

Decelerated β -Decay of Tritium Solved in Titanium

Otto Reifenschweiler

Philips Research Laboratories, Eindhoven, The Netherlands

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It is shown that it is not possible to explain the measured decrease of tritium radioactivity by a change between adsorption at the surface and bulk absorption in small titanium particles as argued in a recent note in this periodical. As to the reduction of titanium oxide by tritium, it is pointed out that the enthalpy of formation of titanium oxide is nearly 4 times that of water.

In a previous letter [1] the author has claimed a sharp decrease of the radioactivity of tritium when the hydrogen isotope was sorbed in small monocrystalline particles ($\varnothing \approx 15$ nm) of titanium and this preparation was heated up to 275°C. With further heating up to 360°C the original radioactivity was recovered. In the heating experiments the radioactivity was measured via the X-radiation by a GM tube. In a recent opposing note [2] Wicke argued that the decrease of the measured radioactivity is not caused by a decrease of the β -activity of tritium and he proposed that it is caused by migration of the tritium atoms from chemisorption at the surface to bulk absorption when the radioactivity decreased and conversely that it returns to the surface at the re-increase of the radioactivity. Indeed it is known that not only does bulk absorption happen in metal hydrogen absorbers but also chemisorption at the surface. This is e.g. described by

Wicke and Brodowsky [3] for the Pd-hydrogen system. However there may be no essential difference between both modes of sorption with respect to the claimed effect of the decrease of the radioactivity of tritium. In both modes of sorption the hydrogen atoms are bound to the metal lattice with a distinct enthalpy of formation. The hydrogen is maintained in harmonic oscillator potential wells, and the local modes $h\omega$ are measured for different systems, as described e.g. for the PdH-system in [3] and for the TiH-system in [4, 5]. But in the present state of investigation it is not possible to distinguish between bulk absorption and chemisorption at the surface of the titanium particles.

It is quite understandable that conventional explanations as e.g. in [2] should be sought to account for the strange course of $a=f(T)$ given in Fig. 2 of [1]. Indeed such a high decrease of λ as claimed in [1] was never observed, and a theoretical explanation is completely lacking. However the effect proposed in [2] cannot explain the course of $a=f(T)$ presented in Fig. 2 of [1]. The Ti-particles ($\varnothing \approx 15$ nm) are arranged in chains with many ramifications*. Thus a very loose structure of the preparation is obtained with much empty space (vacuum) between the Ti-particles of different chains. The time constant for the uptake of tritium is about 10 s. This ensures that the different Ti-particles sorb the tritium to an equal concentration (maximum of entropy). The geometry of our tube (Fig. 1 of [1]) is such that all β -particles are completely decelerated in the Ti-layer and some in the tube wall supporting the layer. The situation is shown schematically in Figure 1. We calculate from the data given in [1] that the mean thickness of the titanium layer is about 0.54 mg/cm². Thus about 80 Ti-particles are piled up in the layer. This layer is a homogeneous source of tritium β -particles. The maximum energy is 18.6 keV, which results in an effective range of about 0.9 mg/cm², that is the thickness of about 130 Ti-particles of 15 nm diameter.

* In [1] two references are given where electron micrographs of such preparations are shown.

Reprint requests to Dr. O. Reifenschweiler, Jan Sluytersweg 13, NL 5645 JA, Eindhoven, The Netherlands.



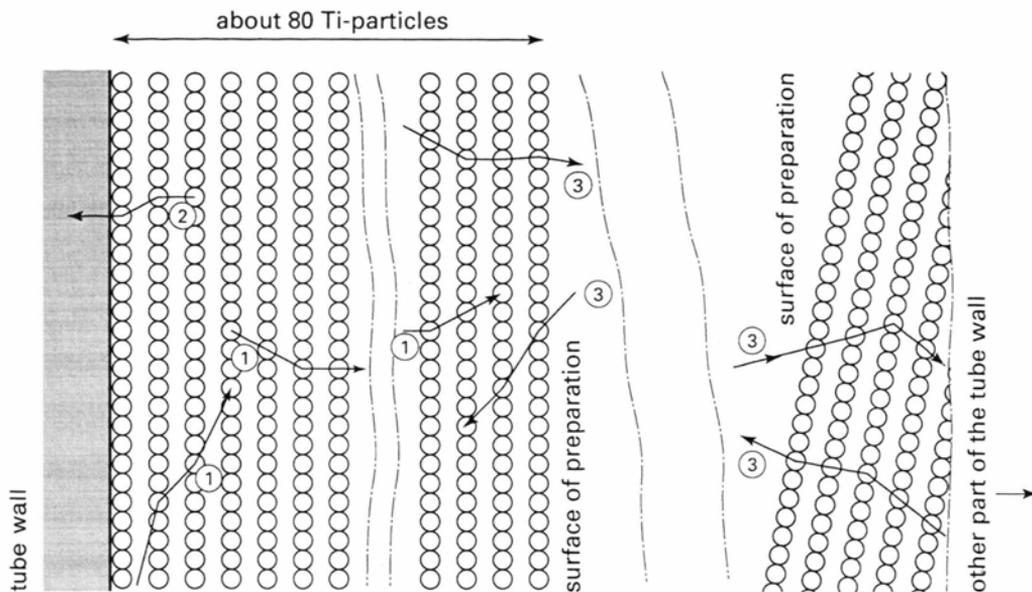


Fig. 1. Electron paths in a titanium-tritium preparation deposited on the tube walls (schematic).

There are in fact three different possibilities for electron paths as shown in Fig. 1:

1. The electron is completely decelerated in the titanium layer.
2. The electron enters the tube wall supporting the layer.
3. The electron leaves the layer and enters it at another place on the tube wall.

It is therefore not lost for the generation of X-radiation. The Ti-layer and the upper part of the tube wall supporting the layer are thus a homogeneous source of X-radiation, whose intensity is proportional to the

β -radioactivity of our preparation. It is completely impossible to distinguish between tritium atoms chemisorbed at the surface or absorbed in the bulk of the individual Ti-particles. Further details of the measuring process are given in [1].

Regarding the contention in [2] that the course of $\frac{\Delta a}{\Delta x} = f(x)$ Fig. 3 of [1] is caused by successive oxidation of titanium and reduction of the titanium oxide by tritium, the author points out that the enthalpy of formation of 1 mol of titanium oxide is nearly 2 times that of 2 mols of water. Furthermore special care was taken that no impurities, especially oxygen, had access to the freshly deposited Ti layer.

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