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Apply PTTL Phenomenon Using Detectors Ultra Sensitivity Type MCP-N

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Abstract:

The use of solid-state detectors has been the primary focus of radiation dosimetry. Reevaluating the dosage using the phenomenon Photo-transferred thermoluminescence PTTL may lead to more thorough findings directly relevant to protecting those exposed to ionizing radiation. Researchers examined the usefulness of TL detectors at (0.5, 1, 2, 5, 10, and 25) mGy. Data from experiments show that when UV light of wavelength λ = 302 nm is applied and 80 °C for 2 h. TL signal appears, but this signal is sufficient to calculate the dosage of the previously read detectors for doses less than 25 mGy. PTTL are not appropriate for a dose reassessment in MCP-N detectors at the high dose. In addition, the count difference expected from a dosage variation of a few mGy is more than the standard deviation of the count figures. The number of PTTL cells often decreases as dosage rises. The number of PTTL for a 25 mGy dosage is much lower than that for a lowe doses. It is reasonable to suppose that, for doses low than 25 mGy, the correlation between dosage and PTTL counts becomes relevant for reevaluating the dose.

Keywords: Thermoluminescence, Lithium fluoride, PTTL, UV.

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تطبيق ظاهرة اللمعان الحراري الناجم عن نقل البوتاسيوم باستخدام أجهزة الكشف فائقة الحساسية من النوع MCP-N

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الملخص

كان استخدام أجهزة الكشف عن الحالة الصلبة هو المحور الأساسي لقياس جرعات الإشعاع. إعادة تقييم الجرعة باستخدام الظاهرة قد يؤدي التلألؤ الحراري المنقولة بالصور إلى نتائج أكثر شمولاً ذات صلة مباشرة بحماية المعرضين للإشعاع المؤين. فحص الباحثون فائدة أجهزة كشف التلألؤ عند (0.5، 1، 2، 5، 10، 25) ملي غراي. تظهر البيانات من التجارب أنه عندما يتم تطبيق ضوء الأشعة فوق البنفسجية بطول الموجة 302 نانومتر و 80 درجة مئوية لمدة ساعتين. تظهر إشارة التلألؤ ، لكن هذه الإشارة كافية لحساب جرعة أجهزة الكشف التي تمت قراءتها مسبقًا لجرعات أقل من 25 ملي غراي. ظاهرة اللمعان الحراري غير مناسب لإعادة تقييم الجرعة في كاشفات MCP-N بجرعة عالية. بالإضافة إلى ذلك ، فإن فرق العد المتوقع من اختلاف جرعة بضعة مللي غراي هو أكثر من الانحراف المعياري لأرقام العد. غالبًا ما ينخفض عدد

خلايا ظاهرة اللمعان الحراري مع زيادة الجرعة. عدد ظاهرة اللمعان الحراري لجرعة 25 ملي غراي أقل بكثير من الجرعات المنخفضة. من المعقول أن نفترض أنه، بالنسبة للجرعات التي تقل عن 25 ملي غراي، يصبح الارتباط بين الجرعة وعدد ظاهرة اللمعان الحراري مناسبًا لإعادة تقييم الجرعة.

الكلمات المفتاحية: التلألؤ الحراري ، فلوريد الليثيوم، ظاهرة اللمعان الحراري، الاشعة فوق البنفسجية

Introduction

As a result of being heated, an insulator or semiconductor emits light, a process known as thermoluminescence. The material can absorb and retain energy from non-ionizing or ionizing radiation (ultraviolet light) [1].
One of the most used techniques for measuring radiation exposure in hospitals is the thermoluminescent (TLD) method, which uses a mixture of lithium fluoride (LiF) and magnesium fluoride (MgF) with titanium dioxide (TiO_2) as a human tissue equivalent. [2]. Activators (LiF: Mg, Ti, Li: Mg, Cu, P) and Li composition (Li-6 and Li-7) in lithium florid thermoluminescence (TL) detectors are employed extensively in space [3].
The late 1970 used to TL material lithium fluoride doped with magnesium, copper, and phosphorus (denoted as LiF: Mg, Cu, P), which was discovered in ultra-high-dose detectors. With a steady, low background, dosages as low as 200 nGy could be measured accurately, and its sensitivity after x-ray doses was nearly 30 times that of normal TLD-100. Due to its favorable characteristics, LiF: Mg, Cu, P emerged as the leading candidate for a novel TL dosimetric material [4].

