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Preliminary study about MA influence in ESR/Alanine dosimetry

Choi Hoon, Choi One, Ha J00 Hee, Lim Young Ki , Kim Chong Soon
Radiation Health Research Institute

1. Introduction

EPR dosimetry technique using alanine pallet has been commonly shown in many papers and especially, in recent days, not only the considerations of potential sources of inaccuracies in the process of detecting and data processing, the analysis of environmental influence(temperature & humid) to the signal intensity is also frequently published[1]. But, in actual application of EPR dosimetry at the low dose range, low S/N ratio, original binder and dosimeter signal and contamination of devices attribute to the inaccurate data[2]. To avoid these matters, the decision of parameters suitable to the purpose of dosimetry should be checked at real laboratory situation. Parameters like modulation amplitude and power level influence apparently to the signal intensity quantity which translated as the dose exposure. It would be interesting to find out such a influence to the final signal intensity by changing parameters[3]. And also, the methods, pitch to pitch or double integration, to estimate intensity could be checked in low dose range for accuracy by using two methods at same sample in sequence. The test result present below consideration about proper method and parameters.

2. Methods and Results

The application of several different parameters to analyze the influence was frequently done for finding proper conditions in other many papers. Also in this experiment, 3 alanine samples, irradiated by 5 Gy gamma rays, were prepared to know different influence by changed parameters. Until now, some ordinary characteristics of alanine is known by papers for example, no dependence on dose rate when irradiated by radiation source and signal fading is nearly 1% a year or better. About the fading rate of alanine was widely know to the great details in these days under the special environmental. Temperature generally is known as the factor in stored situation after irraditon and humidity is also important factor affect after before and after of irradiation[1].

2.1 Preparation of dosimeter and spectrometer

The used dosimeters were BioMax alanine dosimeter which contain α-amino acid alanine, NH_2-$C_\alpha H(CH_3)$-COOH and Teflon as binder material to form dosimeter as pallet(ratio>9/1). Cylindrical form of pallet has the dimension of 5mm in diameter and 3mm in height. This dosimeter was developed for E-scan several years ago. The system for detection of radicals in alaine pallet is X band EMX EPR spectrometer of Bruker.

The dual cavity was also installed in the case of scanning simultaneously standard marker for compensating Q factor change during scanning time. To hold dosimeter properly inside the cavity of spectrometer, quartz tube(ID:5.25mm, open end type) and specially designed Teflon plug(holder) was prepared to fitted well with quartz tube as seen in Fig.1.

The pallet between Teflon plugs was fixed firmly in side quartz tube to avoid signal deviation by trembling or some movement. All the temperature and humidity ,before and after irradiation, is constantly maintained as 22 c° & 20% by environment control system..

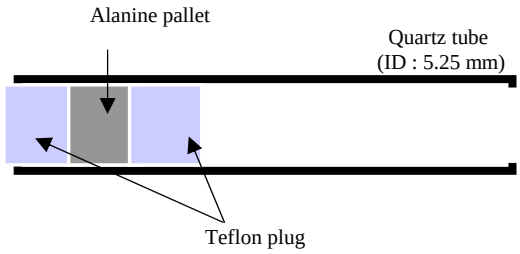

Fig.1 Alanine pallet and Teflon plug in quart tube

Gama ray irradiation was done by blood irradiator with Sc-137 source ranged from 5 Gy to 15 Gy .

2.2 Experiment on parameters

Although the spectrum pattern of alanine is almost similar in general case, power level and modulation amplitude change cause the alanine signal shape change. Simple change of peak configuration happens at the center peak of three main signals of spectrum[4]. The change of modulation amplitude in condition ,that the other conditions are all the same, changes the shape of spectrum as in Fig. 2. This shape change and low S/N rate at the dose range are combined, and create some portion of all inaccuracies. These kind of shape change cause, in range of low dose quantity, discordance which associated with pitch to pitch method and double integration method of area under the signal spectrum. As you see Fig. 2, the shapes change upon the modulation amplitude by over modulation and under modulation. In the sequence, signal intensity by use of pitch to pitch method is getting smaller than value by the double integration method by increasing modulation amplitude. It could be caused by the shape change of center peak in the alanine spectrum. At this try, 3 alanine dosimeters were tested for finding these relative

value change by estimation method. The applied dose quantity was 5, 10, 15 Gy of radiation and the modulation amplitude was changed from 0.30 mT to 0.80 mT. The performing of double integration is applied to the alanine's spectrum area by using program(winepr).

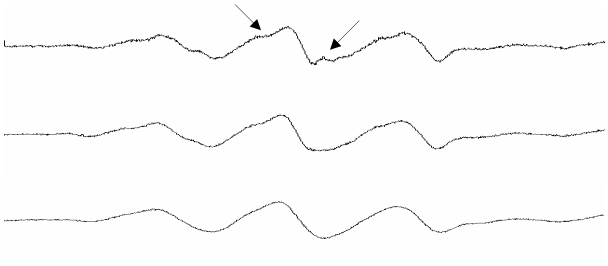

Figure 2. Shape change by over modulation from top to bottom (0.30, 0.50, 0.80 mT), 6.3 mW power, 2 x 10^4 gain

First, the height of center peak of alanine signal is measured and performed double integration. Because these two methods were normally used to quantitate intensity signal of EPR sample. Measuring height of spectrum is more convenient but, at low dose range, it create big measurement value deviation by choosing incorrect g-factor location frequently. Table 1 is the experiment result for 3 alanine pallets for the data comparison by use of two methods.

Table 1. Signal intensity by measuring peak height of spectrum and Double integration process of first derivative EPR signals(5Gy irradiation), height is of the center peak of three peaks

MA	method	Test 1	Test 2	Test 3
3	P to P	11545	9681	11708
	DI/N	0.649	0.495	0.7383
	Ratio	17791	19526	15858
5	P to P	17073	13591	16630
	DI/N	1.183	0.7689	1.128
	Ratio	14431	17675	14743
8	P to P	25839	20954	24673
	DI/N	1.973	1.225	1.733
	Ratio	13096	17105	14237

* MA (Modulation Amplitude), ** P to P (pitch to pitch),
*** DI/N (Double integration normalized to conversion time)

3. Conclusion

At the low dose range, alanine pallets exposed to gamma ray were scanned by EPR spectrometer with different modulation amplitude. After scanning samples, the signal intensity of spectrum was measured by two procedures. First one is the way that just read the height of center peak of alanine spectrum, which is very common and easy method to measuring intensity. The second method is double integration procedure that integrate the area under the absorption spectra line of alanine pallet. From the above Table 1., we can find that the "ratio" value from "P to P" and "DI/N" decrease on the modulation amplitude. If P to P value or DI/N value of each sample is reviewed, then the value it self is increasing with modulation amplitude absolutely, and it is so natural. The change of these ratio means we cannot use both measuring method simultaneously. This is actually the kind of situation never occur in the high dose range, as you see in Fig 2. the arrowed parts are ordinary shown in highly irradiated alanine pallet, even in case, relatively big modulation amplitude be applied. But, in low dose range, such a big modulation amplitude to get the more apparent signal make arrowed parts disappear. In expanding the detection range under 2Gy or 5Gy, relatively big modulation amplitude has advantage to detect very weak radicals signals but it also give us inaccuracy by over modulation. The pitch to pitch method and double integration should not be used simultaneously. In the low dose range, for example about several Gy range, This kind of discrepancy between measuring method should be checked before dose estimation.

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