INVESTIGATION OF FADING IN THERMOLUMINESCENCE PEAK INTENSITIES OF SYNTHETIC QUARTZ CRYSTALS UNDER DIFFERENT CONDITIONS

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science/Doctor of Philosophy.

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Relatedthesiswrittenand usedin accordance withthe academicand ethical rulesby reference toall therelevantliterature,I declare thatthe thesistakes place.

Esme BOZ

To my family and fiancée…..

ABSTRACT

THE INVESTIGATION OF FADING IN THERMOLUMINESCENCE PEAK INTENSITIES OF SYNTHETIC QUARTZ CRYSTALS UNDER THE DIFFERENT CONDITIONS

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Thermoluminescence (TL) is the thermally stimulated emission of light from an insulator or a semiconductor following the absorption of energy in different processes, usually from ionizing radiation.Fading is the process in which there is unintentional loss of the latent information, that is, its response. There are many causes of the process of fading, but the thermal is the main one. In the thermal fading, the traps that present lower entrapment energy will fade faster than the more energetic ones, due to their higher probability of transition. This can generate large errors in the dose assessment.One ofthe materials usedto observe thethermoluminescence eventis quartzcrystal.In this study, the fading of thermoluminescence peak intensities were surveyed in three different environments which are dark ambient, tungsten light and fluorescent light by using two different synthetic quartz crystals.

Key Words: Thermoluminescence, fading, quartz crystal

ÖZ

FARKLI KOŞULLAR ALTINDA SENTETİK KUVARS KRİSTALLERİN TERMOLÜMİNESANS (TL) TEPE ŞİDDETLERİNDEKİ SÖNÜMLERİN ARAŞTIRILMASI

BOZ, Esme

Yüksek Lisans Tezi, Fizik Müh. Bölümü

Tez Yöneticisi: Yrd. Doç. Dr. Hüseyin TOKTAMIŞ

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46 sayfa

Termolüminesans (TL) genellikle bir yalıtkandan yada yarı iletkenden termal olarak uyarılmış ışık yayımıdır, enerji emilimi farklı süreçler olabildiği gibi genellikle iyonizan radyasyondandır. Soğurulan dozda meydana gelen kayıp ise sönümleme olarak bilinir. Sönümlemenin pek çok nedeni vardır ancak termal etki ana nedendir.Termal sönümlemede, düşük tuzaklama enerjisine sahip tuzaklar geçiş olasılıkları daha fazla olduğundan yüksek enerjili olanlardan daha hızlı sönüme uğrarlar, bu da doz değerlendirmesinde yüksek hatalara neden olabilir. Termolüminesans olayını gözlemlemek için kullanılan malzemelerden biri de kuvars kristalidir. Bu çalışmada sentetik kuvars kristalleri kullanılarak termolüminesans tepe şiddetlerinin karanlık, floresan ve tungsten ışığı altında olmak üzere üç farklı ortamda iki farklı sentetik kuvars kristali kullanarak sönümlemeleri araştırılmıştır.

Anahtar Kelimeler:Termolüminesans, sönümleme, kuvars kristali

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CHAPTER 1

INTRODUCTION

Thermoluminescence (TL) is the thermally stimulated emission of light from a semiconductor or an insulator following the absorption of energy in different processes, usually from ionizing radiation[1]. From this description the three essential ingredients necessary for the production of TL can be deduced. Firstly, the material must be an insulator or a semiconductor but metals do not exhibit luminescent properties. Secondly, the material must have at some time absorbed energy during exposure to ionizing radiation. Thirdly, the luminescence emission is triggered by heating the material [2].

Athermoluminescentmaterialwhen exposed toionizing radiationabsorbs some energy, which is stored. The stored energy is released in the form of visible light when the material is heated. Note that TL does not refer to thermal excitation, but to stimulationof luminescence in a sample which was excited in a different way. This means that a TL material cannot emit light again by simply cooling the sample and reheating it another time. It should first be re-exposed to ionizing radiation before it produces light again.

The storage capacity of a TL material makes it in principle suitable for dosimetric applications.Thermoluminescence has been extensively applied in radiation dosimetry, archeological dating, geology and academic studies. Thermoluminescence glow curve analysis is also a suitable procedure applied in the characterization of the effects of impurities, natural and induced imperfections, color centers and trap distributions[5].

