§7. Development of a New Tritium Monitor by Using a Plastic Scintillator with Surface Treatment

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Introduction Measurement of radioactive solutions with plastic scintillator sheets (PS-sheets) by a liquid scintillation counter (LSC) without liquid organic waste were effective of its high counting efficiency[1)]. The PS-sheets used were treated by an atmospheric pressure glow plasma for getting hydrophilicity on its surface (Plasma method) [1, 2)]. It was especially effective for tritium compounds measurement because of its low energy. The counting efficiency of the PS-sheets method with a LSC was same as that of liquid scintillator used. However, the PS-sheets method could not apply large volume to the sheets. It means a detection limit of the PS-sheets method by using LSC is not so high. So, we developed a special prototype detector for PS-sheets, which is recycle of a flow type radioanalyzer developed by NIFS. We reported here results of performance evaluation of the prototype device.

Experimental Tritium-methionine (American Radiolabeled Chemicals: ARC USA) of 0.04 Bq mL^{-1}-50 kBq mL^{-1} were used to dilute with distilled water. The PS used was BC-400 sheet of 0.5 mm thickness (Saint-Gobain, French), which was cut to a size of 48 mm in diameter. ^{14}C-arginine was also used.

The plasma equipment used was dielectric barrier discharge (DBD) plasma [3)]. For the DBD plasma, the flow rate of argon gas was 4L per min, the high voltage was 10 kV, the silicate tube was 60 mm in length and the PS sheet was put 5 mm under the tube. The treatment time was 2 min.

A LSC used was a Tri-Carb 3110TR (PerkinElmer, USA) for evaluation of each activities, which was same amount for applying to the PS-sheets. However, very low activities were impossible to measure with same amounts by a conventional LSC; these samples were estimated with the value before dilution.

The 5 μL distilled sample solution was applied to a PS-sheet which was treated by DBD plasma. It was dried up in a room and then another PS-sheet was put on the sample sheet (an assemblage).

We studied mainly 4 factors as follows: **1.** Wideness of sample solution on the PS-sheets by DBD plasma. **2.** Best condition for photomultiplier tubes. **3.** Qualitative analysis. **4.** Calculation of detection limit with background of PS-sheets[4)]. **5.** Identification of radionuclides.

Results and discussion **1.** By the treatment with DBD plasma, the contact area of the sample solution to the PS-sheets was widened more than 8 times compared with in the case of non-treatment. **2.** Figure 1 shows an example of spectrum with HV:1650 V, coarse gain: 5 and fine gain: 6. This condition was best for tritium evaluated with SN ratio. **3.** Relationship between the activity and net count rate showed good linearity from 0.04 Bq mL^{-1} to 208 Bq mL^{-1}. For example, 0.04 Bq mL^{-1} was measurable with 10 h. **4.** Minimum detection limit calculated was 0.01 Bq mL-1. The prototype device had little shield, so the background count

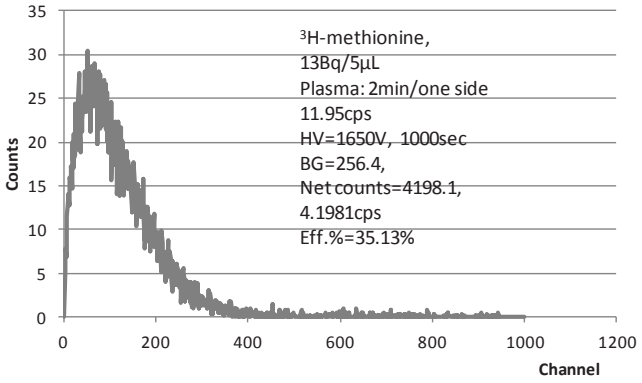

Figure 1 Tritium methionine spectrum by measuring prototype device for PS-sheets. In this case, counting efficiency (=net count rate/activity×100) was around 36% for 5 μL solution.

reduction is necessary to get more sensitivity. **5.** Spectrum measured with PS-sheets showed no quenching. So, identification of radionuclides was possible by using PS-sheets. By this prototype device, when HV : 1670 V, coarse gain : 1 and fine gain : 4, ^{3}H-methionine and ^{14}C-arginine was clearly identified to each other.

Altogether, the prototype scintillation counter was effective for measurement of tritium compound; however, it was impossible to measure tritiated water because of its volatility. So, we need to develop other type device for tritiated water.

Conclusion A prototype device for plastic scintillator sheets was developed. The device was measureable tritium compound with high sensitivity without generation of liquid organic waste. Though the minimum detection limit calculated by the prototype device was 0.01 Bq mL^{-1} for a tritium compound, we need to develop a new prototype device for tritiated water.

1) Furuta, E. et al., *Appl. Radiat. Isotopes*, 93, 13-17 (2014)
2) Furuta, E. et al., *JRNC* 299, 471-476 (2014)
3) Ohyama, R. et al., *Phys. D: Appl. Phys.*, **42**, *10*, 105203 (2009).
4) Noguchi, M.. et al., H. Application Measurement of Radiation. Tokyo: Nikkan Kogyo Shimbunsha, p263-4. 2004. Japanese.