Preliminary Determination of the Neutron Absorption Cross Section of Long-Lived I^{129}*

SEYMOUR KATCOFF
University of California, Los Alamos Scientific Laboratory, Santa Fe, New Mexico
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THE following chain of mass number 129 is known to occur in fission:

$$\text{4.2-hr. Sb} \rightarrow \text{72-min. Te} \rightarrow \text{long-lived I} \rightarrow \text{stable Xe}$$
$$\uparrow$$
$$\text{32-day Te.}$$

An attempt was made by J. Seiler[1] to detect by radiochemical means the long-lived I^{129}. He isolated the iodine from a uranium slug which had undergone irradiation in the Clinton pile for 123 days. The sample decayed essentially to background, with a half-life of 8.0 days which is characteristic of I^{131}. This indicated that the half-life of I^{129} was extremely long, or that its radiations were extremely soft, or both.

In the present experiment this same iodine sample was irradiated simultaneously with two normal iodine samples for 12.8 hours in the Los Alamos homogeneous pile, just outside the BeO reflector. Normal iodine, which is known to consist only of stable I^{127}, should give on slow neutron irradiation only 25-min. I^{128}. However, the sample which also contained some I^{129} yielded several thousand counts per minute of 12.6-hr. I^{130} after irradiation. All three samples were purified radio-chemically, mounted as AgI, and counted with a mica-window Geiger counter. Absorption of the radiations of the 12.5-hr. component in aluminum indicated two beta-rays with maximum energies of 0.54 and 1.02 Mev. This compares favorably with the values for I^{130} reported in the literature of 0.61 and 1.03 Mev.

The neutron absorption cross section of I^{129} could be calculated from the data of this experiment if the number of I^{129} atoms in the samples were known. Unfortunately, this can be calculated only roughly because the isolation of the iodine from the uranium by Seiler was not done quantitatively. Two separate methods of making this estimate were used. The first is based on the fission cross section of uranium, the fission yield of the chain of mass 129 (0.7 percent), the weight of uranium, the time of irradiation, the approximate neutron flux in which the uranium slug was irradiated, and the assumptions that about 30 percent of the iodine in the slug was extracted and that the chemical yield was also about 30 percent. This leads to a value of 7.6×10^{15} for the number of I^{129} atoms and to a value of 2.5 barns (10^{-24} cm^2) for the cross section. The other method of estimation is based on an approximate measurement of the 8.0-day I^{131} activity which was present at the end of the 123-day irradiation in the iodine sample. This assumes that the bombardment of the uranium was steady, especially near the end. The fission yield of I^{131} was taken as 2.5 percent. This leads to a value of 1.9×10^{15} I^{129} atoms and to a value of 10 barns for the cross section. This is thought to be more reliable than the first value, so that a weighted average of the two gives a final value of about 8 barns, which is very probably correct to within a factor of ten.

The neutron flux passing through the iodine samples during their irradiation at the Los Alamos pile was calculated from the activity of the 25-min. I^{128} and the cross section of stable I^{127} (6.25 barns). In the calculations, corrections were made to 100 percent counter geometry, to 100 percent chemical yield, to zero absorber, and for decay.

A half-life of 10^8 years, or longer, for I^{129} is consistent with the results of Seiler's experiment. Such a long period would make it possible for I^{129} to exist in nature. In fact, the two normal iodine samples used in this experiment did show a small amount of residual activity after the decay of the 25-min. I^{128} (see Fig. 1). Some of this may be due to 13-day I^{126} formed by an $(n, 2n)$ reaction, and to impurities. However, there is some indication of a 12.9-hr. period which may be due to 12.6-hr. I^{130}. This sets an upper limit of 3 parts per million for the amount of I^{129} that might

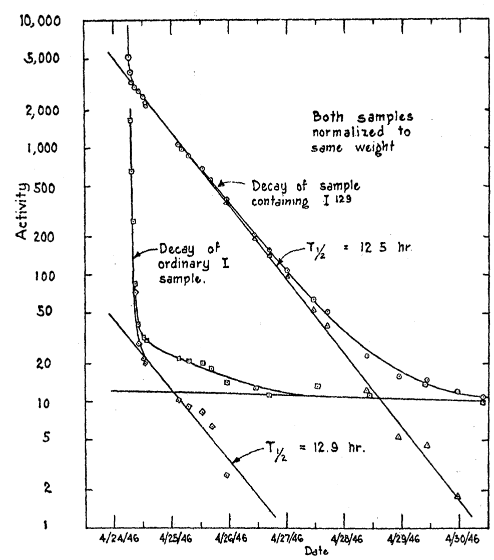

FIG. 1. Decay of 12.6-hr. I^{130} produced by neutron bombardment of long-lived I^{129}.

be present in normal iodine if a cross section of 0.8 barn is taken. The limit is only 0.3 part per million if the most probable cross section of 8 barns is used. Nier reported[2] an upper limit from mass spectrographic data of 25 parts per million. This problem can be investigated further by bombarding larger samples of normal iodine in a higher thermal neutron flux and then subjecting them to more extensive purification.

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[1] Manhattan Project Progress Report CN-1998, p. 2.

[2] A. O. C. Nier, Phys. Rev. 52, 937 (1937).