Fading is the process in which there is unintentional loss of the latent information, that is, its response. Many are the causes of the process of fading, but the thermal is the main one. In the thermal fading, the traps that present lower entrapment energy will fade faster than the more energetic ones, due to their higher probability of transition. This can generate large errors in the dose assessment [3].

The aim of this thesis is to determine the fading in thermoluminescence peak intensities of synthetic quartz crystals under different conditions. The samples are purchased froma companyand experiments were performedin theengineeringphysicslaboratory. In chapter 1, we gave information aboutthesisand a briefdescription offading and thermoluminescence. Chapter 2 has more specific literature survey than chapter 1. It includes information about fading, and its thermoluminescence properties. The essential explanations about the experimental equipment, samples and procedures were given in chapter 3. All the experimental results were given in chapter 4. Finally, we have discussed and concluded all experimental results with support of published studies in chapter 5.

CHAPTER 2

LITERATURE SURVEY

2.1 Theory of Thermoluminescence

Thermoluminescence (TL) is a result of high energy electrons trapped withinthe specimen after the irradiation. Thermoluminescence phenomena can be observed at semiconductor and insulator which contain electrons trapped at defect sites in a metastable condition. The trapped charge can be liberated by heat and will cross the potential barrier and move to a lower energy state with the emission of light. This is called thermoluminescence [6].

Thermoluminescence is observed under condition of steadily increasingtemperature. In the usual thermoluminescence experiments, the TL system is irradiated at room temperature (RT) and later heated through a temperature range where the luminescence is bright, until a temperature level at which all the charges have been thermally excited out of their metastable levels and the luminescence completely disappears. If the light intensity is plotted as a function of temperature (or time) the resulting graphs is called glow curve [7]. Figure 2.1 shows a typical example of the glow curve of fluka.

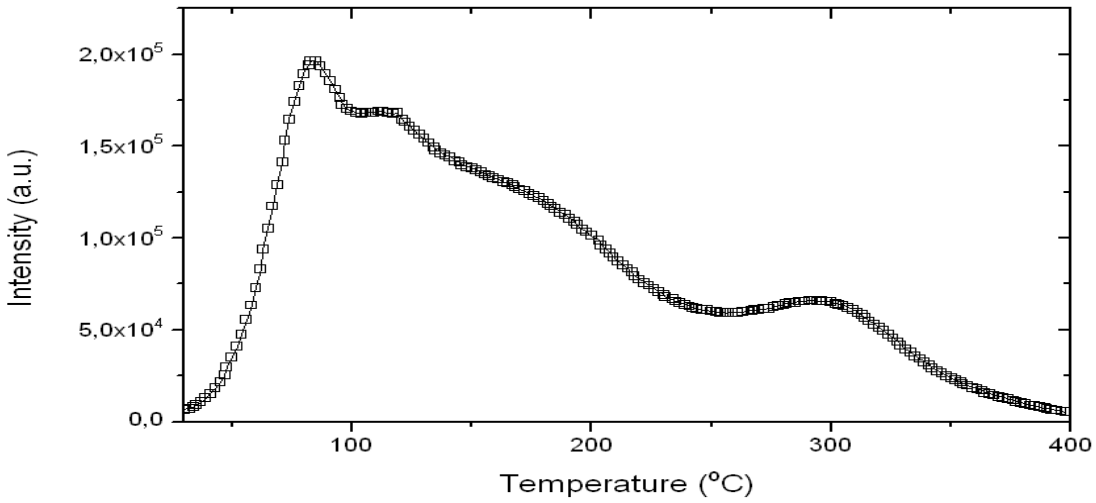

Figure2.1 Typical TL glow curve of Fluka

Thermoluminescence (TL) method is a relatively complex process since itinvolves traps and luminescence centers. When an insulator or semiconductor is exposed to ionizing radiation at room or low temperature, electrons are released from the valance band (VB) to the conduction band (CB). This leaves a hole in the valance band. Figure 2.2 shows trapping of electrons in a crystal as a result of exposure to radiation. Both types of carriers become mobile in their respective bands until they recombine or until they are trapped in lattice imperfections in the crystalline solids.

