§8. Development of Tritiated Gas Monitoring System Using Solid Scintillation and Air Sampling System

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Considering radiation safety and management, development of gaseous tritium monitoring system is indispensable issue. Tritium is known as a radioactive hydrogen isotope emitting low energy beta particles. Artificial tritium is produced mainly in nuclear facilities including the nuclear tests. In a future nuclear fusion facility large amount of tritium will be produced and processed. It also will be useful for safety management to improve the convenient tritium monitoring system. So we started to develop the system with functions of automatic sequential tritium gas sampling and detection system. Principle gaseous tritium sampling method is absorbing the tritiated moisture by dehumidifier. When sampling air is evacuated into the system, moisture is condensed to water and hydrogen and hydride compounds are oxidized to water by catalyst using precious metal. Finally the condensed water is flow into the beta β rays counting instrument. We made feasibility study to measure the tritium concentration by using plastic scintillator and photon counting equipment that is photomultiplier tube. The advantage of using the plastic scintillation system is not necessary to consider disposal of radioactive liquid organic waste.

Presuming that the tritiated air is collected as liquid water we examined sensitivity of the plastic scintillator. Additionally the conventional liquid scintillation counting had been compared using tritiate water.

The plastic scintillator used in this experiment was commercially available NE102A. The actual effective surface area was 2.2 cm^2. The plastic scintillator was put on a plastic plate on which surface a groove of 1mm width, 0.5 mm depth and length of 22 cm was manufactured. The experimental water flowed in the groove. When sample of tritiated water flow into the groove, photons produced by the plastic scintillator with incident β rays. The photons are incident to a photomultiplier tube and electrically counted. Then various tritium concentrations solution was flow into the plastic plate groove. The count rates were obtained substituting the background counts from the gross counts. The tritium concentrations of the test water were varied from 346 Bq/cm^3 to 7,330 Bq/cm^3 in stepwise. Normal count time was fixed 500 sec. Then the effective tritium count rate was small like 3cps/7000Bq/cc because the beta energy is very low as average 5. 7 keV, such low energy of beta particles has a very short range like 5.9 μm in water. However the plastic scintillation detector showed good linearity with the tritium activities. It was also found that the detection limit strongly depends on the effective surface area of the plastic scintillator. Its detection efficiency was about 0.3% as shown in Table 1. As comparison the other β radioactive nuclides of ^{14}C and ^{90}Sr contained water was measured. Then larger detection efficiency was obtained and it was almost the same as estimated efficiency. It was confirmed that large energy β-ray of $^{90}Sr(^{90}Y)$ could be detected perfectly. Because its range is over 1 mm which value is larger than that of tritium. To detect tritiated water it is necessary to increase its effective area.

Table 1 Detection efficiency of plastic scintillator for β radioactive nuclides.

Radionuclide	energy (MeV)	Measured (%)	Estimated (%)
^{3}H	*0.0057	0.32	*0.05
	0.0186		0.5
^{14}C	*0.04	0.68	*2.6
	0.156		28
$^{90}Sr(^{90}Y)$	0.546 (2.28)	59	50

* Average energy assumed

To develop the tritiated air monitoring system, we examine to recover tritiated water from air sample. As preliminary study we planned to manufacture water sampling system as shown in Fig. 1. The principle process flow is to feed the air through a filter, and oxidizing isotopic hydrogen gas to water using precious metal Pd or Pt. Then the water would be recovered by condenser. The condensed water is transferred to the scintillation detector. In the next step, it is necessary to design the tritiated air sampling system. We have a plan to confirm the actual water recovery examination. Here the fundamental study for the oxidizing catalyst had been performed. The useful catalyst would be honeycomb type which has advantage to obtain low pressure drop under high gas flow condition. It had been confirmed that the Pt catalyst is useful for hydrogen oxidation and the Pd catalyst is suitable for methane oxidation. Although real time tritiated air monitor should be done in continuous condition, it is not easy because of the hardness of tritiate air sampling speed. Our air sampling time interval for monitor requires around 10 min. Although it is a batch system, it would be said almost a real time monitor. The acceptable detection limit desired is less than 60 Bq/cc that is the regulation law limit. If the effective scintillation surface area is increased to 24 times, the detection limit would be achieved. The previous radiological experiments had been be conducted as collaboration with Kaken Company.

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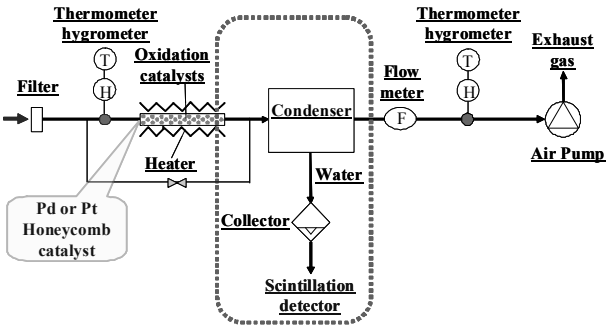

Fig. 1. Principal flow scheme of titiated air sampling and detection by scintillator.