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STUDY OF ENERGETIC DEPENDENCE OF LiF TLDs FOR PHOTONS

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ABSTRACT

The LiF TLDs are widely used for photon dosimetry. However, in the most case the energetic dependence of these TLDs are not taken into account. This work is a preliminary study of energetic photon dependence in LiF TLD (TLD 700, enriched with ^{7}Li).
For this study it was utilized a methodology already used in others works that seek understand the dependence energetic of TLD. It was utilized three different x-ray spectrum and a ^{137}Cs source; Beyond the calculus utilized in previous works, it was built the calibration curve for each spectrum to see the difference in dosimetry that the energetic dependence could cause.

1. INTRODUCTION

One of the main aspect to be taken into account in radiation protection or radiotherapy is the dese in certain regions. The treatment outcome depends on dose delivery accuracy, which must be verified experimentally to assure the correct execution of the treatment plan and patient safety.

Thermoluminescent dosimeters (TLDs) are widely employed for dose measurements in phantom and in vivo due their small dimensions, response reproducibility and relative low cost. However, the detector response depends on the beam quality and may show significant differences due to the source spectrum.

This study evaluated the energetic dependence of LiF TLDs following the methodology from previously published works [1-3] and comparing our results with them.

They were utilized four different photon spectrum for this study, three X-Rays and the ^{137}Cs source. Simulations with Monte Carlo Code, MCNP6, were also performed to be able to compare with the previous works and to obtain more data of our experiments.

2. MATERIALS

2.1. Termoluminescent Dosimeters

This work utilized the TLD-700 of Harshaw, which is TLDs made of LiF:Mg,Ti enriched with ^{7}Li isotope. The shape of TLDs are disks with 3mm of diameter and 0.015mm of width.

On the cycle of use of TLD it was utilized the same thermal treatment on them: 1h in 400°C and 2h in 100°C. And the Harshaw 3500 Reader was utilized to read the TLDs with the following parameters: 1000V of voltage; 60°C of pre-heat; 400°C of final temperature; and 45s of reading duration.

2.2. Irradiations

The TLDs were irradiated in four different spectrum: one of ^{137}Cs source and three of X-Rays at different qualities.

For irradiations at ^{137}Cs, which has photon emission at 662 keV, the TLDs were placed in an acrylic support with thickness of 5mm behind and 5mm cover. This thickness was utilized to provide electronic balance in TLD position. Three different kerma air were delivered in TLDs: 50, 100 and 200 mGy.

The irradiations at x-ray were performed in three different qualities: RQR3, RQR8 and RQT9 [4], the information of each quality is at Table 1. These qualities were chosen due to their high kerma air rate and their differences of mean energy between them.

In these irradiations, the TLDs were placed in an acrylic support with thickness of 5mm behind and none covers. These irradiations were performed for three different air kerma: 25, 50 and 100 mGy.

Table 1: X-Ray qualities [4]

Quality	kV	mA	Mean Energy [keV]
RQR3	100	10	33.7
RQR9	100	10	52.5
RQT9	100	10	67.0

3. METHOD

The analyses methodology in this work are the same as used in previous works [1]. It consists in calculate the relative efficiency, *RE*. *RE* is defined as the observed response per unit absorbed dose in TLD (Equation 1).

$$RE = \frac{\frac{TLR_Q}{D_{TLD_Q}}}{\frac{TLR_{Q_0}}{D_{TLD_{Q_0}}}} \quad (1)$$

TLR is the thermoluminescent response of TLD; D_{TLD} is the absorbed dose in TLD, calculate with MCNP6; *Q* is the quality of the spectrum utilized and Q_0 is the quality of reference spectrum.

A similar equation (1) also was calculated utilizing only the simulation with MCNP6.

$$R_{MC} = \frac{\frac{D_{TLD,Q}}{K_{air_Q}}}{\frac{D_{TLD,Q_0}}{K_{air_{Q_0}}}} \quad (2)$$

K_{air} is the air kerma calculated by MCNP6.

These quantities were calculated in our experiments and compared with the results of previous work [3].

4. RESULTS

First of all, simulations were performed to calculate the relation D_{TLD} / K_{air} and compare with the Davis works [3] for different photon spectrum, included the x-ray qualities utilized by Davis and ours qualities. These value are showed in Figure 1.