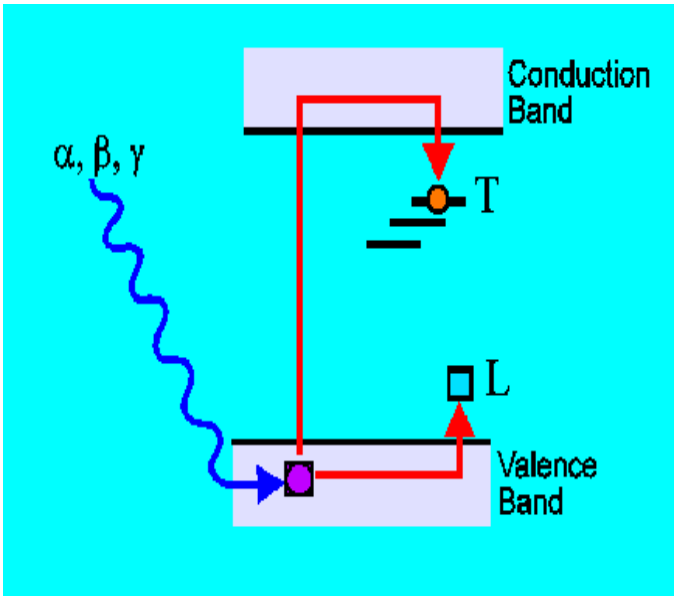

Figure 2.2 Trapping of electrons in a crystal as a result of exposure to radiation

These lattice imperfections play very crucial role in the TL process. The trapped electrons may remain for a long period when the crystals are stored at room temperature or they can be released due to the sufficient energy given to the electrons when the crystal is heated. These electrons may move in the crystalline solid until they recombine with suitable recombination centers that contain hole with the emission of TL light. This process of light emission by thermal stimulation from a crystalline solid after irradiations is called as “thermally stimulated process” or simply thermoluminescence”. Figure 2.3 showsluminescence mechanism of a crystal.

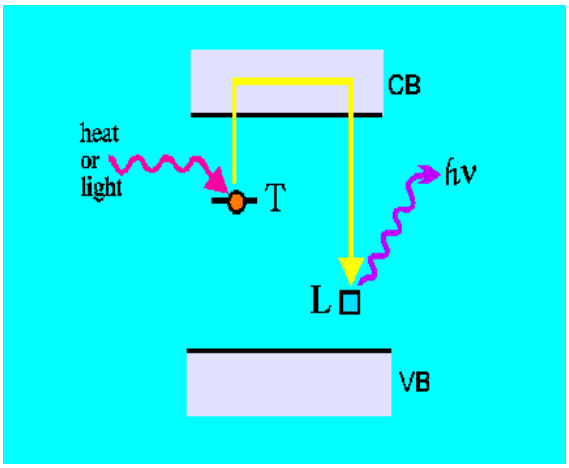

Figure 2.3 Luminescence mechanism of a crystal

In thermoluminescence phenomena there are three essential ingredients necessary for the productions of thermoluminescence. Firstly, the material must be an insulator or a semiconductor-metal do not exhibit luminescent properties. Secondly, the material must have at some time absorbed energy during exposure to radiation. Thirdly, the luminescence emission is triggered by heating the material. In addition, there is one important property of thermoluminescence which cannot be inferred from this statement as it stands at present. It is a particular characteristic of thermoluminescence that, once heated to excite the light emission, the material cannot be made to emit thermoluminescence again by simply cooling the specimen and reheating. In order to re-exhibit luminescence the material has to be re-exposed to radiation, whereupon raising the temperature will once again produce light emission. The fundamental principles which govern the production of thermoluminescence are essentially the same as those which govern all luminescence process, and in this way thermoluminescence is merely one of a large family of luminescence phenomena [8].

