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Application of Alanine Dosimeter as Calibration Dosimeter for Low dose

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ABSTRACT

The calibration of a radiation dosimeter is essential in detection of many Ionizing radiations such as X-rays, alpha rays, beta rays, and gamma rays. The main work is to apply irradiated alanine as a calibrator for electron spin resonance spectroscopy (ESR) readout. The irradiated alanine (alanine dosimeter) usually used in detection of gamma ray at high dose was experimentally irradiated at low dose of 10-50 Gy. In the study, the parameters set ESR read out of alanine dosimeter were such as microwave power, modulate amplitude, time constant and number of scan corresponded to 3.18 mW, 5 G, 0.5 mT, 81.98 ms and 15, respectively. The obtained results were comparable with the reference dose calibrated by Fricke Solution, with the error of not more than 3%. From overall, therefore, alanine measured by ESR technique as alanine dosimeter can one good calibrator that can further applied for monitoring dosimetric behaviours.

Key words: Alanine, ESR paramer, Low dose

INTRODUCTION

Recently, dose radiation dosimetry calibrations are many techniques for used. Fricke solution is one of technique wildly used. It is chemical method and has high accuracy. However, this method has complicate and long time to prepare solution. Office of Atom for Peace of Thailand is radiation quality control and calibrates radiation dosimeter and use Fricke technique in routine. To solve this problem, new technique is necessary for OAP to easy set up in short time.

ESR spectrometry with alanine is now widely recognized as the most accurate method of transfer dosimeter in high dose range. Advantages of ESR/alanine have many mentions such as alanine has properties equivalent to tissue, the readout is a non destructive process, free radicals created when irradiating alanine present a long term atability and the alanine response is fairly independent of energy of radiation and dose rate [3]. On the other hand, ESR/alanine is easy and shot time to use in dose radiation dosimetry calibration laboratory.

In this work, apply alanine dosimeter with ESR spectroscopy at low dose range (10-50 Gy). Determine ESR parameters alanine read out and compare radiation dose with Fricke solution

Materials and Methods

Fricke solutions were irradiated in air and room temperature using a Co^{60} gamma irradiation device. Then the samples were measured absorption dose by UV spectroscopy. Radiation time was calculated from relation of dose time curve. Alanine was obtained from Far West Technology. The samples have 2 set, a set of sample have 4 pellets, it contained in the phantom. One of set were irradiated by gamma ray at room temperature with doses 10, 30 and 50 kGy and another set were irradiated with doses from 1 to 50 kGy. ESR measurements were carried out using a Bruker X-band ESR spectrometer operating at 9.5 HHz. Dose response from ESR and Fricke were compared and discuss.

Results and Discussions

Fricke solutions were irradiated and measured adsorption dose by UV spectroscopy. Fig. 1 shows of expose time according to radiation dose. The best correlation is obtained for linear equation as y =

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mx+c. In this function, *y* and *x* represent the radiation dose in Gy and expose time in second, respectively, and parameter *m* and *c* are constant to be determined. The parameter *m* in this function representing the slope of linear and parameter *c* represent amount of initial radiation dose. From this results, calculated expose time of alanine are 57.2, 182.0 and 306.7 s for 10, 30 and 50 Gy, respectively.

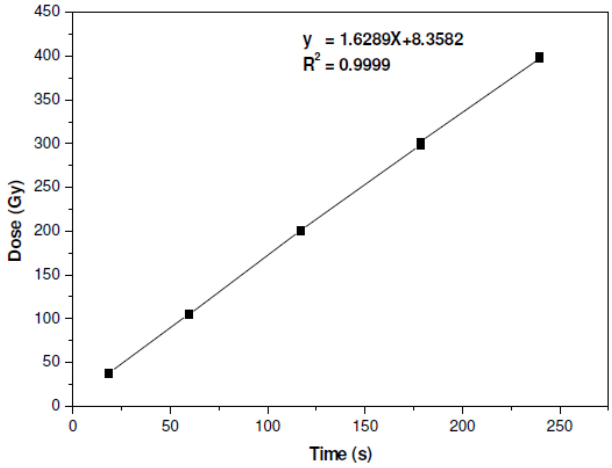

Fig. 1: expose time according to radiation dose from Fricke solution

ESR spectra of alanine before and after radiation are shown in Fig. 2. The results showed that, before irradiation of alanine was ESR silent. After irradiation alanines exhibit typical ESR spectrum due to the free radicals created in alanine by the high energy radiation [1]. The ESR signal was a well known quintet of broad lines separate and accompanied with the satellite lines [3]. The ESR signals intensity was depended on free radicals in irradiated alanine [2].

