ^{129}I were its dominant output, it would be a poor substitute for ^{125}I.

Although ^{125}I emission characteristics are available (*1*), no similar characterization of ^{129}I was found.

To document these spectral characteristics, photon emissions of ^{125}I and ^{129}I sources were kindly examined by Michael E. Phelps of the Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Mo., using a sodium iodide (thallium-activated) crystal detector and a 5-mm thick cooled germanium high-resolution solid state detector. The detector outputs were subjected to pulse-height analysis and are shown in Fig. 1. The characteristic x-rays of each daughter nuclide are shown both at high resolution and as lumped together by the sodium iodide detector. The relatively small numbers of gammas relative to x-rays are quite evident for both nuclides. The gamma rays of ^{129}I constitute only about 12% of its total photon output.

This report is intended to point out that these two spectral peaks of ^{125}I and its common long-lived phantom, ^{129}I, are not at the gamma energies of 35 and 39.5 keV, respectively, but at a considerably lower energy. This could achieve some practical significance if ^{125}I windows were optimized by dial number. Ideally, one would optimize ^{125}I window settings by obtaining a maximum count by adjusting an approximately 25–38-keV window using a ^{125}I uncalibrated source. The count obtained from a calibrated ^{129}I source with this same window setting would be the reference count for subsequent ^{125}I samples.

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REFERENCE

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RADIATION DOSIMETRY OF ^{131}I-19-IODOCHOLESTEROL: THE PITFALLS OF USING TISSUE CONCENTRATION DATA

As part of a program of evaluating ^{131}I-19-iodocholesterol for adrenal scanning, we have been collecting biologic distribution data for radiation dose calculations. The paper by Kirschner, Ice, and Beierwaltes (*1*) presents preliminary distribution data and dose calculations for this compound. By and large, our results correlate reasonably well with theirs. We have discovered a major error, however, in their method of dose calculation that results in an overestimation of the dose to liver and gonads by an order of magnitude.

The MIRD equation used for their calculation is:

$$D = \frac{\tilde{A}_s}{m_t} \Delta\phi$$

which says that the radiation dose to a target organ, t, from a source organ, s, is the product of the amount of radioactivity in the source and the length of time it stays there, $\tilde{A}_s$ (μCi-hr); the rate at which the nuclide puts out energy, Δ; and the fraction of the energy deposited in the target, ϕ. Since the dose, D (rads), is the amount of energy deposited per gram of target, the weight of the target organ, m_t, must be included. In calculating the radiation dose to an organ from the radioactivity localized in that organ (the "self-dose"), the first term of the equation, $\tilde{A}/m$, takes on the appearance of a concentration term (μCi/gm or % dose/gm) times the exposure time in hours. Since it is concentration that is most often measured in radiopharmaceutical distribution studies, there is a natural temptation to use concentration data directly in dose calculations. This is very dangerous. It can be done only under special circumstances.

The difficulty in the calculations in the paper by Kirschner, et al arises when tissue distribution data from dogs are used to calculate the dose to human organs. The authors have carried out the calculations using concentration data (% dose/gm) measured in dogs. In effect, by using the wrong m_t, they have calculated the dose to the human liver, testes, and ovary as if all of the energy were deposited in dog-sized organs. This overestimates the radiation dose to these organs by roughly the ratio of the body weights of the dogs used and "standard man." They have not normalized for the difference in organ weights. It is fortunate that rats or mice were not used for the distribution studies; the calculated radiation dose would have frightened us all away from this useful scanning agent.

In the last paragraph of their paper, the authors report that the initial results from human distribution studies indicate that the gonadal concentration is indeed a factor of 10 lower than in dogs. This is the