2.2 Theory of Fading

Fading is the process in which there is unintentional loss of the latent information, that is, its response. The TL-signal decreases, or fades, over time. The fading have several causes and includes thermal fading, anomalous fading and fading due to optical effects. The dominant component is thermal fading, in which the release of trapped charges is thermally induced [10]. In the thermal fading, the traps

that present lower entrapment energy will fade faster than the more energetic ones, due to their higher probability of transition. This can generate large errors in the dose assessment [9].The time constant for the thermally induced release of trapped charge from a defect is given in equation 2.1:

$$\tau_f = p^{-1} = s^{-1}\exp(E/kT) \tag{2.1}$$

where s is frequency factor(constant), E is the trap depth, k is Boltzmann's constant, T is the temperature and p is the probability per unit time of the release of an electron from the trap. Accordingly we may define a "half-life" for thermal fading, thus:

$$\tau_{1/2} = \ln(2)\tau_f \tag{2.2}$$

for the case of first-order kinetics. Thus, in order for the TL signal to be stable, and therefore usable as a dosimetric property, $\tau_{1/2}$ must be several times longer than both the exposure period, and the period between exposure and readout.

In principle, the two parameters which dictate the thermal fading rate are thus the trap depth E and the frequency factor s. As a result evaluation of these for particular dosimetric peaks has been an important part of TLD material characterization. Nevertheless, the thermally induced loss of the TL signal with time can also be caused by processes other than the simple charge release mechanisms alluded to above. The high temperature pre-irradiation annealing conditions employed with many TLD materials to ensure re-usability place the samples in thermodynamically metastable states. It is advisable, therefore, to use the material as soon as possible after the pre-irradiation annealing treatment [10].

Anomalous fading is when the TL-signal decays significantly, even though it is not expected to do so thermally. It is believed that there are two major causes for this: quantum mechanical tunneling of the trapped charge to the recombination site, and localized transitions which do not take place via the delocalized bands [10]. Localized transition is thermally induced occupation of an energy level from which a transition into the recombination center is allowed [9].

Optical effects include optical excitation of the charge from the trap and consequently a reduction in the TL-signal [11].

CHAPTER 3

EXPERIMENTAL PROCEDURE

3.1 Materials

Quartz crystals are supplied in a variety of shapes and sizes, both as natural or synthetic crystals. The samples utilized in this work were synthetic quartz crystals called Fluka and Aldrich.Their particle sizes are between 0.4-0.142, 0.315-0.130 mm, respectively. Their chemical formula is SiO_2 and they have very low percentage of elements which are shown in Table 3.1 and alsosyntheticquartzcrystals are shown in figure 3.1.

Table 3.1 Extended Specifications of synthetic quartz

Loss on ignition	≤0.1%, 900 °C
particle size	40-100 mesh
Chloride (Cl)	≤50 mg/kg
Ca	≤50 mg/kg
Cd	≤50 mg/kg
Co	≤50 mg/kg
Cu	≤50 mg/kg
Fe	≤100 mg/kg
K	≤500 mg/kg
	≤100 mg/kg
Ni	≤50 mg/kg
Pb	≤50 mg/kg
Zn	≤50 mg/kg

Figure 3.1 Synthetic quartz crystals (Fluka and Aldrich)

3.2.Equipment

3.2.1. Radiation Source and Irradiator

The samples were irradiated at room temperature without subjecting them toany processing.Fluka and Aldrich crystals were irradiated with $^{90}Sr - ^{90}Y$ β-source which is shown in figure 3.2. Stronium-90 emits high energy beta particles from their daughter products (90Sr-0.546 MeV together with 90Y β-2.27 MeV). Beta radiation is absorbed by air, so its intensity reduced with distance much more fastly than inverse square law calculations would designate. The maximum range of Y-90 beta particles in air is roughly 9 meter. The irradiation instrument is an insertion part of the 9010 Optical Dating System which is bought from Little More Scientific Engineering, UK [13]. The irradiation source instrument interfaced to personal computer (PC) using a serial RS-232 port. The materials were exposed to radiation by radiation source about 70 Gy [14].

Figure 3.2 Radiation source

3.2.2 TL Fading Box

The samples were holdat room temperature in fading boxes with dark ambient, fluorescent and tungsten light. The boxes arelight-tight and figure 3.3 shows the fading boxand three different boxes are used for fading, they have different light sources as tungsten and fluorescent.

