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Study for Applying Microwave Power Saturation Technique on Fingernail/EPR Dosimetry

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1. Introduction

There is growing recognition worldwide of the need to develop effective uses of dosimetry methods to assess unexpected exposure to radiation in the event of a large-scale event [1]. One of physically-based dosimetry methods electron paramagnetic resonance (EPR) spectroscopy has been applied to perform retrospective radiation dosimetry using extracted samples of tooth enamel and nail(fingernail and toenail), following radiation accidents and exposures resulting from weapon use, testing, and production. Human fingernails are composed largely of a keratin, which consists of α-helical peptide chains that are twisted into a left-handed coil and strengthened by disulphide cross links [2]. Ionizing radiation generates free radicals in the keratin matrix, and these radicals are stable over a relatively long period (days to weeks). Most importantly, the number of radicals is proportional to the magnitude of the dose over a wide dose range (0～30 Gy) [3,4,5,6]. Also, dose can be estimated at four different locations on the human body, providing information on the homogeneity of the radiation exposure. And The results from EPR nail dosimetry are immediately available However, relatively large background signal (BKS) converted from mechanically induced signal (MIS) after cutting process of fingernail, normally overlaps with the radiation induced signal (RIS), make it difficult to estimate accurate dose accidental exposure [2]. Therefore, estimation method using dose-response curve was difficult to ensure reliability below 5 Gy. In this study, In order to overcome these disadvantages, we measured the reactions of RIS and BKS (MIS) according to the change of Microwave power level, and researched about the applicability of the Power saturation technique at low dose.

2. Methods and Results

2.1 Sample preparation

In this experiment, fingernails were cut using normal fingernail clipper, at first, when samples were collected from volunteers. Toenail clipper with flat edge was used to cut the collected fingernail samples into small 10 pieces (1 mm x 2 mm) of clippings. For measurement in EPR spectrometer, two quartz tubes composed of sample tube and alignment tube were used. Standard manganese source was fixed at the bottom of alignment tube inside and size of sample tube was chosen not to move easily in alignment tube, as shown in Fig. 1.

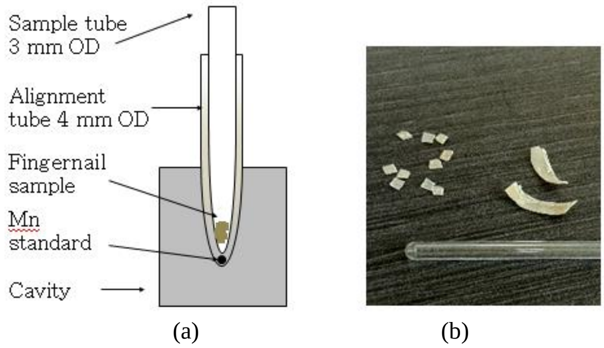

Fig. 1. (a) Cross section of quartz tube and cavity used to hold fingernail sample and Mn standard. (b) Collected big pieces of fingernails and 10 clippings cut by toenail clipper.

2.2 EPR measurement

EMX spectrometer (Bruker Biospin) was used for EPR measurement with x band resonator. Environment factors for measurement were controlled in the following ranges (temperature: 22℃ ~ 25℃, relative humidity: 20 ~ 25%). The following is recording conditions: high-frequency modulation: 100 kHz; amplitude of modulation: 5 G; microwave power (mW): variable, number of sampling point: 1024; sweep width: 150 G.

2.3 Results

Fig 1 shows Saturation behavior of BKS and RIS signal intensity according to increase of microwave power level. In order to obtain more accurate results, we measured fingernail samples which is collected from volunteers within 24 h and irradiated before cutting small piece. Saturation curve of BKS was obtained from unirradiated sample, and RIS graph was calculated using value which is removed BKS from the irradiated sample. As a result, RIS signals continues to increase according to the rise of microwave power level while BKS signal is quickly saturation. It can be estimated that relaxation time of BKS radicals were relatively longer than RIS radicals.