Photo transferred Thermoluminescence phenomenon (PTTL)

The PTTL is the simplest reevaluation technique, produces thermoluminescence (TL) peaks at lower temperatures and is a well-known phenomenon that occurs when electric charge is transferred from deep traps to shallow traps under the influence of light. Ultraviolet (UV) light causes electrons to be ejected from deep traps and into shallower ones. The traps are re-trapped as the heat is applied at a low temperature. Dosage reassessment efficiency is enhanced by the TL detector's novel Phototransferred Thermoluminescence (PTTL) property, which is also particularly beneficial for applications that need a high degree of trust in the dose values, such as personal dosimetry. PTTL may be seen in several thermoluminescent materials, including insulators and semiconductors. Radiation dosimetry and dating may both benefit from the PTTL phenomena. This occurrence allows the TL signal from LiF to be "reread" after the first heating [5, 6].

Material and methods

TL detectors – MCP-N

This study employed 0.9 mm thick, 4.5 mm in diameter MCP-N thermoluminescent detectors. Red card, based in Cracow, Poland, manufactures these detectors; 35 were chosen for the study's measurements. These detectors were first annealed in a SUP-18W furnace/dryer, per the manufacturer's instructions: at 240 °C for 10 min, followed by rapid cooling on an aluminum pad. Annealing is a technique used to prepare TL materials by erasing information caused by radiation exposure and restoring the crystal to its pre-irradiation state. Exposed areas were irradiated at dosages of (0.5, 1, 2, 5, 10, and 25) mGy using an X-ray mobile radiography device, model Intermedical Basic 4003. Measurements of doses taken in were made with the help of a Barracuda X-ray multimeter.
These are the results of the measurements the background. All MCP-N pellets undergo to the post-exposure annealing in a type of furnace/dryer SUP-18W at 100 °C for 10 min before being cooled on a metal pad, per the manufacturer's recommendations. The Reader-Analyser RA'04 was set to X READER mode to read MCP-N type detectors in an argon atmosphere. This λ =302 nm was produced by the LMS-38 8W UV lamp. All through the irradiation procedure, the TL detectors were warmed on the HC17.5D heating plate.
After determining that 80°C was the sweet spot, irradiation was performed at that temperature for 2 h, using the parameters for UV exposure (and heating) duration calculated earlier. All MCP-N pellets undergo to the post-exposure annealing in the furnace/dryer SUP-18W at 100 °C for 10 min before being cooled on a metal pad, maintaining the same conditions as the first annealing. Re-read the detectors under the identical circumstances as before using the Reader-Analyser RA'04. The PTTL efficiency is shown here. The scheme of the procedure of PTTL measurements is presented in Fig.1.

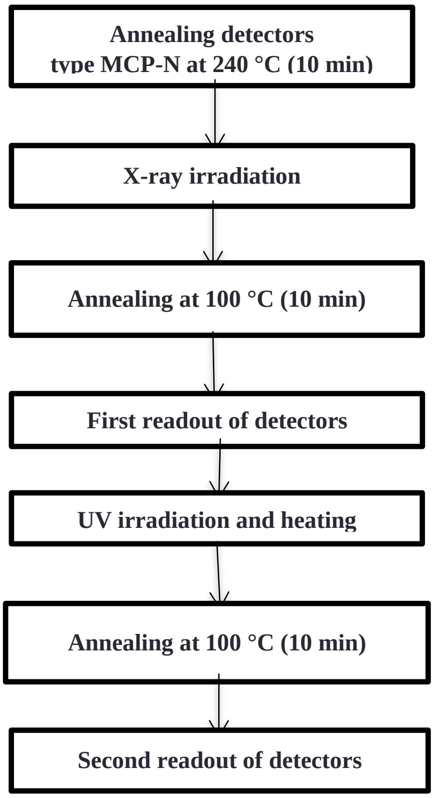

Figure 1: An explanation of how MCP-N detectors' PTTL measurement cycles work, in theory.

