§4. Sensitivity of Plastic Scintillator to Measure the Tritium in Water for Gaseous Tritium Monitoring

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Tritium is a radioactive hydrogen isotope emitting low energy beta particles. Except the naturally generated tritium it is produced artificially mainly in nuclear facilities including the nuclear tests. In a future nuclear fusion facility large amount of tritium will be produced and processed. Considering radiation safety and control, development of gaseous tritium monitoring system is indispensable issue. It also will be useful for safety management to improve the convenient tritium monitor system. So we started to develop the system with functions of sequential tritium gas sampling and automatic measurement. Major system is the air sampling system to capture hydrogen and hydride gases including tritium. When sampling air is evacuated into the system, hydrogen and hydride compounds are oxidized to water by high temperature catalyst of precious metal. The water vapor is absorbed to the liquid absorber by the nebulizer and denuder tube[1)], then the gas and liquid is separated through the separator. Finally the enriched solution is flow into the tritium activity detecting instrument. Then we made feasibility study to measure the tritium concentration by using plastic scintillator and photon counting equipment. The advantage of using the plastic scintillator is not generating organic radioactive liquid waste.

Assuming that tritium is collected as liquid water we had dune sensitivity of the plastic scintillator. As comparison the conventional tritium measurement method had been done by a liquid scintillation counter.

The plastic scintillator used in this experiment was commercially available type NE102A. The plate size was width and length of 35 mm square. To the opposite side plastic plate width of 1mm and depth 0.5 mm long length of liquid flow groove was placed. When sample of tritiated water flow into the groove, photons produced by the plastic scintillator with incident beta β rays. The photons are incident to a photomultiplier tube and electrically counted. Figure 1 shows the experimental photons detecting system. Using this detector the scintillation detecting system was examined. Then various tritium concentrations solution was flow into the plastic plate groove.

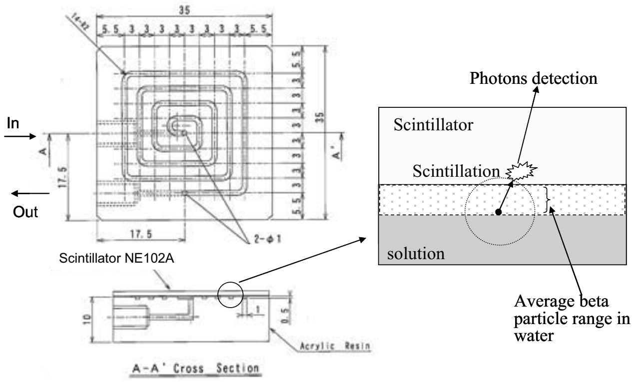

Fig. 1. An equipment of tritiated water flow presumed to be collected from air sampling system and detection image by plastic scintillator.

The relationships between the tritium concentration and photon count rates are shown in Fig. 2. The count rates shown are both the gross count and count after minus the background. At first the tritium concentrations were increased from 346 Bq/cm^3 to 7,330 Bq/cm^3 in stepwise. After that the pure water was injected to clean the groove. And in reverse the tritium concentration was decreased from 7,330 Bq/cm^3 to 346 Bq/cm^3 in stepwise. Normal count time was fixed 500 sec. Although the effective tritium count rate was small, it showed linearity with the tritium activities. It was also found that when the concentrations were decreased from high to low, the count rates observed were slightly higher than the rates when concentrations were increased from low to high. This difference was assumed to be a memory effect. To avoid the memory effect, concentrations were varied from low to high in ordinal experiments. As a reference mixture of tritiated water and liquid scintillator were measured. The relationship between the tritium concentration and liquid scintillation count rate shows good linearity. Also the detection efficiency was estimated at approximately 9%. In contrast, the efficiency for the solid scintillator was less than 1% because the beta energy is very low, that is, the low energy of beta particles has a very short range in water.

Based on the feasibility study of the monitoring system, we got fundamental data to design concept of the tritiated gas sampling and measurement system. In the next step, it is necessary to confirm that actually tritiated water concentration is detectable with the improved photon counting equipment in long time by constant detection efficiency and to do experiments with the air sampling system.

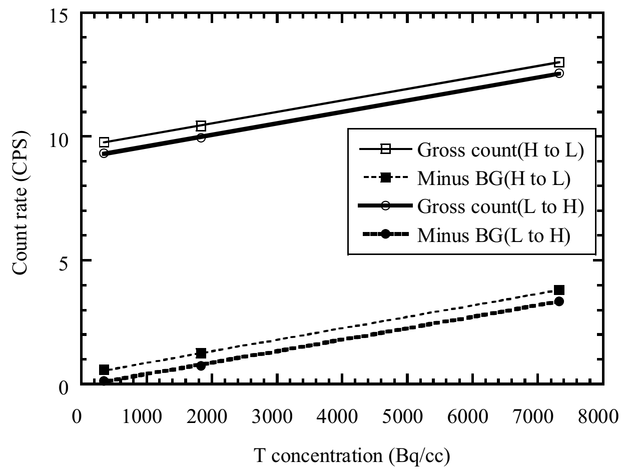

Fig. 2. Measurement of tritium in water by the plastic scintillator. H and L mean high and low concentration respectively.

1) Kurosawa, K.,: Bunseki Kagaku **54** (2005) 1175