

# Enhanced sensitivity of EPR dosimeters using metal ions as dopants.

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L-alanine has since many years been the far most used material for EPR dosimetry. The properties of this material are excellent for the purpose; the material is robust, the radiation induced free radicals are stable in time and the dose response is linear in a wide dose range. The sensitivity of the dosimeter is however not sufficient for accurate, fast and simple dose determinations at doses below 10 Gy. The properties of EPR dosimetry, e.g. the linear dose response and the possibility of repeatable read-outs still make the method attractive for dosimetry in radiation therapy. Therefore great effort has been paid to find a dosimeter material with a sensitivity that is more than 10 times higher than that of alanine. For radiation therapy the dosimeter material should also have about the same atomic composition as tissue to minimize the uncertainties at determinations of absorbed dose in tissue. Recently compounds of formates and dithionates have shown promising properties for this purpose, with a sensitivity that is seven to eight times that of L-alanine [1, 2].

Lithium dithionate ( $\text{Li}_2\text{S}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ ) and lithium formate ( $\text{LiHCOO} \cdot \text{H}_2\text{O}$ ) have been doped with nickel and rhodium salts to concentrations between 0.2 – 1 mass percent [3]. Doped as well as pure samples were irradiated to well determined doses between 1-3 Gy, with 4 MV X-rays from a clinical linear accelerator. The signal from the radiation induced radicals was analysed by means of an EPR spectrometer and the spectra showed a simple, single line. The dose determinations were performed by measuring the peak to peak value of the first derivative of the absorption spectrum. The spin-lattice relaxation,  $T_1$ , was determined for both doped and pure samples by an inversion recovery pulse sequence, using a Bruker EleXsys pulse EPR spectrometer. The signal stability was determined by following the signal strength during 20 days.

It was found that 0.2 mass percent of nickel ions was the most suitable dopant. The spin-lattice relaxation times were considerably shortened by introducing dopants making it possible to increase the microwave power for the doped compounds thus increasing the signal strength. The signal of the doped samples measured peak-to-peak was up to 4 times higher than that of the undoped compounds.

This investigation shows that by introducing metal ions in formates and dithionates the sensitivity is enhanced 3-4 times compared to undoped compounds. The tissue equivalence regarding stopping power or mass energy absorption properties is better for formates than for dithionates and the small concentration of metal ions will not affect this. Spin relaxation determinations give important information about the possibility to increase the microwave power which is valuable in further search for dosimeter materials with even higher sensitivity.

1. Gustafsson, H., Olsson, S., Lund, A. and Lund, E. Ammonium Formate, a Compound for Sensitive EPR Dosimetry. *Radiation Research* 161, 464 - 470 (2004).
2. Vestad, T. A., Malinen, E., Lund, A., Hole, E., Sagstuen, E. EPR dosimetric properties of formates. *Applied Radiation and Isotopes* 59, 181 - 188 (2003).
3. Gustafsson, H., Danilczuk, M., Sastry, M. D., Lund, A. and Lund, E. Enhanced sensitivity of lithium dithionates doped with rhodium and nickel for EPR dosimetry. *Spectrochimica Acta Part A*, in press.