Results and discussion

TL Detectors' Initial Linearity upon Obtaining a Reading

The detectors were exposed to the X-ray to test their sensitivity. The TLD exposure parameters are provided in table 1. The detectors were annealed before radiation exposure using the method shown in Fig.1 above

Table 1: Parameters of exposure.

Number	Dose,mGy	Distance between X-ray tube focal spot and detector, cm	X-Ray tube high voltage, kV	Current-time product, mAs
1	0.5	100	87	8
2	1	100	80	20
3	2	80	90	20
4	5	100	87	80
5	10	80	100	80
6	25	65	100	130

Table 2 illustrate how many counts, on average taken at the TLD reading after being exposed to X-rays. In Fig. 2, illustrate the relation between dose and average counts

Table 2: Dose and an average number of counts after exposure

Dose, *mGy*	Average count
0	368± 112
0.5	2378± 263
1	4874± 603
2	8773± 1364
5	20369 ± 3357
10	35615± 9938
25	94083± 18015

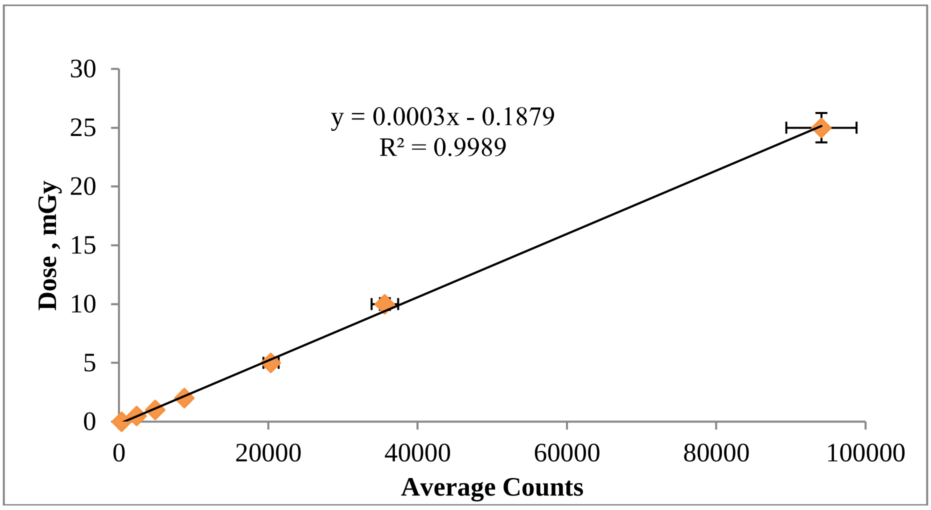

Figure 2: The MCP-N thermoluminescence detector's calibration curve shows the connection between the dose and the number of pulses measured by the detector at its first readout.

PTTL Signal Linearity

Signal linearity was examined at the optimum λ= 302 nm.

The reading of the PTTL signal after UV irradiation at 80°C and 2 h of heating time is displayed as an illustration.

Figure 3 illustrate the correlation between the mean absorbed dose and the number of counts from the PTTL. R^2 = the coefficients describing the slope of linear dependence of counts vs. dose the PTTL signal linearity is acceptable up to 25 mGy.

