§ 6. Development of a Proportional Counter to Measure the Tritium in the Air

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Tritium is included in compounds of water, hydrogen gas, and methane in atmospheric air. Tritium concentration of hydrogen gas in the air; ~50 mBq cm^{-3}-H_2 (~0.025 Bq m^{-3}-air), is 50 times higher than that of water in the air; ~1 mBq cm^{-3}-H_2O (~0.02 Bq m^{-3}-air). Therefore, if hydrogen gas were separated from the other gases, its tritium concentration would be easily measured. The purpose of our group is to develop a real-time monitor to measure the tritium concentration separated as hydrogen gas from the other one in the air.

The development of a detector to measure the tritium concentration is shared in this work. There are flow type of ion chamber and proportional counter for the purpose. The proportional counter was selected as the object because of its higher sensitivity. A proportional counter of 166 cm^3 in real volume was constructed as the detector. To decide the appropriate gas for counting, the plateau characteristics of six kinds of gases (PR, Ar, CH_4, H_2, N_2, and Air), the pulse height voltages, and the effective volumes were investigated. Finally, the minimum detectable concentration (MDC) of the counter was computed from its background count rate and the effective volume according to the equation by Currie[1].

A cylindrical proportional counter, 37-cm long, 29 mm in inner diameter was made of brass. Tungsten wire of 50 μmϕ was used as the anode. Using ^{137}Cs (external source) and/or HT gas (inner source), the plateau potentials of the six gases were investigated, and their operating potentials were determined. At the potential, the pulse height voltages of the preamplifier were measured by an oscilloscope. To correct the tube-end effect, their effective volume was measured by the diffusion method[2]. Table I lists the results. Although PR gas had advantages of low plateau potential and of high pulse, it was not applicable for continuous monitoring because of the expenses. Nitrogen and air were less expensive, but they were not agreeable because of their high and narrow plateaus. Since Ar and H_2 had relative low and wide plateau, they were proved to be available for the counting gas. To obtain high sensitivity for tritium, hydrogen gas itself was suitable. Then, the tritium concentration response of the counter using the counting gas as H_2 was examined using tritiated hydrogen gases ranged from 0.01 to 0.11 Bq cm^{-3}. As shown in Fig. 1, the concentration and the count rate were in good correlation, but there were a few errors in the low concentration region. The MDCs corresponded to the counting time are listed in Table II. The MDC was under the tritium concentration of the hydrogen gas in the air. If the hydrogen gas were purely separated from the air, the concentration could be measured by this counter. However, according to report from the hydrogen separation research group, additive hydrogen should be needed for the hydrogen separation. Thus, the following subject is to construct a counter with lower MDC.

A flow-type proportional counter to measure tritium concentration was constructed. It was validated that the hydrogen gas itself may use for the counting gas. The MDC of the counter was lower than the tritium concentration of the hydrogen gas in the air. The counter may be applied for real-time tritium monitoring.

Table I Experimental results

Gas	Plateau for HT (V)	Pulse height (mV)	Effective volume (cm^3)
Ar	1450 - 1575	10	110
PR	2180 - 2250	3000	128
H_2	2250 - 2400	20	136
CH_4	2500 - 2900	20	121
N_2	3040 - 3070	15	113
Air	3200 - 3210	7	91

Table II The MDC of the counter

Counting time (s)	6	10	60	600	3600
MDC (mBq cm^{-3})	9	7	3	0.9	0.4

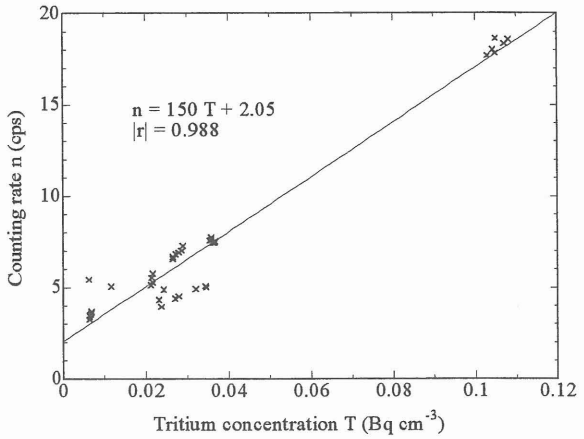

Fig.1 Tritium concentration vs. counting rate.

References
1) Currie, LA. : Anal. Chem. **40** (1968) 586
2) Wu, Y., et al.: Nucl. Instr. Meth. Phys. Res. **343** (1994) 539
3) Ogata, Y. et al.: Proc. 3ed Workshop Environ. Radioactivity. KEK (2002) 109