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MEASUREMENT OF THE ENERGY RESPONSE OF LiF –, CaF_2 – AND $CaSO_4$ – TL-DOSIMETERS

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The most important materials used in thermoluminescence dosimetry (TLD) are LiF, CaF_2 and $CaSO_4$ with various dopants. LiF : Mg, Ti is almost tissue equivalent and therefore the most applied TLD-material in personnel and medical dosimetry. CaF_2 : Dy offers the highest sensitivity of the above mentioned materials and is used in environmental and low-dose dosimetry. $CaSO_4$: Dy can easily be labor made and is the cheapest phosphor. As the effective atomic numbers of CaF_2 and $CaSO_4$ differ markedly from that of tissue material the response curve of both materials must be carefully determined in the energy range dominated by the photoeffect. The energy responses of these three listed phosphors were determined by means of a Bragg monochromator, filtered radiation from a gold target bombarded by electrons from a Van de Graaff accelerator, the radiation of a ^{137}Cs-source (662 keV) and a ^{60}Co-source (1.17, 1.33 MeV). The response-energy dependence of the three dosimeters shows maxima at 35 keV (LiF and CaF_2) and 40 keV ($CaSO_4$).

1. Introduction

The most important materials used in thermoluminescence dosimetry (TLD) are LiF, CaF_2 and $CaSO_4$ matrix systems with various dopants. LiF:Mg,Ti is almost tissue equivalent and therefore the most widely applied TLD material in personnel and medical dosimetry.

CaF_2:Dy offers the highest sensitivity of the above listed materials and is used in environmental and low-dose dosimetry.

$CaSO_4$:Dy can easily be labor made and is the cheapest phosphor.

As the effective atomic numbers of CaF_2 and $CaSO_4$ differ markedly from that of tissue material, the photon energy response curve of both materials must be carefully determined, especially in the photoeffect dominated low energy range [1, 2, 3].

2. The methods of sample irradiation used

2.1. *Irradiation with Bragg-monochromatized X-ray bremsstrahlung*

As already mentioned a Bragg monochromator can be used for the selection of a certain energy in the energy range from 10 to 50 keV [4]. The well defined energy and the straightforward determination of the spectral shape and intensity are advantageous in this energy region with fast changes of sensitivity vs photon energy. The extension of the method up to 80 keV is possible if topas and quartz (SiO_2) are used as monochromator materials.

2.2. *Irradiation with filtered bremsstrahlung from a gold target bombarded with electrons from a Van de Graaff accelerator (energy range 60—260 keV)*

Fig. 1 shows the experimental arrangement used in this energy range. The electrons accelerated in the Van de Graaff (130 keV, 140 keV, 275 keV) are stopped in a water cooled Au-target. The produced bremsstrahlung is filtered.

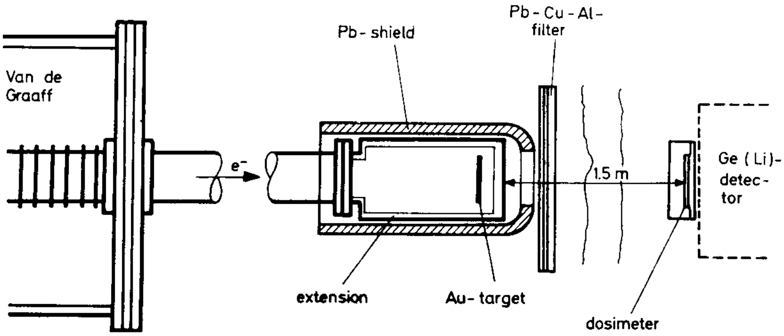

Fig. 1. Irradiation of the dosimeters with filtered bremsstrahlung produced with a Van de Graaff accelerator.

The shape of the filtered bremsstrahlung spectrum and the intensity of the radiation at the place of the dosimeter is determined with a Ge(Li)-spectrometer. A calibrated dose ratemeter was used additionally for the determination of the dose rate. Table I gives the electron energy, the filter combinations, the effective energy of the filtered radiation and the full width of half maximum (FWHM) as the parameter which defines the "homogeneity" of the radiation.

2.3. *Irradiation with 662 keV photons from a ^{137}Cs source*

A collimated beam was used. The source — dosimeter distance was 2 m to provide secondary electron equilibrium (e. equ.) in air at the dosimeter place. Dose rate determination was obtained with a calibrated dose-ratemeter.

Table I

Electron energy (keV)	Filter combination	"Mean energy" photon flux density [keV]	Full width of half maximum [keV]
130	2 mm Cu	72	12
140	1.2 mm Sn	106	30
	5 mm Cu		
275	2 mm Pb	255	43
	2.4 mm Sn		

2.4 *Irradiation with 1.17 and 1.3 MeV photons (1.25 MeV) from a ^{60}Co source*

In determining the dosimeter response for ^{60}Co radiation the following conditions must be used for all mesurements:

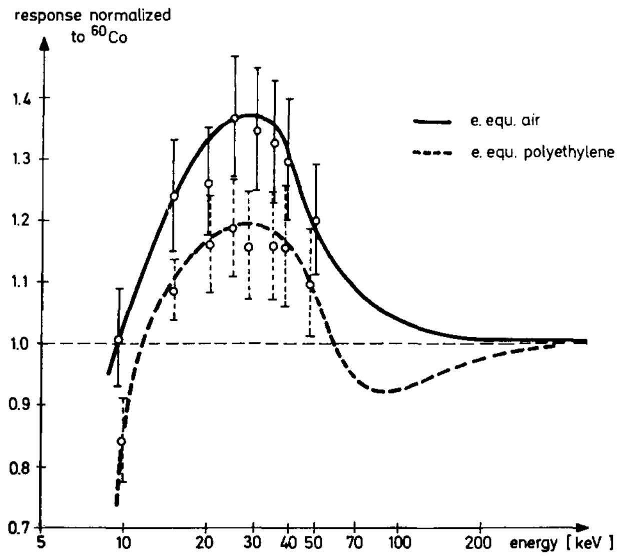

Fig. 2. Response vs energy of TLD-100 (LiF : Mg, Ti) for secondary electron equilibrium (e.equ.) in air and in a polyethylene wrapping.