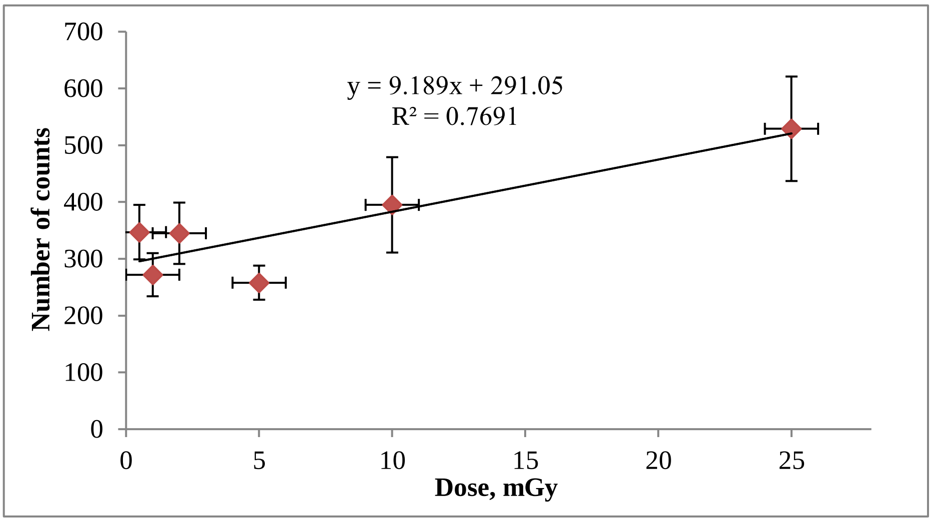

Figure 3: UV signal at PTTL after 2 h of exposure at 80 °C

The figures show that the R^2 values for MCP-N detectors are very low. In addition, the error bars in the vertical direction are rather large compared to the variance in the number of counts. The PTTL signal seems insufficient to permit re-evaluation of the dosage in the applied dose range.

TL Glow Curves

The thermoluminescence glow curve [6] describes the amount of light released after energy release and how it relates to the temperature. The following pictures show the TL glow curves produced from dosimeters exposed to X-rays at dosages of (0.5, 1, 2, 5, 10, and 25) mGy, at both the first readout (blue) and the second readout or After UV (brown). After being the detectors were subjected to UV irradiation at 302 nm and 80 °C for 2 h, all the instances in Fig.4-9 were re-read:

When highly sensitive detectors with low doses are exposed to ultraviolet radiation, the process PTTL is very clear.

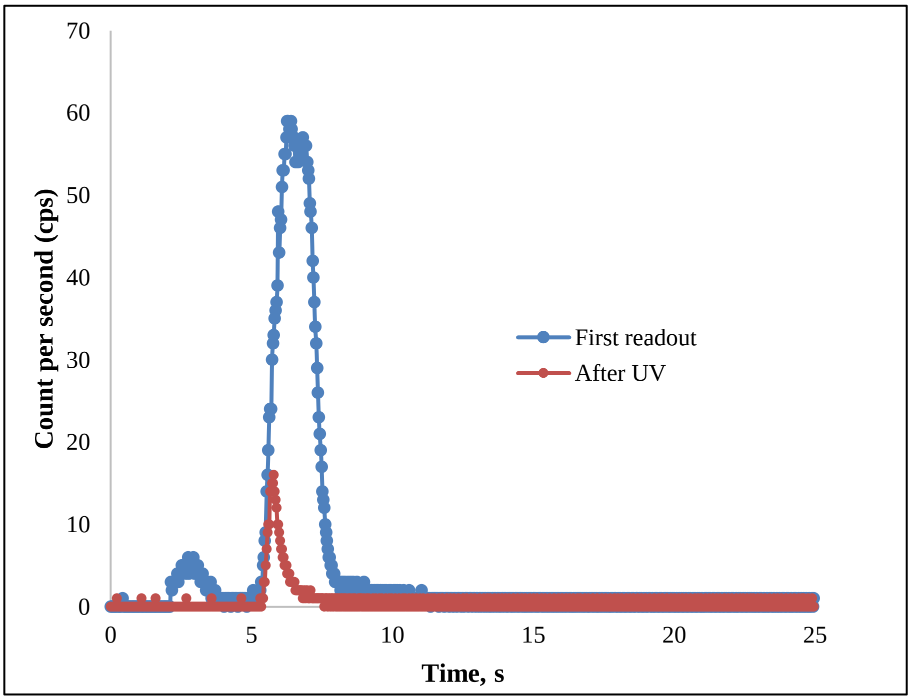

Figure 4: TL curves were obtained from reading the detector at dose 0.5 mGy.

