# A novel method for alpha dosimetry using peeled-off Gafchromic EBT3 films

Kwang-Ho Lee* and Eun-Hee Kim
*Department of Nuclear Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 151-744, Republic of Korea*
**zhsks022@snu.ac.kr, Corresponding Author: eunhee@snu.ac.kr*

## 1. Introduction

Gafchromic EBT3 is a film dosimeter which was developed for easy dosimetry at radiotherapy environment. EBT3 film consists of diacetylene monomer, which turns from yellow to green when it senses ionizing radiation. Thus, one can estimate dose imposed to film by measuring the optical density of film. EBT3 film has been used in dose measurement for photon, proton, and electron beams but not for alpha particles. Both sides of diacetylene monomer layer are covered with 100 μm-thick polyester coating layers, through which alpha particles even at several MeV cannot penetrate. A recent study demonstrated the use of EBT3 film in alpha dosimetry by peeling off one side of polyester coating layer [1]. Their study did not inform the reliability of measurement using the peeled-off films.

In this study, we evaluated the feasibility of EBT3 film as a substitute for conventional alpha dosimeters and checked the uncertainty of dose measurements obtained with peeled-off EBT3 films. We also applied this film dosimeter to measuring of the fluence distribution at cell targets in a culture dish set in the alpha irradiation chamber of the Radiation Bioengineering Laboratory (RadBio Lab) at Seoul National University (SNU).

## 2. Materials and Methods

### *2.1 Film preparation*

With Gafchromic EBT3 films (Lot no. 01261601), one side of the polyester coating layer was peeled off by using a cutter knife (Fig. 1). Films were cut into circular shape of 31 mm in diameter. Every piece of circular films was marked at the top in order to indicate the peeled-off side of film and its landscape direction because the scanner was sensitive to the direction of film.

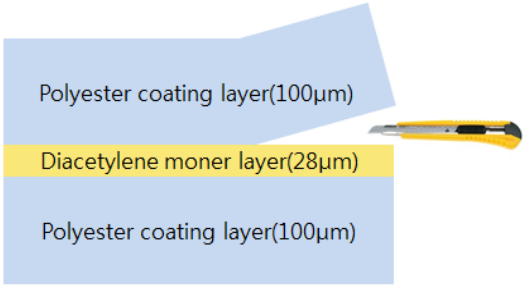


**Fig 1.** A schematic diagram of peeling off the Gafchromic EBT3 film

### *2.2 Alpha irradiation*

The alpha irradiation chamber in the RadBio Lab at SNU [2] is installed with a 3.7 MBq Am-241 source of 9.5 mm in active diameter (AM1A2100U, Eckert&Ziegler). The peeled-off film was loaded on the bottom of cell culture dish with the peeled-off side directed toward the source. According to the earlier AASI (Advanced Alpha spectrometric Simulation) Monte Carlo simulations [2], dose rate at the center of cell dish was 0.34Gy/min for the source to sample distance (SSD) of 30 mm. In this study, SSD was set at 30 mm. Alpha particle exposures were made to have film doses ranging from 1.19 Gy to 11.9 Gy at the intervals of 1.19 Gy.

### *2.3 Image processing*

Films were scanned with an EPSON Expression 10000XL scanner [3] before irradiation and at 24 h after irradiation. At each dose level, background and exposed films were scanned 5 times. Optical densities were calculated by Eq. (1)

$$Opitcal\ Density = log\left({SV_0}/{SV}\right) \cdots (1)$$

where $SV_0$ and $SV$ are the scan values of a film before and after irradiation, respectively.

## 3. Results and Discussions

### *3.1 Feasibility of alpha dosimetry using EBT3 films*

The optical density values for the radiation exposure of films at different doses were fitted to the calibration curve as shown in Fig. 2. The calibration curve was represented by the second-order polynomial function in Eq. (2).

$$Dose = 64.45 \cdot OD + 47.40 \cdot OD^2 \cdots (2)$$

The correlation coefficient of the fitting curve for the measured data was 0.998.

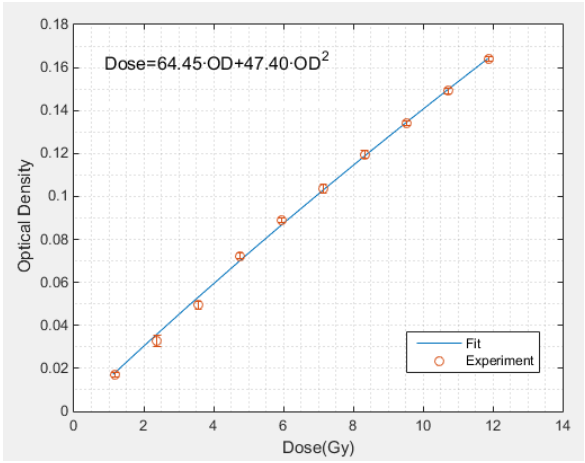


**Fig 2.** A dose calibration curve of Gafchromic EBT3 film for alpha exposure. The circles present the measurement data using films. The error bars indicate the standard deviations.