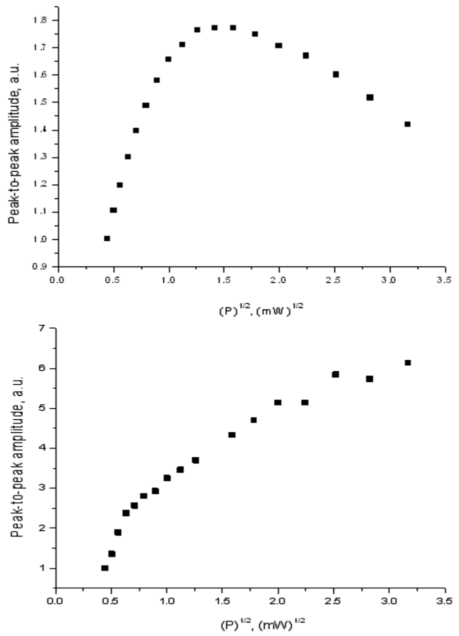

Fig. 2. Saturation behavior of BKS (upper panel) and RIS (lower panel) spectrum on microwave power level (30dB~14 dB)

Fig 3 shows created dose-response curve using the differences of these saturation behavior and calculated measurement values of blind samples by regression equation. Blind samples were made using fingernails collected from 3 volunteers and irradiated two bundles of 1Gy and 3 Gy (A, B). Experimental results using power saturation method was able to distinguish between 1 Gy and 3 Gy but it also showed a large deviation, especially in 3Gy samples.

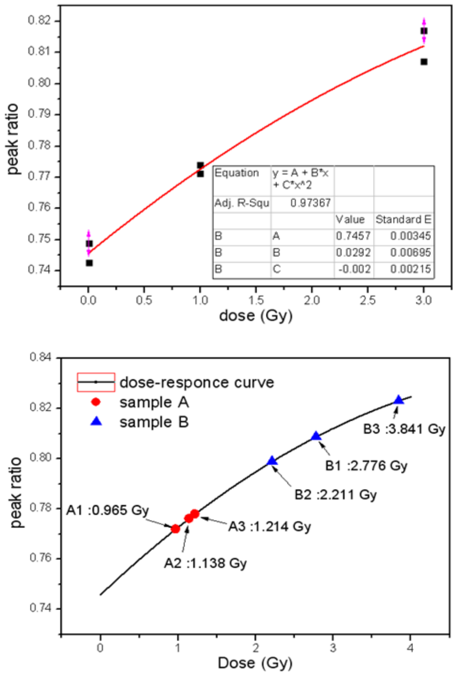

Fig. 3. Dose-response curve using microwave power Saturation technique (upper panel) and blind test using 1, 3 Gy sample.

3. Conclusions

In this study, we investigated the possibility of microwave power saturation technique in fingernail dosimetry. Although this method was difficult to apply in more than 3 Gy due to saturation by irradiation dose, we consider that it may be use ancillary method when victims of radiation clearly did not receive high dose or approximate dose by other estimation methods was less than 3 Gy. However, more studies of this method must be done in order to use the actual emergency dose assessment. Especially, it needs improvement of relatively long pretreatment time, implementation of standardized sample handling and study on the change of the measured value over time after irradiation. Therefore, we are currently conducting additional experiments to overcome this problem and more accurately measure irradiation dose.

REFERENCES

[1] Simon, S.L., Skinner, A.R., Swartz, H.M., 2010. Guest editorial: editors'' remarks. Health Phys. 98 (2), 93-94.

[2] Chandra, H., Symons, M.C.R., 1987. Sulfur radicals formed by cutting alpha-keratin. Nature 328, 833-834.

[3] Black, P.J., Swarts, S.G., 2010. Ex vivo analysis of irradiated fingernails: chemical yields and properties of radiation-induced and mechanically-induced radicals. Health Phys. 98, 301-308.

[4] Reyes, R.A., Romanyukha, A., Trompier, F., Mitchell, C.A., Clairand, I., De, T., Benevides, L.A., Swartz, H.M., 2008. Electron paramagnetic resonance in human fingernails: the sponge model implication. Radiat. Environ. Biophys. 47, 515-526.

[5] Romanyukha, A., Reyes, R.A., Trompier, F., Benevides, L.A., 2010. Fingernail dosimetry: current status and perspectives. Health Phys. 98, 296-300.

[6] Swartz, H.M., Flood, A.B., Gougelet, R.M., Rea, M.E., Nicolalde, R.J., Williams, B.B., 2010. A critical assessment of biodosimetry methods for large-scale incidents. Health Phys. 98, 95-108.