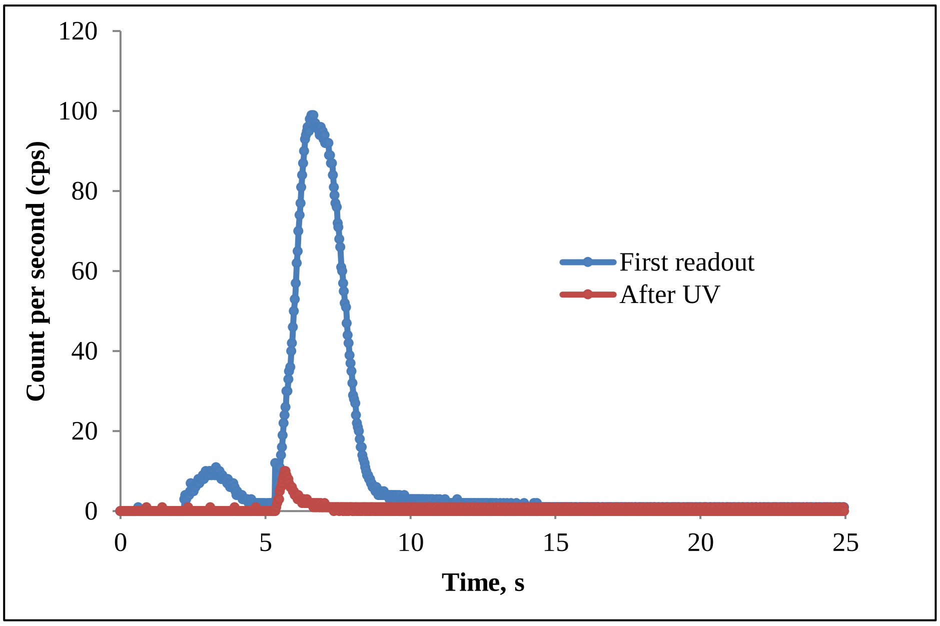

Figure 5: TL curves were obtained from reading the detector at dose 1 mGy.

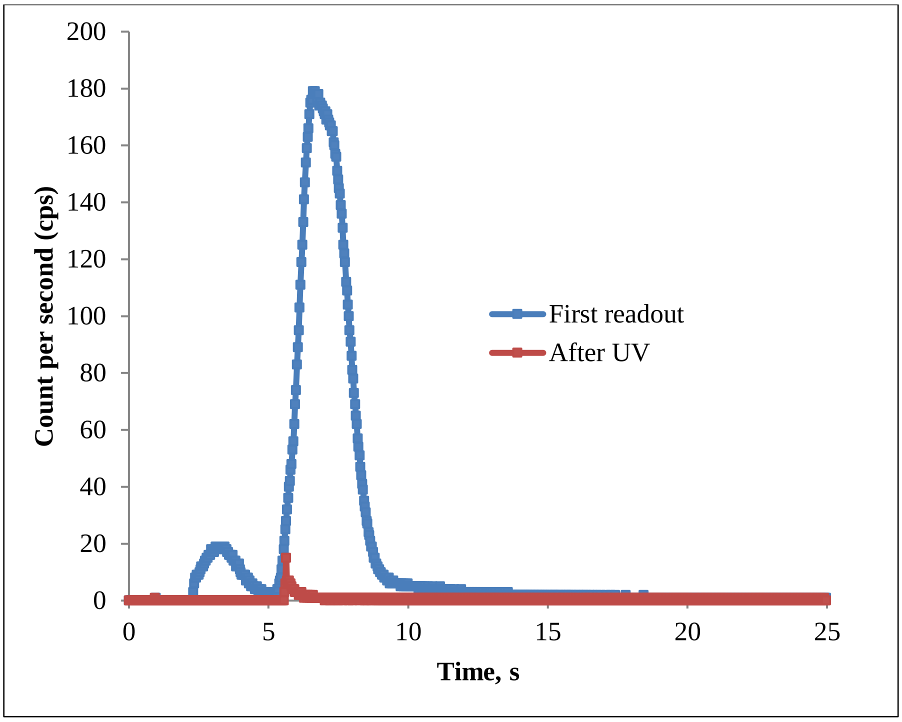

Figure 6: TL curves were obtained from reading the detector at dose 2 mGy.