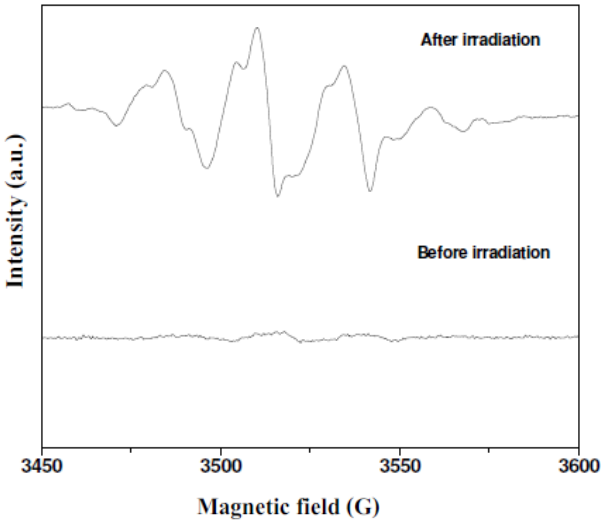

Fig. 2: ESR spectra of alanine before and after radiation

To determine four ESR parameters such as microwave power, modulate amplitude, time constant and number of scan. The samples were irradiated by gamma ray at room temperature with doses 10, 30 and 50 Gy. The variation of peak to peak signal intensity with the applied microwave power, time constant, modulate amplitude and number of scan were given in fig. 3a, 3b, 3c and 3d, respectively. From the Fig. 3a-b, it found that the behavior of all the samples with incident microwave power and time constant were similar. The intensity increased rapidly with increasing of microwave power at low microwave power and decreased slowly at high microwave power. All samples have maximum intensity about 3.18 mW and 81.92 ms. However, Fig. 3c-d shows relative of intensity with amplitude and number of scan, respectively as a linear. The ESR signals increase with rising of amplitude and number of scan. Then we calculated maximum intensity different from each interval of

amplitude and number of scan. The maximum intensity of amplitude and number of scan are 5 G and 15 times, respectively.

Another set sample was irradiated 10, 20, 30, 40 and 50 Gy and measured ESR spectrometer with selected maximum parameter (3.18 mW, 81.92 ms, 5 G and 15 times) and shown in Fig 4. Fig. 5 shows relation of radiation dose and intensity. Fitted curve of data with polynomial function is $y = a + bx + cx^2$. In this function, y and x represent the ESR signal intensity and applied radiation dose in Gy, respectively, and the parameter a, b and c are constant to be determined. The parameter a in this function representing the ESR signal intensity at zero applied dose mean that the relative amount of free radical species of unirradiated sample and parameter b and c represent the rate of radical production and radiation yield upon irradiation at room temperature. The parameter of a, b and c of alanine calculated from fitting procedures was found are 17.852, 3.809×10^{10} and 0,004(r^2 = 0.9951). From this function we can calculate new radiation dose from calibration curve and compare with Fricke solution dose and show results in Table 1. From the results, the percentage errors are not more than 3%. Therefore, ESR technique could alternative applying for alanine dosimeter for 10 to 50 Gy.