Figure 3.3 Fading box

3.2.3 TL Analyzer and TL Measurement

The glow curve measurements for Fluka and Aldrich crystals were made using a Harshaw TLD System 3500 Manual TL Reader which is shown in figure 3.4 [12]. The technical architecture of the system involves both Reader and a DOS-based IBM –congruent computer attached through a standard RS-232 serials communication port to control the 3500 Reader. The basic block diagram of reader is shown in figure 3.5. All functions are divided between the reader and the specialized TLD. Shell software runs on the PC. All data storage, instrument control, and operator inputs are performed on the PC. Signal acquisition and conditioning are performed in the reader. In this way, each glow curve can be analyzed using a best-fit computer program based on a Marquardt algorithm minimization procedure,associated to first order and general order kinetic expressions. The program resolves the individual peak present in the curve, giving the best values for the different peak parameters. The instrument includes a sample change drawer for removing and inserting the TLD elements. The reader uses contact heating with a closed loop feedback system that produces adjustable linearly ramped temperatures from 1 ^{o}C to 50 ^{o}C per second accurate to within ± 1 ^{o}C to 400 ^{o}C in the standart reader [14].

Figure 3.4 TLD reader

The Time Profile (TTP) is user defined in three segments: Preheat, Acquire, and Anneal, each with independent times (Pre-read anneal: adjustable 0 to 1000 sec, Linear ramp: adjustable from 1 ^{o}C to 50 ^{o}C per second, Post-read anneal: 0 to 1000 sec) and temperature (Pre-read anneal: room temperature to 200 ^{o}C, Post-read to improve the accuracy of low-exposure readings and to extend planchet life, the 3500 provides for nitrogen to flow around the blanchet. Glow curves were measured using a platinum planchet at a linear heating rate of 1 ^{o}C/s.Time duration between irradiation and necessary TL operation was always kept constant at about 1 min, except for the storage time experiment.

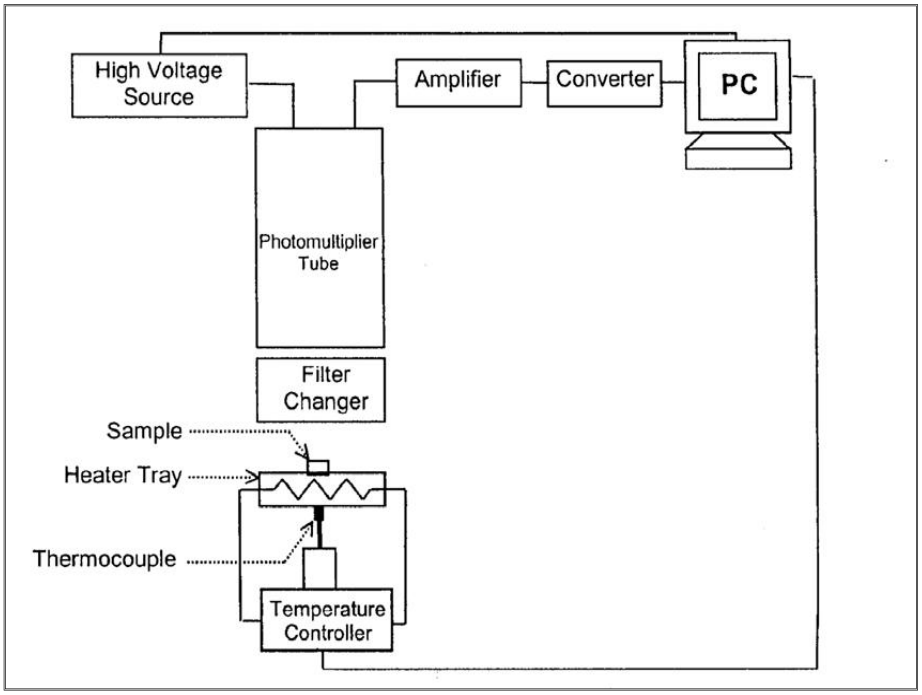

Figure 3.5 Basic block diagram of TL reader

3.3. Experimental Procedure for Fluka and Aldrich

In this study, two different syntheticquartz crystals which are Fluka and Aldrich quartz crystals were used.

In this study, each Fluka and Aldrich samples were weighedto 20 mg and were irradiated with beta rays from a calibrated $^{90}Sr - ^{90}Y$source up to 70 Gy and then they were stored in the dark room, fluorescent and tungsten light room at room

temperature to evaluate the fading in the intensity of Fluka and aldrich sample. Within one minuteafter this,the sampleswere takenin the sample containers in a dark environment and the samples taken fromthe boxeswere placed inspecial boxesprepared forfading. Three different boxes were prepared for fading, firstone is dark ambient andsecond one is fluorescent light and third one is tungsten light boxes. The samples, were waited in these fading boxes for 1, 2, 4, 8, 16, 32, 64, 128, 256 and 512 hours, were taken to the reading containers and read out with a Harshaw QS 3500 manual type reader that is interfaced to a PC where TL signals were studied and analyzed.