In Fig. 3, the circles on the solid line indicate the uncertainties of dose estimates calculated from the optical density measurements whereas the plus signs on the dashed line indicate the fitting errors at individual dose estimates. Dose estimates carry uncertainties of less than 9 % but no lower than 4 % in the range of up to 12 Gy. The calibration curve in Fig. 2 approximates the measured estimates with errors of less than 10 % decreasing down to 0.4 %.

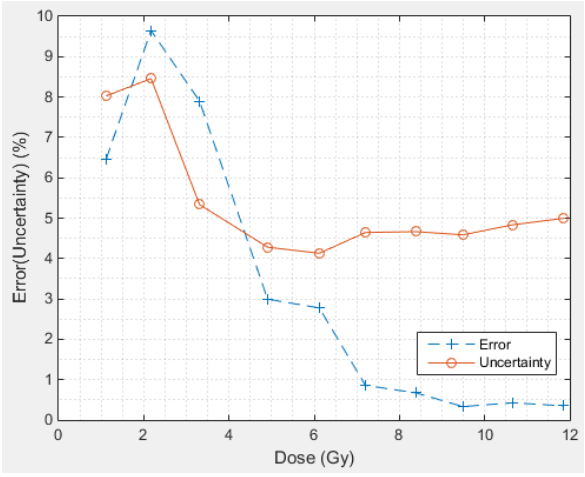


**Fig 3.** The percent uncertainties of dose estimates using Gafchromic EBT3 films (circles on the solid line) and the percent fitting errors (plus signs on the dashed line) for dose levels of up to 12 Gy.

### *3.2 Radial distribution of alpha particle fluence*

In Fig 4, the radial distribution of alpha particle fluence entering the cells attached to the bottom of cell dish at SSD of 30 mm was obtained by measurement with films and compared with that calculated in earlier study [2].

The measurement data (solid curve) show more severe non-uniformity of dose in radial direction than the calculated data (dashed curve). The non-uniformity in radial direction was identified by calculation in the earlier study [2]. The discrepancy between the measurement and the calculation is attributed to the uncertainty of measurement data obtained from limited number of measurements.

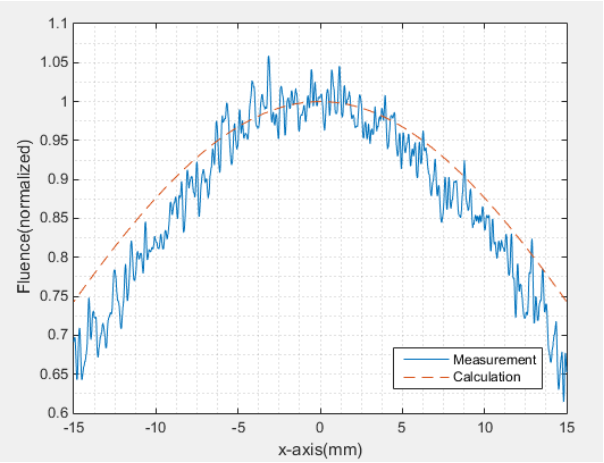


**Fig 4.** Normalized radial distributions of alpha particle fluence entering the cells attached to the bottom of cell dish at SSD of 30 mm by measurement (solid curve) and by calculation (dashed curve).

## 4. Conclusions

In this work, we confirmed the feasibility of using Gafchromic EBT3 films for alpha dosimetry. The peeled-off EBT3 films can make a convenient alpha dosimeter by carrying an uncertainty less than 9 %.

## REFERENCES

[1] Mukherjee B, Gholami YH, Bhonsle U, Hentschel R, and Khachan J, A Unique Alpha Dosimetry Technique Using Gafchromic EBT3® Film and Feasibility Study for an Activity Calibrator for Alpha-Emitting Radiopharmaceuticals, The British Journal of Radiology, Vol.88, p.20150035, 2015.
[2] Ki-Man Lee, Ui-Seob Lee and Eun-Hee Kim, A Practical Alpha Particle Irradiator for Studying Internal Alpha Particle Exposure, Applied Radiation and Isotopes, Vol.115, p.304-311, 2016.
[3] B.C. Ferreira, M..C. Lopes, and M. Capela, Evaluation of an Epson Flatbed Scanner to Read Gafchromic EBT Films for Radiation Dosimetry, Physics In Medicine and Biology, Vol.54, p.1073-1085, 2009.