ESR Signal Fading of PTFE/ESR Dosimetry

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1. Introduction

At present, there are twenty operational nuclear power plants(NPPs) in Korea. Aging in these NPPs must be therefore effectively managed to ensure the availability of functions throughout the plant service life. In general, for estimation of the absorbed dose, alanine/ESR dosimeters were used. We are also estimating the dose quantity of cables and equipments position in the NPP using alanine/ESR dosimeters as a method of calculating aging effect by heat and radiation[1]. But there are some problems that analyzing high dose position by only single dosimeter. So, we introduced new dosimeter, polytetrafluoroethylene (PTFE). Most of the estimated dose values inside the nuclear power plant were below almost 10Gy, but some dosimeters were estimated above 1kGy for about one or two fuel cycle. PTFE was useful in high precision high dose dosimetry[2]. We founded appropriate parameter for measuring dose quantity and made dose-response curve[3]. In this study, we obtained measurement precision of PTFE, and measured signal fading, so confirmed possibility of PTFE as additive dosimeter.

2. Methods and Results

2.1 PTFE dosimeters

The molecular structure of PTFE is known as -(CF2=CF2)-. PTFE is a fluorocarbon solid, as it is a high molecular weight compound consisting wholly of carbon and fluorine. It is a linear polymer having no branching and is highly crystalline having melting point of 330℃[4] If it is exposed to radiation, it could produce free radical of -(CF2=CFO·)-. Absorbed dose range is between 10^2 ~ 10^6Gy[2]. The PTFE (radius : 5.25mm, height : 5.45, weight : 263mg) dosimeter pellets were measured by inserting into two side open type-quartz tube(Figure 1). And we used the Mn^{2+} as correction sample which puts in the PTFE holder (Holder does not exposed any radiation). Gamma irradiation to PTFE dosimeters was done by cesium-137 at rate of 6Gy/min±4% in blood irradiator(IBL 437C).

2.2 ESR System and measurement parameter

ESR measurements were performed at normal atmospheric conditions mostly using Bruker EMX spectrometer equipped with an X-band bridge and cavity. ESR spectrometer were recorded with a microwave power sweep of 20.02mW, a modulation frequency and amplitude of 100kHz and 0.4mT, a time constant of 40.96ms. The number of sampling points was 1024 and microwave frequency was about 9.75GHz. Before measuring samples were stabilized for 10 minutes, and measured at room temperature.

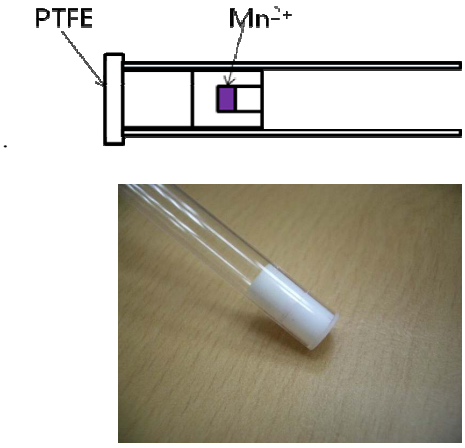

Figure1. PTFE dosimeter pallet and quartz tube

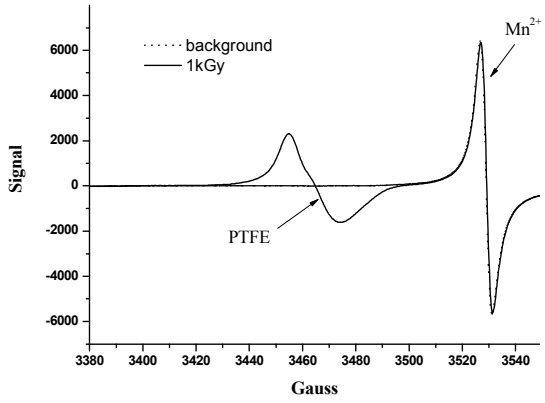

Figure2. ESR spectrum of PTFE

Figure2 shows background sample of PTFE and spectrum of irradiated sample at 1kGy radiation. The peek which was appeared on 3520~3540G is signal of the standard sample, Mn^{2+} for the correction.

Table1. Relative standard deviation of PTFE measured by EMX

	Dose	1,000 Gy
PTFE	EMX spectroscopy Response variation of "x/y ratio"	1.36%
	EMX spectroscopy Repetition variation of "x/y ratio"	0.41%

Table1 shows the result which measures relative standard deviation(RSD) of the PTFE sample. RSD is the absolute value of the coefficient of variation, and is widely used in analytical chemistry to express the precision and repeatability. We evaluated the precision of measurement with repetition and response measurement. The sample measured 10 times respectively.

2.3 signal fading

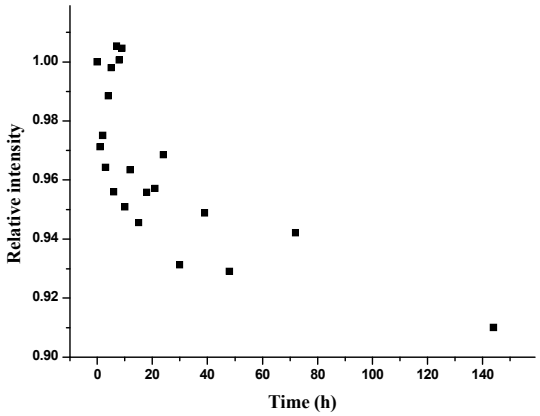

Figure3. signal fading of PTFE dosimeter

In order to observe signal fading of the PTFE, we prepared the sample which exposed 1000Gy gamma ray. Figure3 was the result which measures the PTFE in period of seven days. Signal fading appeared with about 8%.

3. Conclusion

In order to overcome a problem that analyzing dose quantity by only single dosimeter, we recognized the necessity of new dosimeter. So we tried to introduce the PTFE, and we advanced the fundamental experiment. We founded appropriate parameter for measuring dose quantity and then make dose-response curve using PTFE[4]. In this experiment, we obtained measurement precision of PTFE, in getting the reliability of measurement. And using signal fading of sample, we evaluated a dosimeter where the PTFE is useful. From measurement result, signal fading appeared with about 8%. Signal fading ratio of the other papaers was different[2][5]. This result will be originated from difference of experimental environment(dose ratio, etc.). With the signal change observation which is continuous, we will be seen signal fading continuously should have happened or be saturated. PTFE is installed already in Nuclear power plant. In order to overcome the situation where signal fading becomes larger as exposed for a long time, a more research is necessary.

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