# Correction of a Dose Calibration Method for Alpha Particle Irradiator

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*Several alpha particle irradiators for in vitro cell cultures have been proposed for the research on internal exposure to radon progenies. In our previous study, two typical dose calibration methods for alpha particle irradiator were compared. The dose rates calculated with typical equation and AASI-code for the cell culture dish with 14.14 mm diameter were 0.56 and 0.64 Gy/min at the SSD of 20 mm. For the dish with 31 mm diameter, the dose rates were 0.24 and 0.28 Gy/min at the SSD of 35 mm, respectively. The values calculated with AASI -code were approximately 1.13 and 1.14 times bigger than those calculated by the equation. In this study, the specific correction factors $M_L$ and $M_T$ for the typical equation are proposed to increase the accuracy of dose calibration. The percentage difference between the corrected dose-rate calculated with typical equation and the dose rate calculated with AASI-code in two case are 2 and 6 %. Agreement between the two methods for dose calibration are better than before correction.*

## I. Introduction

According to United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR), alpha-particle exposure to radon and its progenies is the most important contributor of internal radiation dose to the world population. Several alpha particle irradiators for in vitro cell cultures have been proposed for the research on internal exposure to radon progenies. There are two common dose calibration methods for alpha-particle irradiator, but they used only one method to calibrate a dose rate and did not cross checked the results with those derived from other methods [1, 2, 3, 4, 5]. In our previous study for a practical alpha particle irradiator, two typical methods for dose calibration were compared [6]. The dose rates calculated with typical equation and AASI-code for the dish with 14.14 mm diameter were 0.56 and 0.64 Gy/min at the SSD of 20 mm. For the dish with 35 mm diameter, the dose rates were 0.24 and 0.28 Gy/min at the SSD of 30 mm, respectively. The values calculated with AASI -code were approximately 1.13 and 1.14 times bigger than those calculated by the equation. In this study, specific correction factors for the typical equation are proposed to increase the accuracy of dose calibration.

### I.A. Correction factors for dose calibration

The typical equation for the dose rate calculation can be expressed in the below:

$$\frac{\mathrm{dD}}{\mathrm{dt}}\left[\frac{Gy}{s}\right] = 1.6 \times 10^{-19}[\frac{J}{ev}] \cdot F[cm^{-2} \cdot s^{-1}] \cdot L[\frac{MeV}{cm}] \cdot \rho^{-1} \times 10^{3}[\frac{cm^{3}}{kg}] \quad (1)$$

where F is the number of alpha-particles passing the cell layer per unit area and time, L is average LET of alpha-particles, ρ is the density of cell layer. In the equation (1), it is assumed that particles pass the cell layer vertically. But most particles pass the cell layer obliquely in short SSD, so the track length of alpha-particle in the cell layer is lengthened up to 1.2 times. The average LET of alpha particles are slightly increased passing through the cell layer, but the L in equation (1) is the one at the entrance to cell layer. Thus additional correction factor for equation (1) is required. A modified expression of equation (1) is

$$\frac{\mathrm{dD}}{\mathrm{dt}}_{\mathrm{m}}\left[\frac{Gy}{s}\right] = \frac{\mathrm{dD}}{\mathrm{dt}}\left[\frac{Gy}{s}\right] \cdot \mathrm{M}_T \cdot \mathrm{M}_L \ (2)$$

where $M_T$ is a track length correction and $M_L$ is an average LET correction. The track length correction, $M_T$, is the mean ratio of extended track length to vertical one. The track length correction factor is calculated with random number sampling method by using a simple MATLAB code. The average LET correction, $M_L$, modifying the average LET of alpha-particles passing through the cell layer can be calculated by the median value for the LET at entrance and exit to cell layer means the average of that changed by passing through the cell layer.

Two correction factors in each case and the dose rate calculated by equation (2) are listed in Table 1. The percentage difference between the corrected dose-rate calculated with equation (2) and the dose rate calculated with AASI-code in two case are 2 and 6 %.

TABLE I. Calculated values for the correction factors, dose rate calculated with equation (2) and that with AASI-code.

| **Diameter of dish (mm)** | **SSD (mm)** | **$M_T$** | **Fractional std. dev. of $M_T$** | **$M_L$** | **$M = M_T \times M_L$** | **Dose rate (Gy/min)** | | **Percentage difference (%)** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | **Equation (2)** | **AASI-code** | |
| 14.14 | 20 | 1.077 | 0.0000004 | 1.040 | 1.120 | 0.63 | 0.64 | 2 |
| 35 | 30 | 1.049 | 0.0000004 | 1.044 | 1.095 | 0.26 | 0.28 | 6 |

## II. CONCLUSIONS

The percentage difference between the corrected dose-rate calculated with equation (2) and the dose rate calculated with AASI-code in two case are 2 and 6 %. Agreement between the two methods for dose calibration are better than before correction. While AASI-code can trace an alpha-particle and reflect the incidence angle and LET change, dose calibration with alpha-particle energy spectrum measured by IISD always requires the correction factor for those. Thus calibration with the AASI-code is much fairer way.

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