Change of spectrum shape in Alanine/ESR dosimetry in NPP

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1. Introduction

Alanine/ESR dosimetry, already known as a dosimetric method in medical and industrial field, was applied to estimate dose quantity at cable locations within a nuclear power plant as a part of equipment qualification program[1]. The alanine dosimeters were fixed on the targeted cable or nearest position to measure dose quantity to get accurate value. Alanine dosimeters, which installed for one fuel cycle, were scanned by commercially used two different ESR systems, e-scan and EMX series for alanine dosimeters. To estimate more accurate dose, two environmental correction factors, irradiation temperature and dosimeter weight, were used in calculation of absorbed dose quantity. Most of the estimated dose values inside the nuclear power plant were below 10 Gy, but some dosimeters positioned at high radiation field, seems to be beside 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 exposed to the mixed radiation field, gamma, neutron and other rays. The effect of neutron ray to the shape of alanine spectrum was published[2] in the process of finding new materials for ESR dosimeters or trying to advance the sensitivity of dosimeters. By use of lithium formate material, the change of spectrum line width and signal rate on the microwave power level was experimented under the different radiation field. Like the other experiment, in this paper, the alanine dosimeter spectrum shape from NPL(gamma rays) were compared to the those of dosimeters from nuclear power plant. Difference of dosimeter spectrums would be showed by comparing specific ratio of specific part of each spectrums .

2. Methods and Results

2.1 Dose estimation on e-scan & EMX series

The e-scan is a benchtop ESR (Electron spin resonance) spectrometer dedicated to the evaluation of absorbed dose in alanine dosimeters (either film or pellet). With the appropriate accessories, the e-scan measures absorbed dose from a few Gray to about 200 kGy. EMX spectrometer were recorded with a microwave power of 2.9mW, a modulation frequency and amplitude of 100kHz and 0.2mT, a time constant of 40.96ms. The magnetic field sweep width was 16.0mT, while the number of sampling points was 1024. the microwave frequency was about 9.73GHz.

2.2 alanine dosimeters

L-α-alanine has attracted considerable interest for use in radiation dosimetry and has been formally accepted as a secondary standard for high-dose and transfer dosimetry. In this experiment, used dosimeters were BioMax alanine dosimeter which contain α-amino acid alanine, CH_3-$CH(NH_2)$-COOH and Teflon as binder material to form dosimeter as pallet. The alanine dosimeter pellets was 5mm in diameter and 3mm in height and weighed 64.5±0.5mg.

2.3 Experimental

Alanine dosimeters from different environment were scanned by two EPR systems, 24 dosimeters (4 dosimeters per dose point) exposed at NPL for Co-60 and 16 dosimeters from nuclear power plants. First, all the dosimeters were measured by e-scan alanine analyzer for acquiring reference dose at least 4 times per dosimeter. Measured value from e-scan was used as referenced dose quantity for another experiment.

Generally, the spectrum of alanine does not show satellite relatively small peak beside main peak as spectrum in Fig 1. But, in this experiment, relatively high microwave power value was applied to get such a spectrum which has small satellite peak in central parts of alanine spectrum. The Y and X value was acquired by measuring pitch to pitch value of two peaks and compared as you can see in Fig 2.

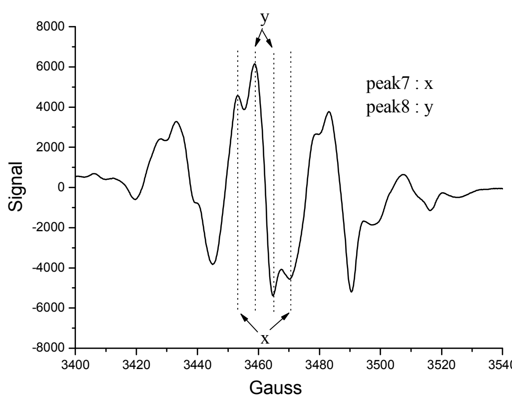

Fig 1. Alanine spectrum exposed to Gamma ray (Co-60, 1 kGy)

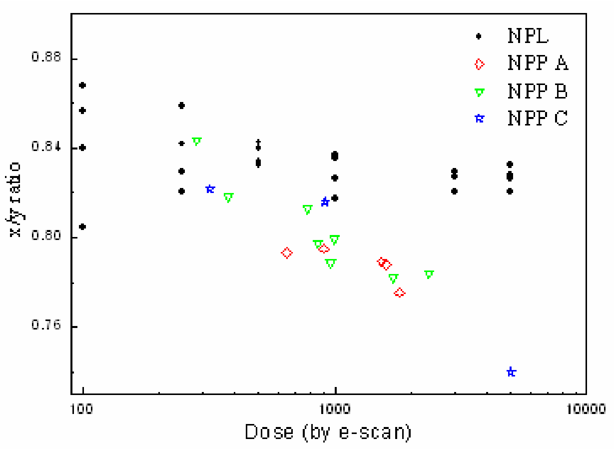

Fig2 . Plotting of x/y ratio of alanine dosimeters (NPL: alanine dosimeters exposed at national physics laboratory, NPP A and B: HWP type, NPP C: LWP type)

As you can see in Fig 2, the ratio of alanine dosimeters from nuclear power plant show lower values at relatively high dose range than that of dosimeters exposed at NPL. The difference of these ratio seems to be widen as increasing the alanine dose quantity. Actually, in Fig 2, high dose dosimeters were installed in Containment Vessel of nuclear power plant, which exposed to gamma ray and thermal neutron rays simultaneously.

3. Conclusion

The difference of each dosimeter, for example, weight or irradiation temperature, could be compensated by applying proper correction factors. As published before[3], the spectrum of alanine seems to be composed of three different radicals(R1,R2,R3) and each one responds linearly to the exposed ionization radiation. But, under the environment of mixed radiation field, slightly different LET value of each radiation causes the change of some ratios in spectrum like pitch to pitch value of central peaks as we can see above Fig 2.plot. Actually, some shape change of alanine spectrum seems to be caused by different radiation field components, in this case, thermal neutron rays in mixed radiation field. The sensitivity of alanine dosimeter to neutron rays is so low, it can not be compared to that of gamma rays, thus all of the alanine spectrum signal could be regarded as coming from gamma rays. The change of signal shape seems to be possible, if the comparative portion of neutron rays is relatively high in all of the mixed radiation rays. So it means the dosimeters showing changed ratio value might be exposed to great neutron rays compared to many of other dosimeters in power plant. The relaxation time of thermal neutron rays which involved in saturation level affects the R2 radical's signal intensity composing x peak in Fig 1. Quantitative analysis of ratio change could be done by studying neutron dose data in nuclear power plant in future.

REFERENCES

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

[2] B. Ciesieelski, L.Wielopolski, The effects of boron on the electron paramagnetic resonance spectra of alanine irradiated with thermal neutrons. Radiation research 144, 59-63(1995)

[3] Mojgan Z. Heydari, Eriik Malinen, Eli O. Hole, and Einar SaJ.M. Dolo, V.Feaugas, Analysis of parameters thgstuen , Alainine Radicals. 2. The Composite Polycrystalline Alaine EPR Spectrum Studied by ENDOR, Thermal Annealing, and Spectrum Simulations, J. Phys. Chem. A 2002, 106, 8971-8977