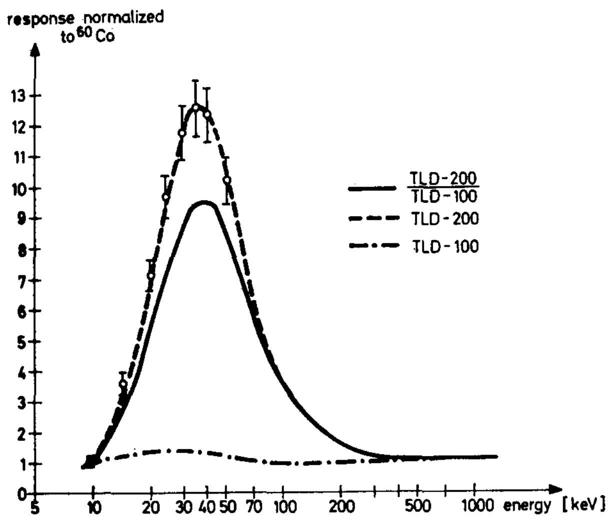

Fig. 3. Response vs energy for TLD-200 (CaF_2 : Dy), TLD-100 and the relation of TLD-200/TLD-100-response for e.equ. in air.

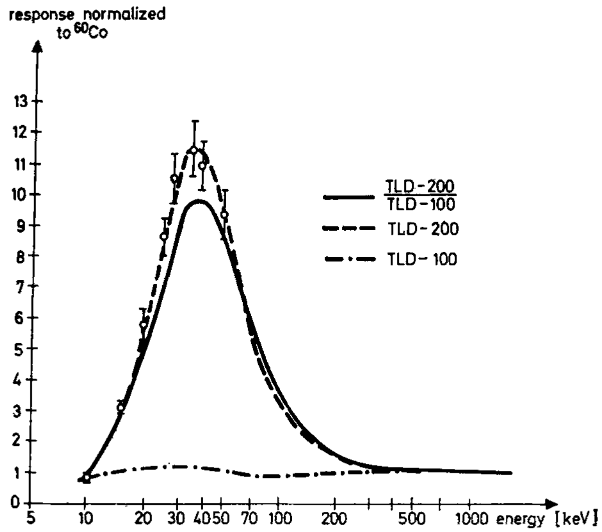

Fig. 4. Response vs energy for TLD-200, TLD-100 and the relation of TLD-200/TLD-100-response for e.equ. in a polyethylene wrapping.

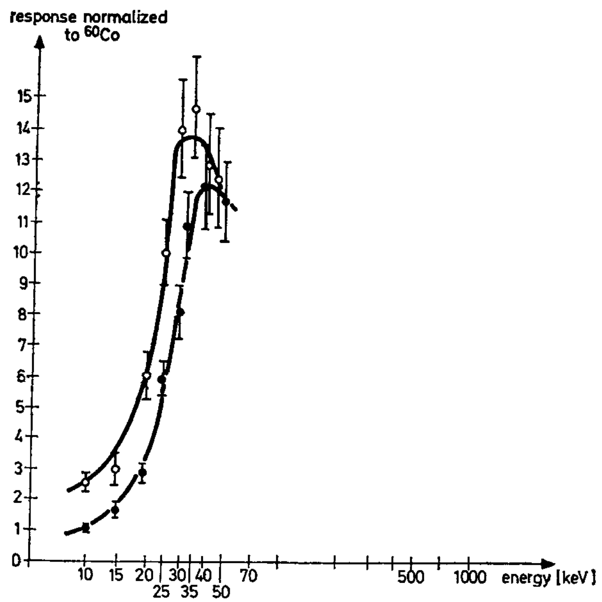

Fig. 5. Response vs energy for a labor made $CaSO_4$: Dy (0.1%) in a small "plexiglass"-box (open circle) and in a gelatine capsule.

— the distance from the ^{60}Co source must be large enough to obtain e. equ.
— same material and thickness for the dosimeter wrapping to obtain e. equ. in the material.

3. Results

3.1. Results for TLD-100 (LiF) and TLD-200 (CaF_2)

Fig. 2 shows the energy dependence of the response of TLD-100 in the case of secondary electron equilibrium in air and in a polyethylene wrapping. The response is normalized to ^{60}Co response.

Figs. 3 and 4 show the response vs energy for TLD-100 and TLD-200 and the relation of TLD-200/TLD-100-response.

3.2. Results for labor made $CaSO_4$:Dy (0.1%)

Fig. 5 shows the energy dependence of $CaSO_4$ obtained with Bragg-monochromatized radiation for $CaSO_4$ powder in a small "plexiglass" box and in a gelatine capsule.

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