02Da09

Rate of Double Strand Breaks of Genome-sized DNA by β-rays from Tritium –Dependence on Tritium Concentration, Water Temperature and DNA Concentration–

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Quantitative evaluation of the rates of DNA damages by low energy β-rays is important for better understanding of biological effects of tritium. In the previous study [1], we measured the rate of double strand breaks (DSBs) in high concentration tritiated water (5.2 MBq/cm^3) using a single molecule observation method. Clear irradiation effects were observed after 7 days immersion under sterilized conditions though the influence of microorganisms (e.g. bacteria) was far stronger under non-sterilized conditions. In this study, the dependence of the rate of DSBs on tritium concentration, DNA concentration and water temperature were examined.

Giant genome DNA molecules of bacteriophage T4 GT7 (166 kilo base pairs) were used as samples in the present work. DNA molecules were immersed and suspended in sterilized tritiated water and non-radioactive sterilized water at 3 °C and 10 °C for 1–35 days. For comparison, ^{60}Co γ-ray irradiation was also performed. The tritium concentration was adjusted to be 1300 Bq/cm^3 and 4 –5.2 MBq/cm^3. The concentration of DNA was set to be 0.1–105 nmol base pairs/cm^3. After mixing with a fluorescent dye, a drop of DNA solution was put on a glass substrate coated with poly-L-lysine. The DNA molecules were extended and fixed on the surface of glass substrate. Then, the length of DNA molecules was measured using a fluorescence microscope.

The effects of β-rays from tritium for the DNA molecules were not observable at 1300 Bq/cm^3 after the immersion for 35 days. Meanwhile it was found that the rate of DSBs clearly increased at 5.2 MBq/cm^3 even after the immersion for 7 days. Based on experimental results, the effects of β-ray irradiation were far smaller than those of oxidation and thermal effect at low dose rate (0.1 mGy/day at 1300 Bq/cm^3). No significant difference was observed in the rate of DSBs at 10 °C and 3 °C in tritiated water of 4 MBq/cm^3. The DSB rates under the irradiation of tritium β-rays and ^{60}Co γ-rays decreased with increasing DNA concentration in water. This is because a DNA molecule acts as a shield for other DNA molecules against reactive species at high DNA concentrations. There was no visible difference in the DSB rate between tritium β-rays and ^{60}Co γ-rays in a low DNA concentration region (< 10 nmol base pairs/cm^3). At higher DNA concentrations, the rate of DSBs under the β-ray irradiation was slightly higher than that under the γ-ray irradiation probably due to a larger linear energy transfer (LET) value of the former. Detailed discussion will be given in the presentation.

[1] Y. Hatano et al., Fusion Eng. Design, 146 (2019) 100-102.