Preliminary research for estimating homogeneity of Ni-63 foil source by using peeled-off EBT3 film

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1. Introduction

Gafchromic EBT3 film is a film dosimeter used to measure radiation dose for quality assurance in radiation therapy for the high sensitivity and low energy dependence in measuring absorbed dose rate [ref]. Nickel-63 is a pure beta source for electron capture detector, beta-voltaic battery or random number generator. In previous research, we developed an electroplating device to fabricate thin foil Ni-63 source for beta-voltaic battery. Dose rate measurement with EBT3 film was conducted to estimate radioactivity of Ni-63 sources and radioactivity measurement was conducted by using liquid scintillation counter (LSC). Since EBT3 film is composed of three layers which two protective layers cover active layer, low energy betas from Ni-63 (E_{max}=66.7 keV) could not reach the active layer to transfer radiation energy. It resulted in uncorrelated result if dose rate was compared to the radioactivity.

In previous studies, alpha particles which show very short range were detected using peeled-off EBT3 film in Figure 1 [1]. The peeled-off EBT3 film was made by removing protective layer, which the alpha particles were able to transfer energy to the active layer without energy loss. In this study, we preliminarily simulated peeled-off EBT3 film to estimate homogeneity of the electroplated Ni-63 source. Monte-Carlo simulation was used to simulate peeled-off EBT3 film to measure dose rate from the Ni-63 sources.

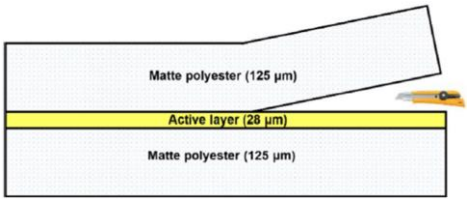

Fig. 1. Peeled-off EBT3 film to remove protective layer to measuring short range radiation such as alpha or low energy beta radiation [1].

2. Methods and Results

2.1 Measurement of Ni-63 foil source with original EBT3 film

We fabricate several Ni-63 foil sources with the electroplating device. EBT3 films were exposed to the Ni-63 foil sources for 17.25 hrs and the absorbed dose rate was derived by scanning the films. Figure 2 shows that dose rate is not correlated well to the source activity.

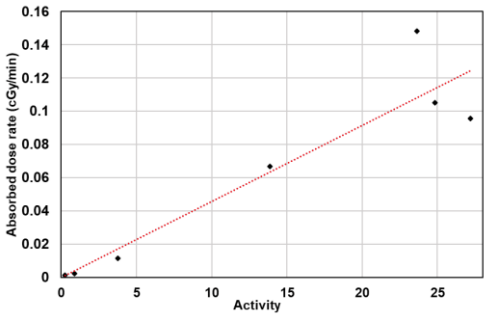

Fig. 2. Absorbed dose rate (unpeeled EBT3 film) is fitted to the activity (LSC).

2.2 MCNP simulation of EBT3 film with the Ni-63 foil

MCNP6® code was used to simulate range of beta particles from Ni-63. MCNP6® is a Monte Carlo radiation transport code developed by Los Alamos National Laboratory, USA. The Ni-63 energy spectrum was extracted from ICRP publication 107 [2]. Spatial distribution of the beta was calculated with TMESH tally and the penetration depth was calculated with F4 tally.

2.3 Simulation results for range of the betas in EBT3 film

First, penetration depth in original EBT3 film was calculated. We assumed that the Ni-63 source was located the film without gap, and the beta particle. The simulation result shows that beta particles loss energy in depth of 30 μm. It is correspondent to the range of 70 μm) of beta particle at 70 keV [3].

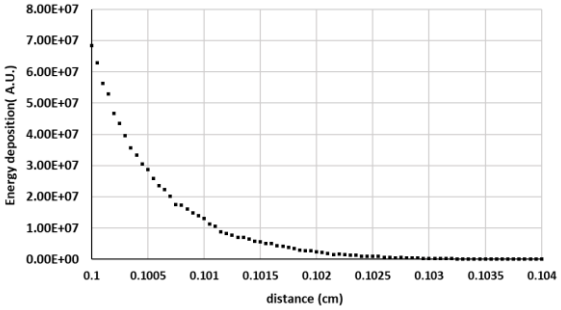

Fig. 3. Energy deposition in the protective layer. Most beta particles loss their energy in a range of 30 μm which does not transfer energy into the active layer.

Next, energy deposition depth with peeled-off EBT3 film was calculated. The exposure situation was

identical. Most beta particles loss energy in 30 μm, which means the active layer has enough thickness to estimate the radiation dose from Ni-63.

Finally, spatial distribution of the betas was calculated. Since beta particles struck with electrons in matter, its pathlength is not straightforward as like alpha particle. So we assumed the form of pencil beam to inspect the divergence of the betas in the active layer.

3. Conclusions

Simulation for measuring low energy beta radiation with peeled-off EBT3 film was conducted to estimation of Ni-63 foil source. It predicted that peeling protective layer of EBT3 film would increase accuracy for measuring dose rate and peeled-off film could be applied for estimating radioactivity or homogeneity of the Ni-63 source.

REFERENCES

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