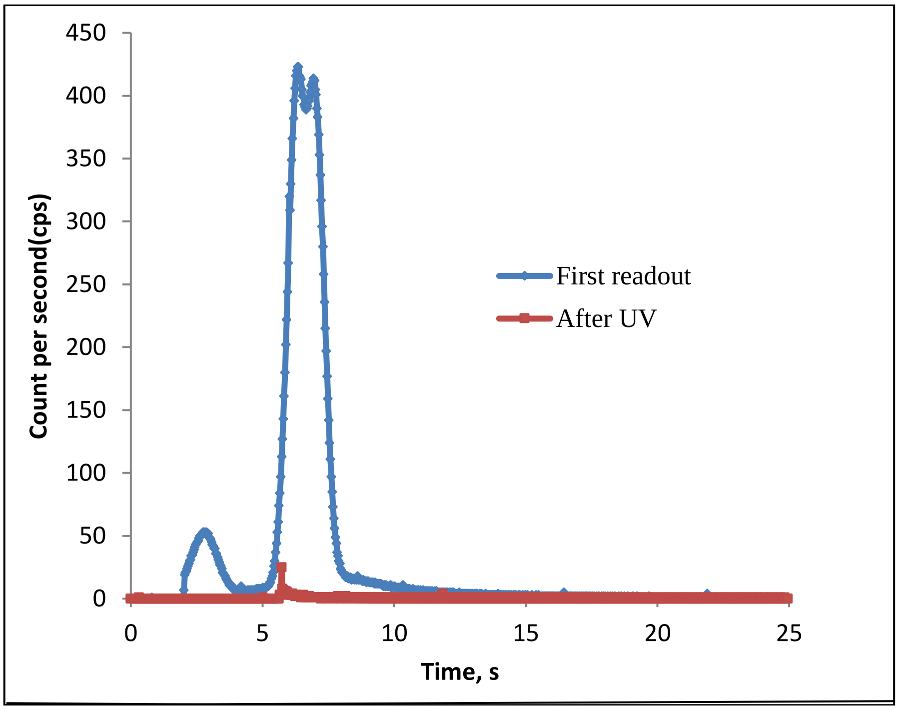

Figure 7: TL curves were obtained from reading the detector at dose 5 mGy.