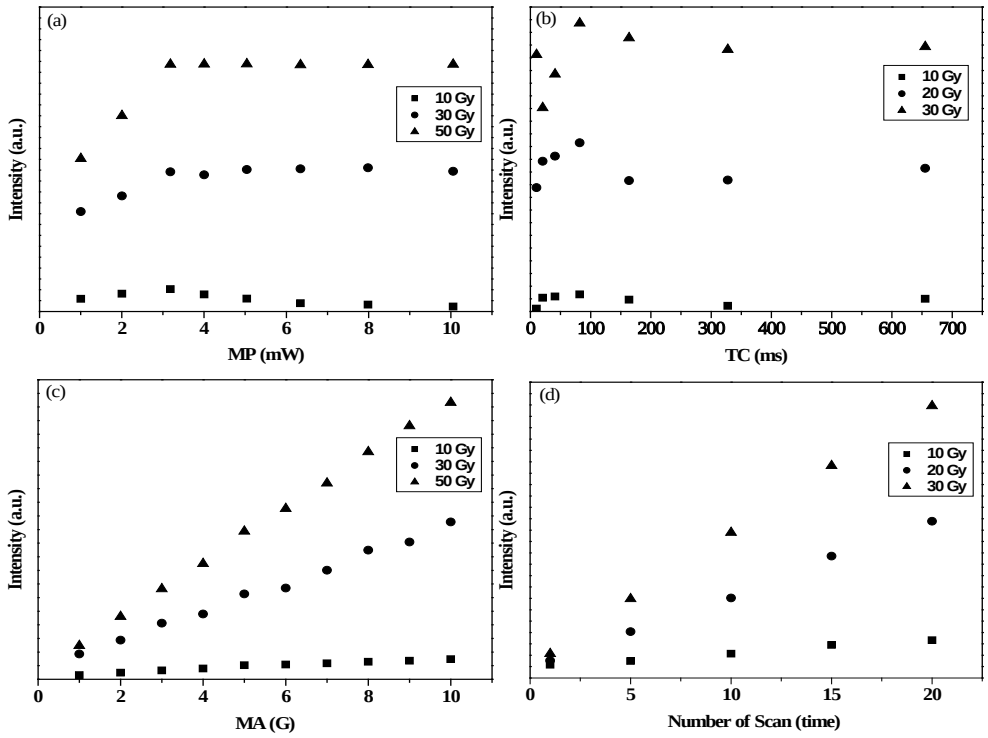

Fig. 3: The variation of peak to peak signal intensity with different ESR parameters (a) microwave power (b) time constant (c) modulate amplitude and (d) number of scan

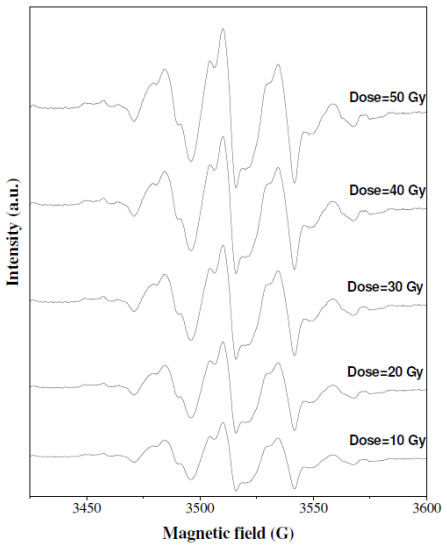

Fig. 4: ESR spectra of alanine after radiation varies different irradiation dose

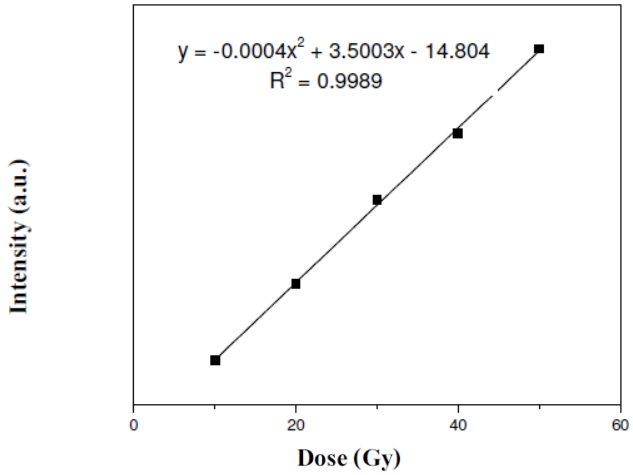

Fig. 5: dose response dependence of the alanine dosimeter

Table 1: Radiation dose from calibration curve with ESR and Fricke solution

Dose (Gy)	Intensity	Dose (Gy) From calibration	%Error
10	20.05	9.95	0.54
20	54.49	19.75	1.24
30	92.20	30.46	1.55
40	122.03	38.92	2.70
50	160.14	49.70	0.61

Conclusion:

In this work, alanines were radiation dose at 10, 30 and 50 Gy and measured ESR spectroscopy. The ESR parameters for alanine read out are microwave power: 3.18 mW, time constant: 81.92 ms, modulate amplitude: 5 G and number of scan: 15 times. All parameters used in low dose radiation dosimetry calibration. The percentage errors of radiation dose are not more than 3% when compared with Fricke solution. ESR technique could alternative applying for alanine dosimeter for 10 to 50 Gy.

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