# LETTERS TO THE EDITOR

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**Communications should not in general exceed 600 words in length.**

## Radioactivity Produced by Bombarding Thallium

Previously published data on the activities produced in thallium show several periods: $4\pm0.5$,[1] 4.1,[2] and 5[3] min. produced by slow and fast neutrons, 97 min. by slow neutrons[1,4] and 50 min. by fast neutrons.[3] The similarity between the short period and the half-life, 4.76 min., of the naturally radioactive isotope of Tl, actinium C″ ($Tl^{207}$) led to a careful comparison of the two activities, since the latter could be made from Tl only by the unknown $(D, \beta^+)$ reaction.

The thallium used for bombardment was purified by the following successive processes: recrystallization of thallous nitrate and sulfate, oxidation to thallic chloride, extraction with ether, conversion to thallous sulfate, electrolytic deposition as thallium metal. The metal was fused in a current of hydrogen and rolled into a thin sheet.

The activity obtained by short bombardment of the Tl, with slow and fast neutrons and deuterons, had an average half-life of $4.23\pm0.03$ min. Actinium C″ was separated chemically from the active deposit of actinium, and the average value, $4.77\pm0.05$ min. was obtained under the same conditions of measurement with the Lauritsen electroscope. The difference between the two values is much beyond the experimental error, leaving no doubt that they are not identical.

In order to make certain the chemical nature of the 4.23-min. period, the very active material from the deuteron bombardments was separated chemically, using the insolubility of thallous iodide, chromate and chloride, the solubility of thallic chloride in ether and of thallous sulfide in dilute acid. In all cases the activity followed the reactions of thallium.

The activity is produced by neutrons from the Be+D and Li+D reactions, both when wrapped in cadmium and when surrounded by 10 cm of paraffin. It is thus induced by both slow and fast neutrons and this in intensities of the same order of magnitude. Since the two stable isotopes of Tl are present in the amounts: $203-29.5$ percent, $205-70.5$ percent, the evidence supports the conclusion of Heyn,[2] that the isotope is $Tl^{204}$, produced from $Tl^{203}$ by neutron capture and from $Tl^{205}$ by the $(n, 2n)$ reaction.

The range of the negative $\beta$-particles in Al is $0.75\pm0.05$ g/cm$^2$, which gives $1.6\pm0.1$ Mev as the energy (using the relation $R=0.526E-0.094$). Sargent[5] gives the similar value 0.68 g/cm$^2$ for the range of the $\beta$-rays from AcC″, from which the energy 1.47 Mev follows. The $\gamma$-ray or bremstrahlung background of the $Tl^{204}$ is about 0.01 percent of the total activity.

Intense slow neutron bombardments, lasting up to four hours, have not shown any period of the order of the 97-min. half-life. However, 1 to 2-hour deuteron bombardments produce a weak activity, about five times the background of the Geiger-Mueller counter used, which has been chemically identified as thallium. It shows a decay in $2\frac{1}{2}$ months corresponding to a half-life of 1 to 2 years. A similar decay is shown by an activity produced by 4-hour slow neutron bombardments, with intensities about equal to the background. This seems to indicate that the activity is due to $Tl^{206}$, produced from $Tl^{205}$ by $(D, p)$ and $(n, \gamma)$ reactions.

Bombardment of thallium by deuterons also produced a strong activity with a period of $52\pm1$ hours which has been chemically identified as lead by several reactions: the precipitation of lead sulfide, chromate and sulfate, and the solution of the latter two in acetate and alkali. A fractional precipitation of lead sulfate was carried out by acidifying a solution of lead sulfate in sodium acetate. The activity per milligram of the three fractions obtained was the same within the experimental error of about five percent.

The absorption curve of this lead activity in Al shows a $\beta$-activity with a range of $0.11\pm0.01$ g/cm$^2$ indicating an energy of 500 kev, accompanied by a $\gamma$-ray activity equal in intensity to six percent of the total. The energy of this has not yet been determined.

$Pb^{204}$ and $Pb^{206}$ are the two possible isotopes of lead which could be produced from $Tl^{203}$ and $Tl^{205}$ by the usual $(D, n)$ reaction. Both of these are, however, stable. The results would suggest that the activity is due to a metastable state in one of them which emits a $\gamma$-ray that is internally converted into the observed $\beta$-rays.

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