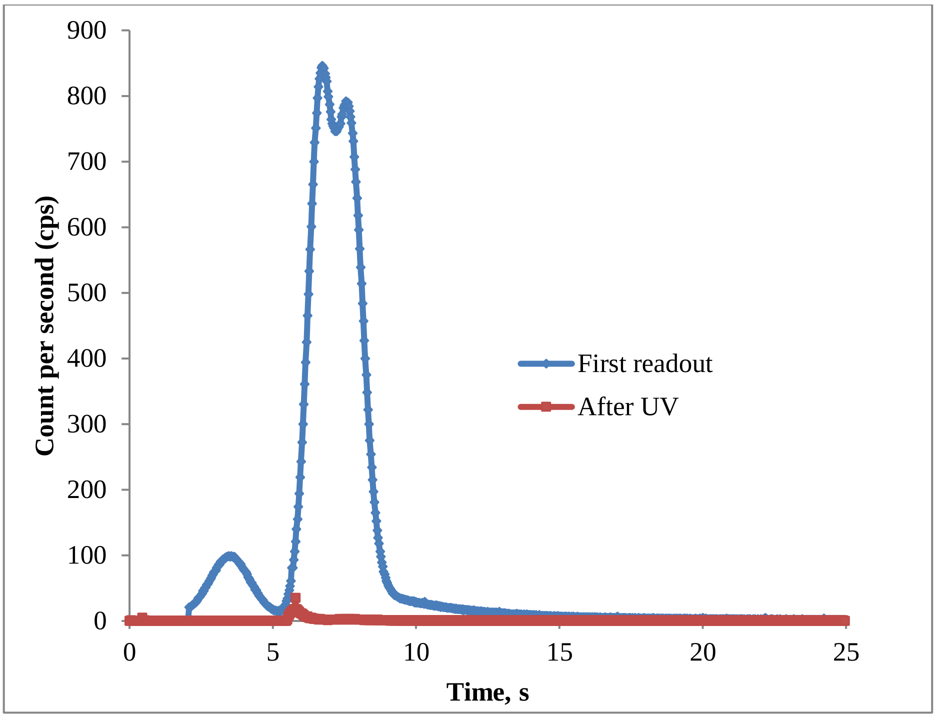

Figure 8: TL curves were obtained from reading the detector at dose 10 mGy

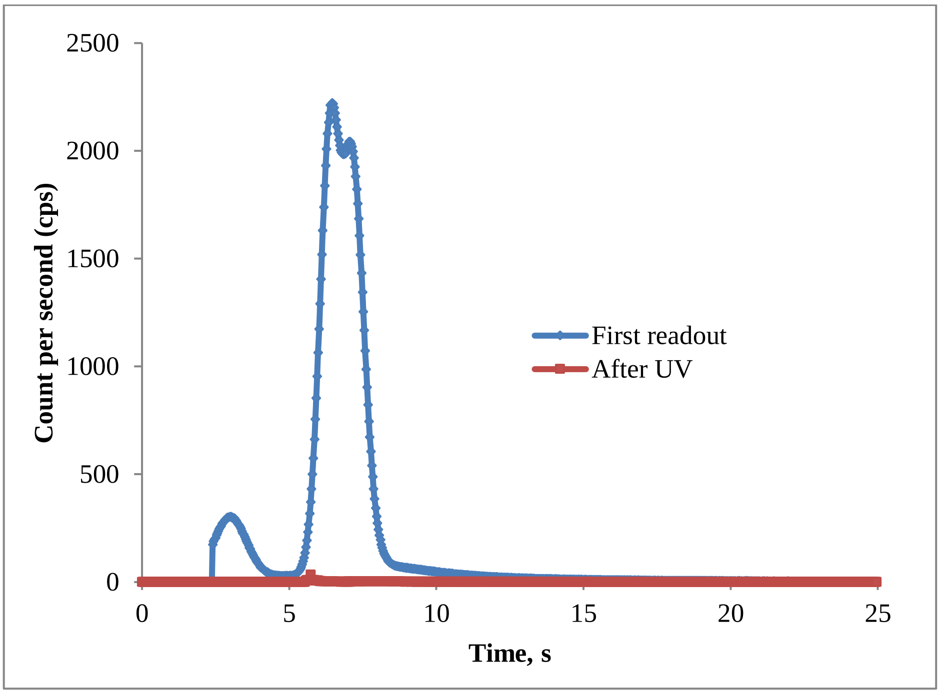

Figure 9: TL curves were obtained from reading the detector at dose 25 mGy

Calculated efficiency of PTTL Method

Dosimeters measure the average dose of ionizing radiation deposited in a sensitive volume and provide this information to the user. The highest efficiency value is the dose 0.5 mGy and the lowest efficiency value is the dose 25 mGy. Efficiency consists of N_1 representing the first reading of the detector and N_2 representing the second reading or after ultraviolet radiation, it is the ratio of N_2 over N_1. Both glow curves have their maximum amplitudes at 80 °C. A single peak in the light curve is seen for PTTL. The effectiveness of the PTTL technique is seen in Table 3.

Table 3: show the efficiency calculation for the PTTL method.

Dose mGy	First, read out (N_1)	After UV (N_2)	(N_2/N_1)	%
0.5	2459	373	0.152	15.2
0.5	2865	312	0.109	10.9
0.5	2215	400	0.180	18
0.5	2477	368	0.149	14.9
0.5	2658	284	0.107	10.7
1	5665	257	0.045	4.5
1	5594	277	0.05	5
1	5041	307	0.06	6
1	5129	305	0.059	5.9
1	5185	215	0.041	4.1
2	10280	301	0.03	3
2	10549	278	0.026	2.6
2	10150	390	0.04	4
2	11667	402	0.034	3.4
2	10625	353	0.033	3.3
5	23973	309	0.013	1.3
5	18213	263	0.014	1.4
5	15685	234	0.015	1.5
5	23356	244	0.01	1
5	22093	242	0.01	1
10	56909	289	0.005	0.5
10	45351	392	0.009	0.9
10	50325	390	0.008	0.8
10	50998	523	0.01	1
10	45975	380	0.008	0.8
25	110043	387	0.004	0.4
25	143267	555	0.004	0.4
25	117079	640	0.006	0.6
25	110141	549	0.005	0.5
25	129363	520	0.004	0.4

Conclusion

- MCP-N detectors are 25-30 times more sensitive in everyday TL readings
- Experiment results show that in the dose range of less than 25 mGy the MCP-N detectors, the PTTL phenomenon is suitable for dose re-assessment because the application of UV light with a λ= 302 nm causes a sufficient TL signal to determine the dose of the detected detectors. read it beforehand. A count difference of a few mGy dose differences is more than the standard deviation of the count digits. The number of PTTL cells often decreases with increasing dose.
- For doses lower than 25 mGy, the relationship between dose and PTTL count becomes relevant for dose re-evaluation.

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