Dose Components of Alanine Detectors in Mixed Neutron-Gamma Fields

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Introduction: ESR dosimetry is investigated at the TRIGA Mark II Reactor at the University of Mainz. Purpose is the identification of suitable dosimeter materials for mixed neutron and gamma fields. Alanine pellets have been irradiated in different phantom materials and shieldings. By Monte Carlo modelling dose values and components could be identified [1].

Experimental: The irradiations took place in the thermal column of the TRIGA Mainz [2]. For the experiments the front position in a 20 cm x 20 cm channel in the upper left centre of the thermal column has been used. The foremost part of each phantom has a distance of about 95 cm to the reactor core. The channel is equipped with a 5 cm thick 20 cm x 20 cm Bismuth shield to reduce the primary gamma flux. Alanine dosimeters have been irradiated in a Polymethyl-methacrylate (PMMA) phantom, in a Teflon phantom, with a boric acid neutron shield and an additional bismuth gamma shield.
The alanine pellets are made of 90 % alanine microcrystals and 10 % paraffin wax. Irradiated with ionizing radiation, alanine forms the stable radical CH3–ĊH–COOH. Using an electron spin resonance (ESR) spectrometer, the unpaired electron at the carbon atom can be detected. The value of the ESR signal correlates directly to the number of radicals. The irradiated alanine pellets, have been manufactured and read out at the primary standard laboratory at the National Physical Laboratory (NPL), United Kingdom [3].
The signal in each pellet correlates to an equivalent ^{60}Co gamma dose by a factor called the relative effectiveness (RE). To determine the RE values and to predict the dose and its components for each pellet, we use the Hansen & Olsen alanine detector response model [4] together with FLUKA [5], a multipurpose transport Monte Carlo code. For the simulations performed, a two dimensional surface source of photons and neutrons has been implemented via a user written source routine. The plane is located perpendicular in the thermal column, 63 cm away from the centre of the core in the simulated geometry.

Results: As in previous results [1] the measured dose response of all pellets could be reproduced by the calculations. In Figure 1 the measured and calculated alanine dose response for the PMMA phantom is compared. Figure 2 shows the regarding calculated dose components. The proton dose is generated in the ^{14}N(n,p)^{14}C reaction. The secondary gamma dose is generated by various (n,γ) reactions, dominated by the 2.2 MeV gamma of Hydrogen. The primary gamma dose is deposited by gammas form the reactor core.

The dose rates found in the other three experiments are similar but lower, due to missing dose components. Teflon consists of no hydrogen. Therefore the dose by secondary gammas is lower. With the gamma shield the primary gamma dose has been reduced by a factor of 100 according to the simulations. In the neutron shield no proton dose has been observed, but a higher secondary gamma dose due to the 0.48 MeV gamma generated as a result of the ^{10}B(n,α)^{7}Li reaction by 94 % of the Li ions, which are in an exited state.

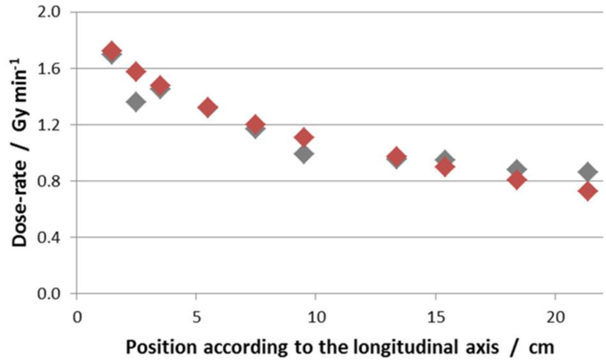

Figure 1. Results of the dose measurements (red) and Monte Carlo simulations (grey) for the PMMA phantom

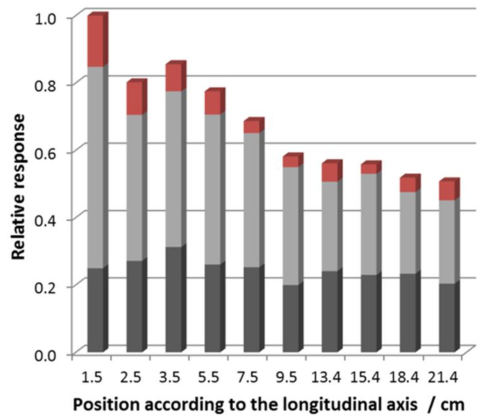

Figure 2. Calculated relative dose composition in the PMMA phantom (red – proton dose, light grey – secondary gamma dose, dark grey – primary gamma dose)

References

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