§3. Tritium Water Monitoring System Based on CaF_2 Flow-Cell Detector

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A liquid scintillation counting system is usually used for measuring tritium concentrations in effluent water, because it has high sensitivity to tritium. However, continuous measurements in real time are impossible with this system, because it uses batch processing and takes a long time to obtain its final measurements. Moreover, special attention must be paid to the selection of a scintillation cocktail. That is, one must consider the chemical form of the liquid sample to be measured and the mixture ratio of the effluent water sample and scintillation cocktail. Furthermore, the measured sample becomes radioactive organic liquid waste containing tritium that has to be processed under the rules of radiation-related law. To overcome these disadvantages, a system for monitoring tritium containing water was developed by using a solid scintillator in place of liquid scintillation cocktail in the flow-cell detector. In the present study, the tritium water monitoring system was developed and evaluated its performance measuring standard tritium water samples with known tritium concentrations.

The tritium water monitoring system is schematically shown in Fig. 1. The system was designed for measuring tritium concentrations in effluent water and is composed of a flow-cell detector, a pair of photomultiplier tubes (PMT), a circuit unit (including a high-voltage power supply and a coincidence counting module), a water flow pump, a multichannel pulse height analyzer and a sample bottle. The flow-cell detector was fabricated using a solid scintillator, and the tritium-containing water sample for the performance test was put in a sample bottle that simulated an effluent water tank at a radiation facility. The water sample was pumped into the flow-cell detector through a pipe by using a water flow pump, and it flowed out of the system at the water outlet. The pump stably sent the tritium-containing water sample into the flow-cell detector. The detector was wedged between two photomultipliers. The background noise in the respective photomultipliers was reduced through the use of the coincidence counting method.

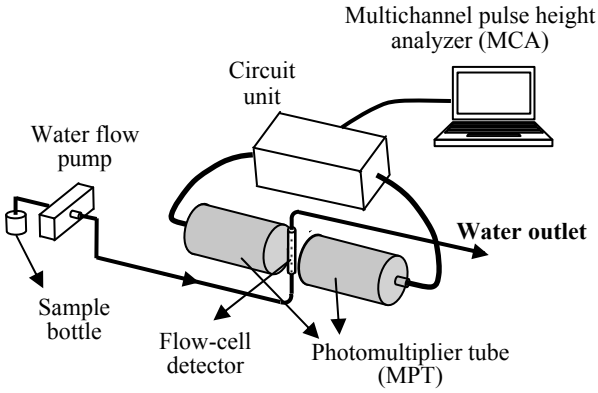

Fig.1 Conceptual diagram of tritium detector using a flow-cell detector.

The main part of the flow cell detector is a 44 mm long Teflon PFA (Perfluoroalkoxy) tube (inside and outside diameters: 3 and 4 mm). The Teflon PFA tube was selected because of corrosion resistant, low water absorption, and high diaphaneity. The tube had metal mounting hardware at each edge, and the overall length of the detector was 85 mm. Granular CaF_2 (Eu) was stuffed into the tube as solid scintillator. Three sizes of CaF_2(Eu) were examined: 50, 100 and 300 μm in diameter (Types 3, 2 and 1).

The results are shown in Fig. 2. X and Y axes are tritium concentration and count rate (cpm) based on 10000 sec measurement of two flow-cells for the respective Types, and circles, squares, and triangles denote Types 1, 2 and 3. In Fig.2, the lines derived by linear regression are shown with the respective linear functions and R^2-values of the fitted lines. The inclinations of the lines are steeper for smaller CaF_2(Eu) grains. Steeper means higher tritium detection sensitivity. The reason is that smaller grains have a larger total surface area in contact with flowing effluent water containing tritium. These results suggest that the present system worked as expected. Furthermore, it is found that the relation between count rate and concentration was definitely linear for 50 and 100μm CaF_2(Eu) because the R^2-

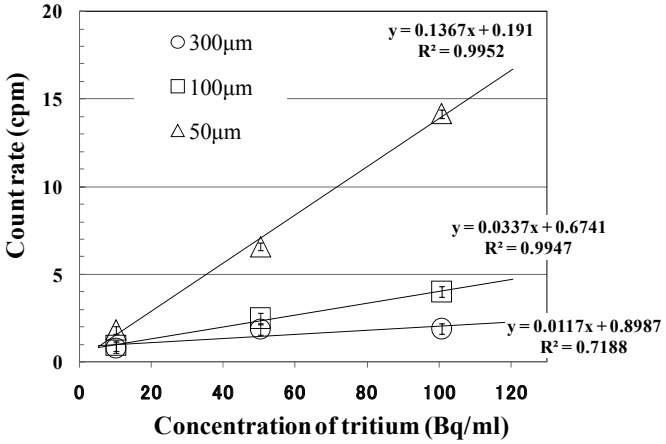

Fig.2 Relationship between tritium concentration and count rate.

This system is the first such real-time monitoring system able to measure tritium concentrations in water continuously flowing through the solid scintillation detector. In the case of 50μm CaF_2(Eu), the detection limit of tritium in water may be as low as 10 Bq/ml. This is low enough to monitor tritium in effluent water, because the regulated maximum concentration of tritium in effluent water is 60 Bq /ml at an outlet of a controlled area. However, the measurement time was 10000 sec, which is too long from the viewpoint of radiation management. In the near future, it should be try to shorten the measuring time of the monitoring system.