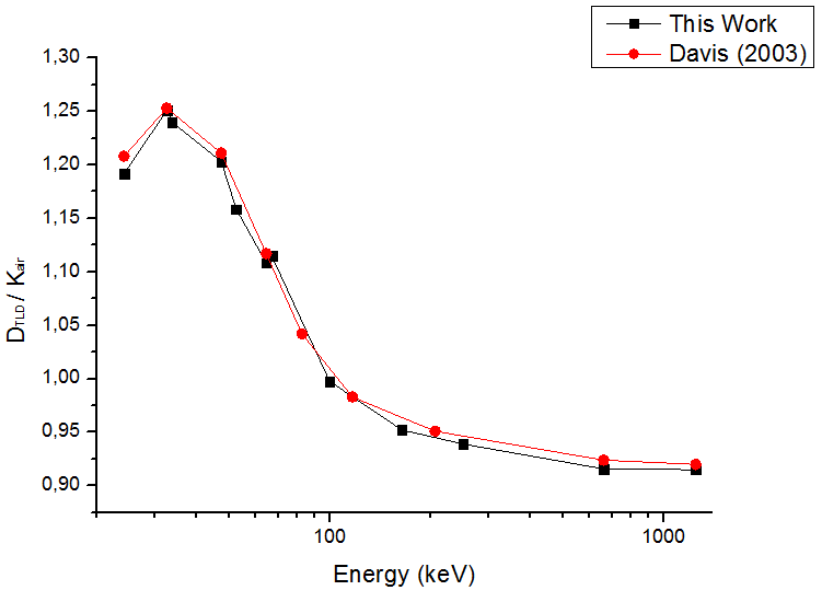

Figure 1: Comparison between this work and Davis work [3]

The simulation results of this work agree with the results obtained by Davis, and showed that there are dependence energetic for photon in LiF TLDs.

From irradiations at ours four different spectrum, they were created the calibration curves for each spectrum. These curves are at Figure 2.

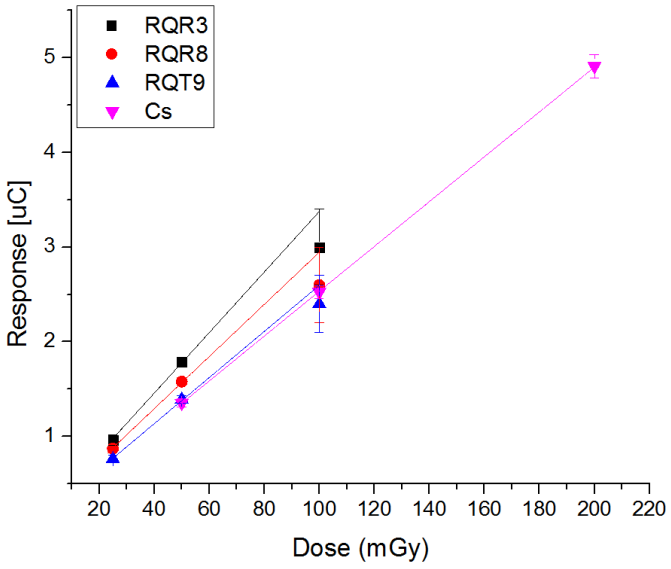

Figure 2: Calibration curves for each photon spectrum

From Figure 2, it is possible to see again that there is an energetic dependence for photon. For better analyses of these differences, the Table 2 shows the angular coefficient of each curve.

Table 2: Angular coefficient of each quality beam

Mean Energy [keV]	Angular Coefficient [uC/mGy]
33.7	0.032 ± 0.003
52.5	0.028 ± 0.002
67.0	0.024 ± 0.002
662.0	0.0237 ± 0.001

From angular coefficient of each curve it also can be seen the energetic dependence in LiF TLDs. If the wrong calibration curves is used, the dosimetry error could reach 35%.

The *RE* and R_{MC} value with ^{137}Cs with reference source are showed in Table 3. For better analyses, the *RE* value was calculated from the angular coefficient of calibration curve.

Table 3: *RE* and R_{MC} value with ^{137}Cs with reference source

Mean Energy [keV]	*RE*	R_{MC}
33.7	1.4 ± 0.1	1.35
52.5	1.2 ± 0.1	1.26
67.0	1.0 ± 0.1	1.21
662.0	1	1

The values of R_{MC} was what it is expected when they are compared with data obtained by Davis [3]. However, the *RE* value only agrees for RQR3 and RQR9; for RQT9 (67 keV) the *RE* value obtained by experimental data is lower than expected. A better study for these case is necessary.

3. CONCLUSIONS

This work was a preliminary study of energetic dependence in LiF TLDs. The results until now showed a strong difference at deposited dose and response of TLDs due to difference in photon spectrum, which these TLDs were irradiated.

They were showed the difference in calibration curves of different photons spectrums. These differences may cause huge mistakes in dosimetry if it is utilized a calibration curve that not correspond the real mean energy of beam. These differences could reach 35%, what showed the importance of a deeper study of energetic dependence of TLDs.

This work has studied four different photon spectrum so far. But in the future works it will be study more spectrum.

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REFERENCES

1. Massillon-JL, G., et al., *Influence of phantom materials on the energy dependence of LiF:Mg,Ti thermoluminescent dosimeters exposed to 20–300 kV narrow x-ray spectra, 137Cs and 60Co photons.* Physics in Medicine and Biology, 2014. **59**(4149-66).
2. Nunn, A.A., et al., *LiF:Mg,Ti TLD response as a function of photon energy for moderately filtered x-ray spectra in the range 20-250 kVp relative to 60Co.* Medical Physics, 2008. **35**(5): p. 1859-69.
3. Davis, D., et al., *The response of LiF thermoluminescence sodemeters to photon beams in the energy range 30 kV x rays to 60Co gamma rays.* Radiation Protection Dosimetry, 2003. **22**: p. 89-96.
4. International Electrotecnical Comission, *Instruments as used in the non-invasive measurement of X ray tube potential in diagnostic radiology*, 2005.