§11. Development of Proportional Counter to Measure Tritium in Atmospheric Air

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Tritium will be generated at the D-D plasma experiment, which will be one of the next projects of National Institute of Fusion Sciences. The D-D reaction includes D+D→^{3}He+n and D+D→T+p, which will generates tritium. The tritium concentration in the work place and the environment should be promptly monitored to guarantee safety of the experiments. Chemical species involving tritium in the atmospheric air are predominantly H_2O, H_2, and CH_4. The sensitivity of conventional tritium gas monitors is too low to detect the legal tritium concentration. Alternative method is a liquid scintillation counting by measuring the trapped water vapor and trapped vapor of water oxidized hydrogen and methane. The method, however, requires lots of time and labor to collect the vapor, to exchange the chemical forms of hydrogen and methane gases, and to count the samples. The purpose of this study is to investigate a feasibility of a real-time monitoring of tritium on the water vapor in the atmospheric air.

The flow through type of proportional counter, 130-mm long, 29 mm in inner diameter was made of brass. The anode was made by a tungsten wire of 50 μmϕ. The block diagram is shown in Fig.1. PR gas, Ar, and hydrogen were used for counting gases at room temperature. The plateau characteristics were measured using an external ^{137}Cs source. The change in the counts was collected via a multichannel scaler.

The experimental setup is illustrated in Fig.2. First, the remaining air in the system was purged by Ar, and the magnesium column was heated at 550°C. Then water in the evaporating flask was heated to generate water vapor. The water vapor was fed into the magnesium column, and was reduced to hydrogen gas[1]. The gas was desiccated and was drawn into the proportional counter. At first step, water including natural tritium (natural water) was fed in the evaporating flask, and the generated hydrogen with Ar was counted. Next, water of which tritium concentration was 12 kBq cm^{-3} was put into the flask and the vapor was fed into the column. Finally, natural water was put into the flask again.

The plateau potentials were 2000-2300 V, 1450-1650 V, and 2530-2550 V, for PR gas, Ar, and hydrogen, respectively. The plateau for hydrogen was somewhat narrow than the previous counter constructed by us[2]. Therefore, Ar was used for carrier of the water vapor and for counting gas.

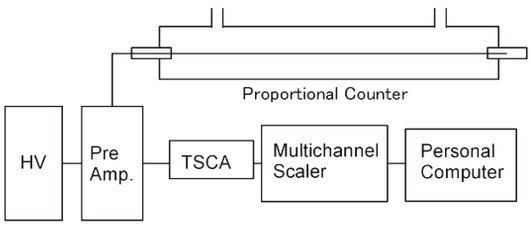

Fig.1 Block diagram of the system.

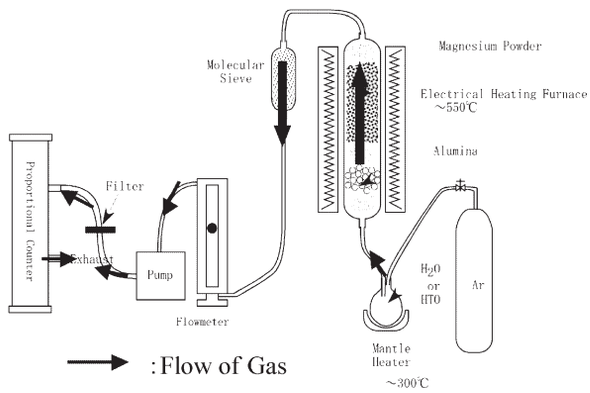

Fig.2. Experimental setup.

The count rate for the natural water was about 3 cps, which was the background count rate. After the tritiated water was put into the flask, the count rate was exponentially increased and was reached 12 cps. The count rated was gradually decreased after the natural water was put into the flask again.

The hydrogen concentration in the counting gas was 1.5%. Considering the hydrogen concentration, the background count rate, and the effective volume of the counter, the minimum detectable concentration (MDC) for 10 min counting was 0.016 Bq cm^{-3} at atmospheric temperature of 20°C and the relative humidity of 50%. The MDC was one-fiftieth of the legal limit of tritium concentration for work place, i.e., 0.8 Bq cm^{-3}.

Tritium on the water vapor in the atmospheric air was measured using a proportional counter by reducing the water to hydrogen. Real-time tritium monitor is feasible by applying this method.

References

1) W. W. Bowman and M. B. Hughes, Methods of Low-Level Counting and Spectrometry, IAEA, Vienna, (1981) 353.
2) Ogata, Y. et al.: Proc. 19th on Radiation Detectors and Their Uses. KEK (2005) 177.