§3. Comparative Testing of Various Flow-Cell Detectors Fabricated Using CaF_2 Solid Scintillator

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For measuring tritium concentrations in effluent water, a liquid scintillation counting system is often used because it has high sensitivity to tritium. However it is impossible for this system to continuously measure tritium concentration because measurements are performed in batch processing. Moreover, following the measurements, radioactive organic liquid waste containing tritium is generated. In order to solve these problems, the development of a tritium water monitoring system using CaF_2 solid scintillation materials was started. The monitoring system is schematically shown in Fig.1.

The system consists of a flow-cell detector, a pair of photomultiplier tubes, a high-voltage power supply, a coincidence counting module, a water flow pump, and a multichannel pulse height analyzer. The high-voltage power supply and coincidence counting module are installed the circuit unit in Fig.1. The system is able to

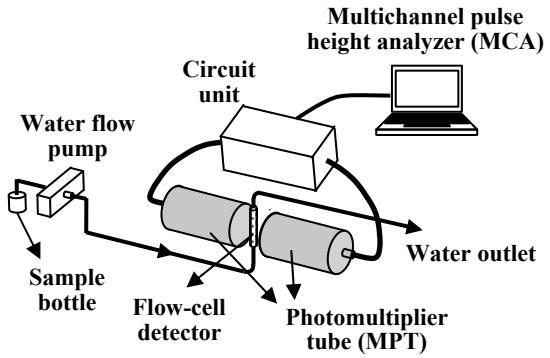

Fig. 1 Conceptual diagram of tritium detector using a flow-cell detector.

continuously measure tritium concentration in water flowing through a flow-cell detector without regard to liquid scintillator and its radioactive waste.

In the previous study, CaF_2 solid scintillator was selected as raw materials of the flow-cell detector from the view points of chemical stability, luminescence intensity, granular grain size, stable supply, affordable price and so forth. The first flow-cell detector was fabricated using 50 micron-size granular CaF_2 and examined its performance with 10000 sec measurement using tritium water and linearity between count rates and tritium concentrations was confirmed. The result suggested that the system reasonably worked as a tritium water monitoring system.

In the present study, four types of flow-cell detectors were fabricated using the same granular CaF_2 solid scintillation materials and examined for purpose of improvement of the system performance including lowering of detection limit and shortening of measuring time. The four types of flow-cell detectors were a single 3mm-diameter cell (a S3-cell), three 3mm-diameter cells in series (T3-cells), a single 5mm-diameter cell (a S5-cell), three 5mm-diameter cells in series (T5-cells).

Photographs of two of the four flow-cell detectors are shown in Figs. 2(A) and (B). Figure 2(A) shows an S5-cell embedded in a cartridge holder and Figure 2(B) shows T3-cells embedded in series in a cartridge holder. Two other S3-cell and T5-cells also were used embedded in the same cartridge holder as shown in Fig. 2.

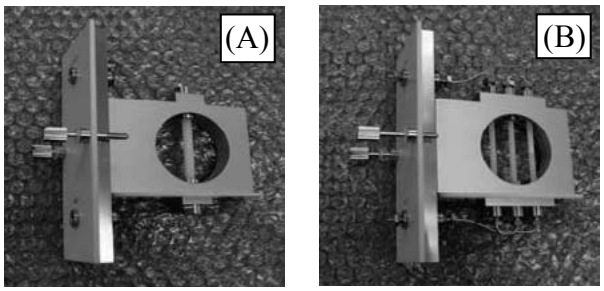

Fig. 2. Photograph of new CaF_2 flow-cell detectors:
(A) Using a single 5-mm diameter cell (S5-cell)
(B) Using three 3-mm diameter cells in series (T3 cells).

These cells were comparatively examined by the measurement of various tritium water samples with deferent concentrations from 0.5 to 40 Bq/ml. In the measurement, radiation counts detected in the cells were accumulated for 10000 sec while the water sample continuously flowed through them. The water flow velocity was fixed at 1 ml/min for a S3-cell and a S5-cell and 0.5ml/min for T3- cells and T5-cells. In the case of three cells in series, loss of pressure was very large, and a flow velocity was set to be smaller to avoid the cells breaking down.

The result is shown in Fig.3. In Fig.3, lines derived by linear regression are also drawn. The inclinations of the lines are steeper in the order of T5-cells, a S5-cell, T3-cells,

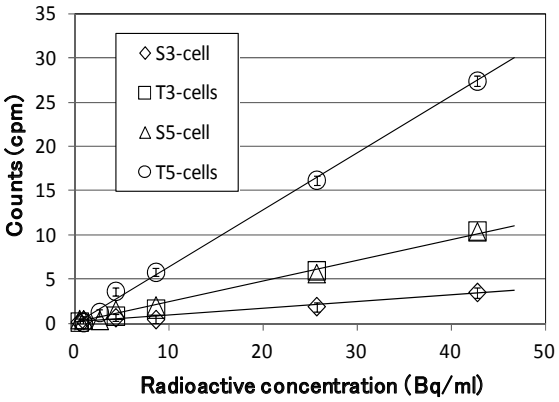

Fig.3 Relationship between tritium concentration and count rate.

and a S3-cell, where both lines for T3-cells and a S5-cell are almost overlapped. Since the steep angle corresponds to radiation sensitivity, T5-cells are most sensitive. The results suggest that relation between count rates and concentrations was definitely linear above a few Bq/ml. Taking accounts these results the tritium water monitoring system could be improved in the future study.