DOSIMETRY OF ELECTRON AND GAMMA RADIATION WITH DL-ALANINE

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INTRODUCTION

A dosimetric method based on the quantitative determination of stabilised free radicals in irradiated crystalline DL-alanine by electron spin resonance (ESR) spectroscopy was proposed as early in 1962[1]. Since then, alanine dosimeters owing to their unique properties have been investigated by many authors and used in dosimetry of various types of radiation, namely gamma rays, electron and neutrons.

Alanine is a simple aminoacid, on irradiation at room temperature predominantly free paramagnetic radicals of the type CH_3 - CH - COOH are produced.

This paper reports the application of powder DL-alanine/ESR dosimeter for measurement of absorbed dose of gamma radiation from ^{60}Co sources and reactor nucleus and electron beams from accelerator. The obtained results give useful information about the instrumental care necessary to obtain the needed overall accuracy in determination of absorbed dose.

MATERIALS AND METHODS

Commercially available purified crystalline amino acid DL-alanine (Merck) has been investigated for use in radiation detection. The chemical composition of alanine (CH_3 - $CHNH_2$ - COOH) is close to that of tissue, thus providing good similarity to biological systems in absorption of radiation energy[2].

The microcrystalline powder is transferred to suitable sized quartz tubes for X band ESR spectrometry.

The irradiations were performed using a panoramic ^{60}Co gamma ray source, electrons emitted from an accelerator (Dynamitron II) for industrial purposes with samples sealed in glassy ampoules. The samples irradiated at the IPEN Reactor - IEA-R1 were sealed in poliethylene film and covered with Cd foil. All doses given further are expressed as dose to water, as determined by of Fricke dosimetry for gamma ray irradiations.

The ESR spectra were all recorded at room temperature using a JEOL spectrometer (model: JES-ME 3X) with a microwave cavity (TE_{011} mode) operating a frequency of 9400 MHz (X band) and an constant microwave power of 0.1 mW. The magnetic field setting was 334 mT, the field scan range was 25 mT, the scan time was 0.3 s, and the magnetic field modulation amplitude and frequency were 0.5 mT and 100 kHz, respectively, for all dose - response measurements. The gain was always adjusted so that an optimum ESR signal was obtained. The ESR spectrometer sensitivity was checked by introducing into the cavity a DPPH sample (2,2- diphenyl - 1- picrylhydrazyl) contained in a sealed quartz tube.

The ESR spectra was recorded as the first derivative of the paramagnetic absorption spectra where the response of the alanine was expressed as the maximum peak to peak amplitude of the ESR spectra and measurement taken at different days were normalised using a Mn^{2+} reference sample.

RESULTS AND DISCUSSION

The Figure 1 shows the first derivative (ESR spectrum) of the microwave absorption signal of an alanine dosimeter irradiated with ^{60}Co gamma rays at 1 kGy.

The reproducibility of ESR signal height depends on the short and long term stability of the instrument parameters, as well as on the reproducibility of the position of sample inside the microwave cavity. Short-term stability was investigated by carrying out repeated recordings of an irradiated sample. Each parameter was changed after a recording had been completed and then adjusted again, keeping the sample inside the cavity all time. Variations in the shape of ESR spectra of DL -Alanine irradiated with gamma ray and electrons measured at different microwave power were studied.

Post irradiation stability of the DL-alanine response as a function of absorbed dose was investigated for absorbed doses from 1 to 60 kGy over a storage period of 180 days at room temperature (about 15-28 ^{0}C) and indicates sufficient longevity.

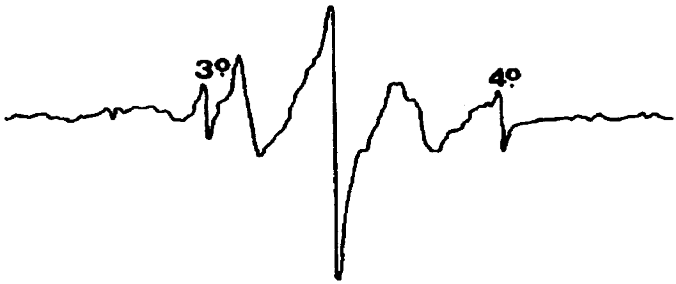

Figure 1. ESR spectrum of alanine irradiated with ^{60}Co gamma rays at 1 kGy[3].

The same signal-dose relationship was obtained for both gamma rays (1.25 MeV) and electron beams (1.14 MeV). No dependence of the response on dose rate has been found in the range from 0.21 to 1.16 kGy/h.

In the dose range of 10^2 to 10^5 Gy, the dose-response signal showed a linear relationship and the precision was less than 2%. At dose levels greater than 10^5 Gy the dose response curve begins to saturate, it is shown in Figure 2.

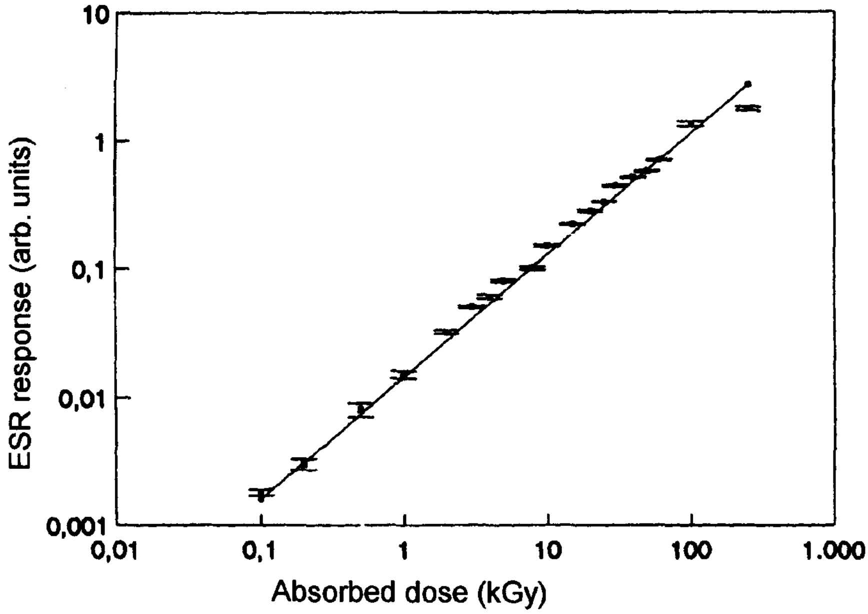

Figure 2 .Dose-response curve of DL-alanine irradiated by ^{60}Co gamma rays[3].

CONCLUSION

The obtained results in this work using a non-destructive readout technique demonstrate that the alanine dosimeter has the long-term stability of radiation induced response, accuracy and reproducibility to be suitable for application in high-level dosimetry. The dosimetric information obtained from the measurement of the gamma absorbed dose in reactor nucleus, are in general accordance with the results determined by thermoluminescence.

REFERENCES

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