§4. Sensitivity Improvement of Plastic Scintillator by Surface Treatment-early Stabilization

Furuta, E. (Ochanomizu Univ.),
Ohyama, R., Yokota, S. (Tokai Univ.),
Watanabe, Y. (Saint-gobain),
Kawano, T.

Introduction Tritium measurement in the environment is important because of safety. Generally, tritium labeled compounds are measured by a liquid scintillation counter (LSC) because of its low energy. Though the measurement efficiency of LSC is high, the liquid scintillation cocktail dissolved with radioactive samples becomes radioactive liquid waste fluid. Also the cocktail is not safe for human being and it is environmental load. We measure radioactive samples with plastic scintillator sheets (PS) by LSC without liquid scintillator[1]. The PS used is treated by an atmospheric pressure glow plasma for getting hydrophilicity on its surface (Plasma method)[2, 3]. It is useful method. However, the method needs several hours to get stable measurement efficiencies because water molecule acts as a shield before they evaporate. We tried to decrease the elapsed time by using silica gel.

Experimental The tritium samples except for tritiated water of 18.5 MBq mL^{-1} (American Radiolabeled Chemicals: ARC USA) of unknown compound 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 30-50 mm length and 13 mm in width. The radioactivity was evaluated 40 Bq per 5 μL, which was same amounts of putting on the PS sheet, by using liquid scintillator of ACS-2.

The liquid scintillation counter used was a Tri-Carb 3170TR (PerkinElmer, USA). The counting time was 2 min for each sample with 10 cycles of 3 repetitions.

The plasma equipment used was dielectric barrier discharge (DBD)[4]. For the plasma treatment, 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 1 min. For rapid stability, 15 white grains of silica gel (Wako Co.) were put in a glass vial for measurement of PS sheets. To confirm the effect of silica gel, the PS sheets with the same amount of tritium sample without silica gel were measured at the same time.

Results and discussion The graph shows the relationship between the measurement efficiencies of tritium and elapsed time after putting the sample on each one PS sheet. The figure shows two merits. First; the measurement efficiencies of the Plasma method were higher than those of normal PS method with non-treated PS sheets. Second; without silica gel, the measurement efficiencies of PS sheets were not constant within almost 6 hours. Especially, the measurement efficiency of plasma-treatment PS sheet increased rapidly, and after 6 hours it became almost 21-22% in constant. On the other hand, when silica gel beads were put in a vial, measurement efficiencies became constant and high within 1-3 hours. In this case, the 1-3 hours mean the first measurement chance for the sample because of in measurement order. It is considered that

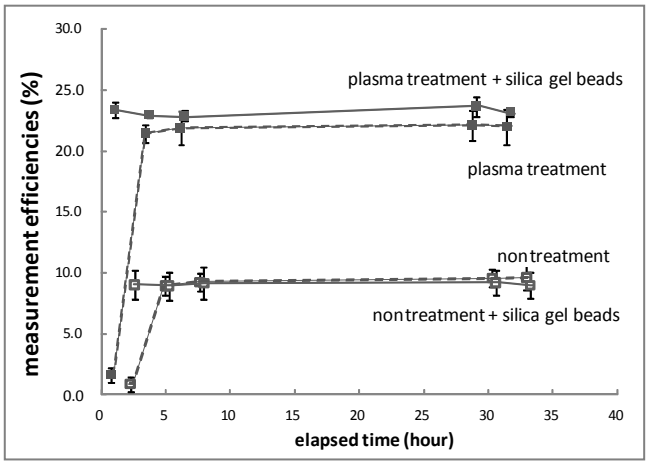

Figure Relationship between the measurement efficiency and the elapsed time with one PS sheet of tritium compound measurement. The solid lines show measurement efficiencies with silica gel beads and the dotted line show them without silica gel beads.

the elevation of measurement efficiencies was related to H_2O vaporization of the applied sample. Because of tritium low-energy beta ray, almost all of the beta ray energy was absorbed by H_2O molecules before absorbed by the PS compounds. Then little beta-ray energy could be converted to fluorescent energy, which was detected by the photomultiplier tubes of the LSC. However, as time passed, almost all the H_2O molecules vaporized on the PS surface, and beta rays could be more efficiently absorbed by the PS compounds.

Conclusion Plasma treatment gave large improvement to measurement efficiencies of tritium samples with PS sheet, but in ordinary process of Plasma method, PS sheet needed at least 6 hours for 5 μL sample solution to obtain constant measurement efficiencies, but the issue of occurring 6-hour waiting time was solved by putting silica gel beads in a vial.

1) Furuta, E. et al., LSC 2008,19 (2009)
2) Furuta, E. et al., JRNC 298, (in press) (2014)
3) Furuta, E. et al., Appl. Radiat. Isotopes (accepted)(2014)
4)OHYAMA, R. et al., *Phys. D: Appl. Phys.*, **42**, *10*, 105203 (2009).