Evaluation of Radiation Dose Distribution in Lithium Formate Pellets using EPR Imaging

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Purpose

Electron paramagnetic resonance (EPR) spectroscopy has been successfully applied to determine radiation dose by using alanine as a radiation–sensitive material: the EPR signal intensity directly reflects the number of stable free radicals produced in solid matrix, and provides a quantitative measurement of the absorbed dose. Here, we hypothesized that this principle can be extended by using EPR Imaging in order to provide convenient information on the spatial dose distribution. For that purpose, we selected lithium formate as a dosimetric material. Compared to alanine, lithium formate possess a high stability, is tissue equivalent and shows a sensitivity which is 7 to 14 times higher than alanine (E. Lund et al., 2005). Moreover, the irradiated lithium formate presents a single EPR line which is particularly convenient for imaging purpose. As a proof of concept, we developed cylindrical tablets of lithium formate, and evaluated by EPR imaging the distribution of free radicals after irradiation by X-Rays or by brachytherapy implants.

Methods and materials

Samples of polycrystalline lithium formate monohydrate were made in the form of cylindrical pellets (d=22 mm, h=9 mm ± 1mm) with a manual pellet press (50 Kg/cm^2). Some pellets were external irradiated using an X ray beam (250 kV) having a lead protection in order to visualize the different non-irradiated shapes. For brachytherapy studies, a small hole (1 mm diameter) was made in the middle of the pellet, in which a radioactive wire of ^{192}Ir was introduced. The EPR images were acquired using an EPR Elexsys E540 system. For that purpose, the irradiated pellets were put in the centre of an L-Band EPR cylindrical resonator operating at 1.1 GHz.

Results

The figures below show the distribution of irradiated-induced free radicals in the lithium formate pellets. Fig.1 shows a pellet which was homogeneously irradiated. Fig. 2 shows an EPR image received on a pellet where a lead plate (triangle shape) was partly covering the surface. In Fig.3, the EPR image was obtained on a pellet irradiated in its centre by a brachytherapy wire. The colour code directly reflects the gradient of dose received by using this radioactive material.

Conclusions

Lithium format pellets represent a new modality to assess, by EPRI, the gradient of dose distribution after irradiation. This method offers unique spatial information, especially for the study of dosimetry around brachytherapy seeds.

References

[1] E. Lund et al. 2005. Applied Radiation and Isotopes 62; 317-324

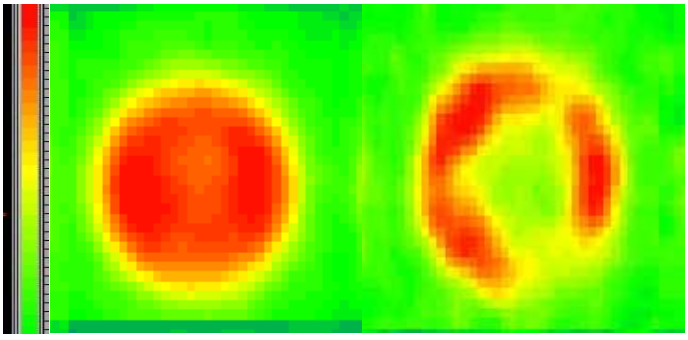

Fig. 1 Homogeneously irradiated pellet

Fig. 2 Pellet irradiated with triangle lead protection

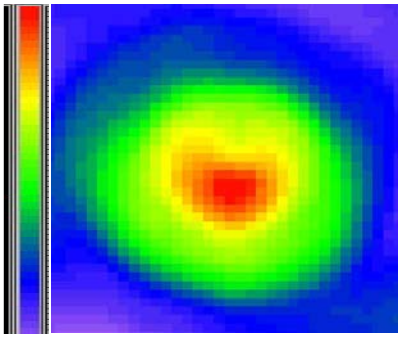

Fig.3 Pellet irradiated in the centre by an ^{192} Ir wire