Preliminary study about PTFE/ESR Dosimetry

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1. Introduction

Currently, we are 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]. Most of the estimated dose values inside the nuclear power plant were below almost 10 Gy, but some dosimeters positioned at high radiation field area, might be beside the coolant loop in containment vessel, were estimated above 1 kGy for about one or two fuel cycle. These high dose positions could be considered as positions which was exposed to the mixed radiation field, not only gamma radiation from environmental surroundings, but also neutron rays from reactors directly or indirectly. Major cause of aging by irradiation is known as gamma rays, neutron radiation is regarded as minor one, so all the absorbed dose by gamma and neutron dose which measured by alanine pallet could be the value of over estimation of real dose quantity. And there are also some problems that analyzing high dose position by only single dosimeter. Therefore, we tried to introduce additive dosimeter which is known as polytetrafluoroethylene(PTFE) for enhancing the accuracy and getting only gamma dose quantity. In this experiment, we want to found appropriate parameter for measuring dose quantity and then make dose-response curve using PTFE as another complementary dosimeter.

2. Methods and Results

2.1 ESR System

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 mircrowave power sweep of 20.02mW, a modulation frequency and amplitude of 100kHz and 0.2mT, a time constant of 40.96ms. The modulation amplitude was 0.6mT, while the number of sampling points was 1024. the microwave frequency was about 9.75GHz.

2.2 PTFE dosimeters

The molecular structure of PTFE is known as -(CF2=CF2)-. If it is exposed to radiation, it could produce free radical of -(CF2=CFO·)-. Fading of radiation-induced ESR signals is no more than 2% after a year of storage under standard condition and 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).

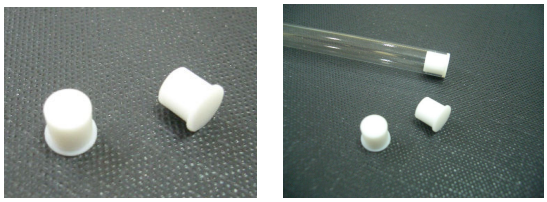


Figure 1. PTFE dosimeter pallet and quartz tube

2.3 measurement parameter

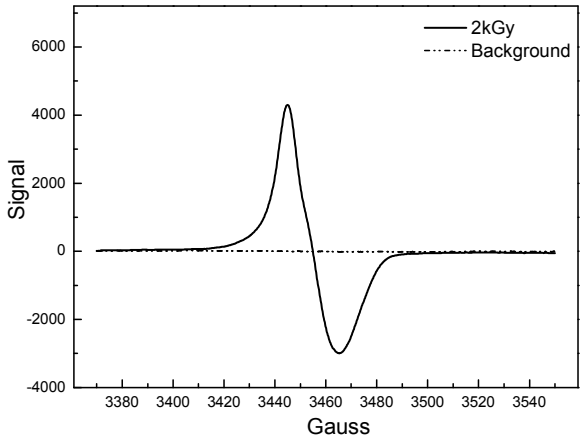
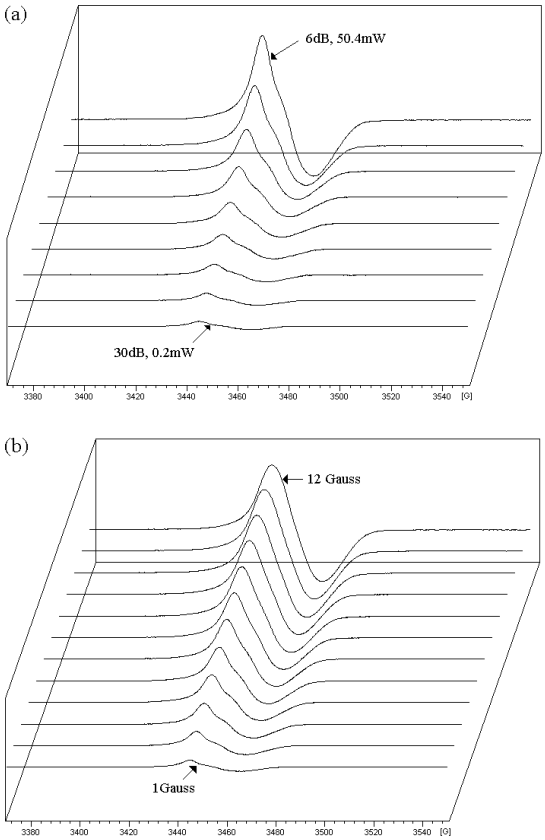


Figure 2. ESR spectrum of PTFE

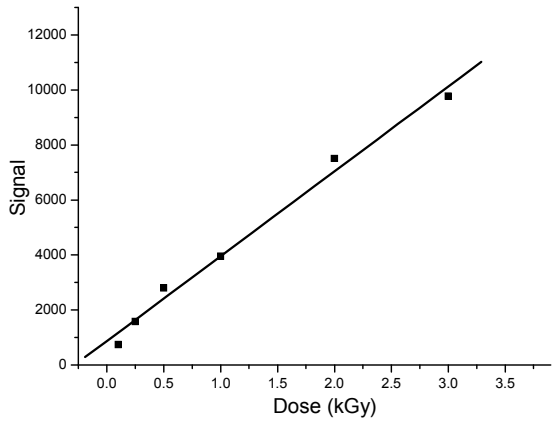
Figure 2. shows, background sample of PTFE and spectrum of irradiated sample at 2kGy radiation. After measuring general spectrum of PTFE, we changed microwave power and modulation amplitude to compare each ESR spectrum for finding appropriate parameter of PTFE (Figure 3). The microwave power range was decreased by the 3dB from 30(0.2mW) to 6(50.4mW)dB and the modulation amplitude was changed by the gauss from 1 gauss to 12 gauss. As the microwave power and modulation amplitude increases, the spectrum becomes narrower.



Figuer3. ESR spectrum by (a) microwave power and (b) modulation amplitude change

2.4 calibration curve

The standard sample was irradiated by 0.091Gy/s using ^{137}Cs gamma source. Figure 4 shows that a calibration curve was drawn by six points such as 0.1kGy, 0.25kGy, 0.5kGy, 1kGy, 2kGy and 3kGy.



Figuer 4. dose-response curve of PTFE dosimeter

3. Conclusion

For introducing the PTFE/ESR dosimetry in the NPP, we performed basic experiments. We get general spectrum of background PTFE/ESR spectra with and without irradiation for basic signal information. And we also changed the microwave power and modulation amplitude for finding appropriate parameter which will be used to scanning PTFE dosimeter. Based on the above results, dose response curve was drawn by specific range (0.1~3kGy). Until now, the PTFE/ESR dosimetry was appropriated in radiation assessment by experimental results, however, it need to further study for reducing errors and controlling influential factors such as sample mass or experimental temperature.
PTFE(Teflon) is being used as binder material in Alanine pallet which is installed already in Nuclear power plant. So the comparing of signal intensity with that of alanine is required to translate signal shape of ESR spectrum from alanine pallet. Even though it is minor binding material which weight percent is at most 3% in alanine pallet, PTFE is well know as its better signal intensity on ESR than that of L-α-alanine material. Contribution of PTFE seems to be precious for detailed signal analysis of alanine dosimeters.

REFERENCES

[1] IAEA, Assessment and Management of ageing of major nuclear power plant components important to safety, IAEA-TECDOC-1188

[2] I. Milman, V. Putyrsky, M. Naimark and V. Popov, PTFE IN HIGH DOSE ESR-NMR GAMMA DOSIMETRY. Radiation Protection Dosimetry Vol. 47 No. 1/4pp. 271-272 (1993)