§7. Separation Method for Measurement of Radiation Dose Emitted from Tritium in High Gamma-ray Radiation Fields by Using an Imaging Plate

Ohuchi-Yoshida, H. (Pharm. Sci., Tohoku Univ.),
Kondo, Y. (Ishinomaki Univ.),
Kawano, T.

Non-destructive and quantitative measurements of the amount of tritium retained on/in plasma-facing materials (PFMs) of magnetic fusion devices are of great importance to control of fuel particles and ensure safety for maintenance work in the fusion systems. We have been developing an approach to detect tritium using the bremsstrahlung induced by beta rays with an imaging plate (IP) in order to detect tritium in regions deeper than the escape depth of beta rays[1]. An IP, a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor. In the fuel-processing systems of D-T fusion facilities, gamma-ray radiation deriving from components activated by neutron would seriously affect tritium measurement. Separation measurement method of radiation dose from tritium and those from other nuclides is required. Based on a preceding work[2], we determined that dominant gamma nuclides produced by neutron activation after operation in fusion reactors are ^{55}Fe, ^{60}Co, and ^{54}Mn. In this study. we examined the effect of ^{60}Co and ^{54}Mn irradiation to PSL values, obtained by irradiated with tritium sources, in mixed radiation fields with tritium and ^{60}Co or ^{137}Cs. The ^{137}Cs source was used as a substitute of a ^{54}Mn source. A ^{54}Mn source is not available and gamma emission energy from ^{137}Cs source is close to that from ^{54}Mn. ^{55}Fe emits quite low energy X-rays (5.9 and 6.5 keV), indicating the effect of ^{55}Fe to dose in fusion reactors can be negligible.

We used four small borosilicate glass tubes filled with pure tritium gas of 12.5, 25, 50, and 100 MBq, respectively as the tritium sources. The IP was irradiated simultaneously with collimated ^{60}Co gamma rays and tritium. The ^{60}Co gamma-ray irradiation was conducted with 0.5 m to 2.3 m distant from the source. By varying the distance from the source to the IP, the dose rate was varied. The same experiment was conducted by irradiating the IP with the tritium sources and a ^{137}Cs point source.

The energy dependence of the IP response in the range of 1 keV to 2 MeV obtained by calculation is shown in Fig.1. The PSL response of the IP has a peak at 20-50 keV and steeply decreases towards higher energy, falling by one hundredth at around 1 MeV.

In Fig.2, the PSL values obtained by tritium sources with simultaneous irradiation by ^{60}Co (a) and ^{137}Cs (b) are shown as a function of dose rate. It was found that the effect of ^{60}Co irradiation to PSL values, obtained by irradiated with tritium of 12.5 MBq, was negligible by dose rate of 4.38 μGy/min and there was only 7.0% difference of PSL values, obtained by irradiated with tritium of 100 MBq, between dose rate of 0.0013 and 9.22 μGy/min, which is equivalent to approximately 7,000 times higher than natural radiation. The effect of ^{137}Cs irradiation to PSL values by tritium, was not observed by dose rate of 0.77 μGy/min and 8.0% difference of PSL values by tritium was observed between dose rate of 0.0013 and 1.7 μGy/min, however, ^{137}Cs irradiation at 5.84 μGy/min affected strongly to PSL values by tritium. The difference in effect of ^{60}Co and ^{137}Cs irradiation to PSL values by tritium is explained by the difference in the PSL response to photon energy between them, as shown in Fig.1.

These results indicate that the bremsstrahlung X-ray induced by tritium beta ray can be easily separated from gamma ray emitted from ^{60}Co or ^{54}Mn in mixed radiation fields by utilizing the large difference in the PSL response.

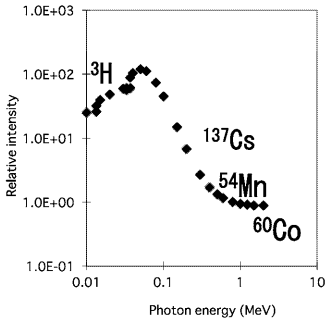
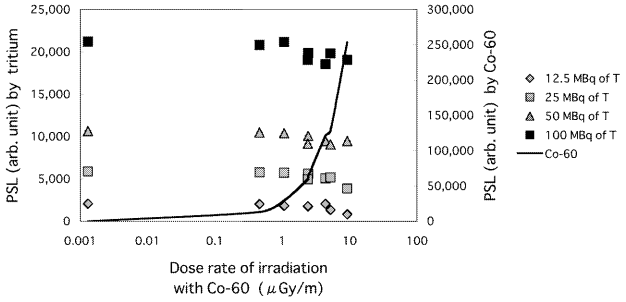
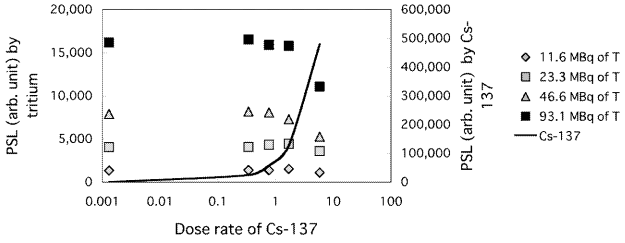


Fig. 1. Calculated energy dependence of the IP response in the range of 1 keV to 2 MeV.



(a)



(b)

Fig. 2. PSL values obtained from tritium sources with simultaneous irradiation by ^{60}Co (a) and ^{137}Cs (b).

1) Ohuchi, H., Hatano, Y.,: *Radiochimica Acta*, in print.
2) Handa, H. et al.: Fusion Eng. Des. **28** (1995) 515.