Eachexperimentwas repeatedthree timestobe confirmed their accuracy. Each crystal was read out twice and the second read out is considered to be background of reader plus crystal and was subtracted from the first one and all of the analyses have been carried out after subtraction operations.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSIONS

In this work, we examined the experimental results under four main folders:

- Glow curve variation
- The variation of TL peak temperature
- Theeffect of storage time on maximum TL peak intensity
- The investigation of kinetic parameters.

Experimentswere performedforeach of the threeambient and for each of the two syntheticquartz crystals.

4.1 Glow curve variation

In this part, we investigatedthe variation of glow curve of Fluka and Aldrich crystals for three different environments which are dark ambient, fluorescent light and tungsten light.For two synthetic quartz crystals, TL glow curve graphics are obtained.

4.1.1 Samples waiting in dark room

Figure 4.1 and 4.2 showa typical analyzed glow curve of quartz crystals waiting in dark ambient for Fluka and Aldrich samples, respectively. In figure 4.1, maximumpeakintensitydecreaseswith increasing storage time for low and high temperature peaks but low temperature peaks reducedmore. Maximum peaktemperature increases with rising storage timefor low temperature peaksbut there is no significant changein high temperature peaks. In figure 4.2, maximumpeakintensitydecreaseswith increasing storage time for low and high

temperature peaks but low temperature peaks reducedmore. After 512 hours for low temperature peak, TL glow curve of Fluka sampledecreases about 75 % of its initial value, TL glow curve of Aldrich sample decreases about 90 % of its initial value and for TL glow curve of Aldrich sample, while low temperature peaks completely disappeared, high temperature peaks did not change like that.

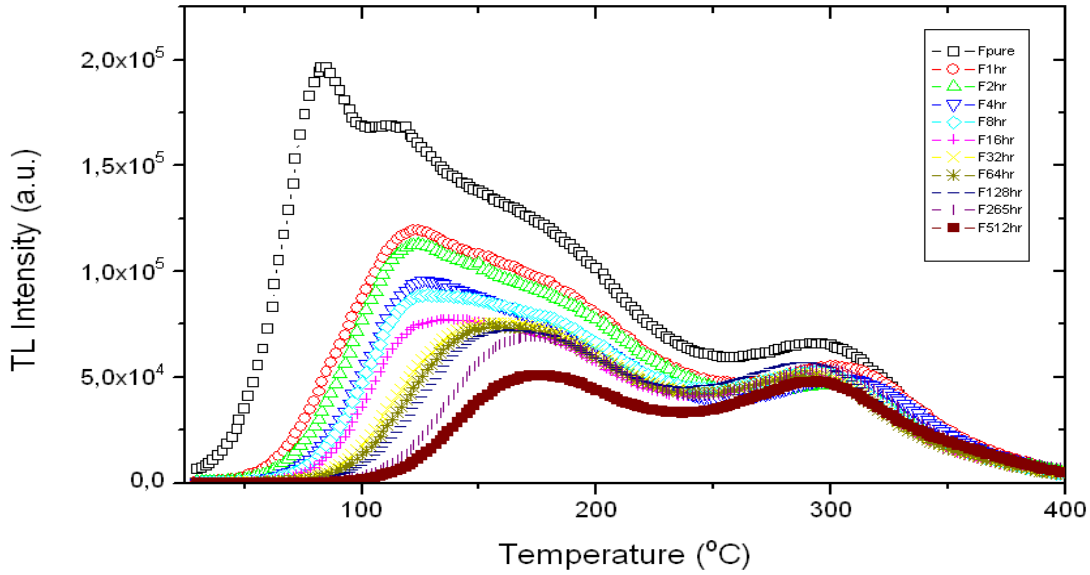

Figure 4.1A typical analyzed glow curve of Fluka quartz crystal waiting in dark room, measured after ≈ 70 Gy irradiation at room temperature (RT).

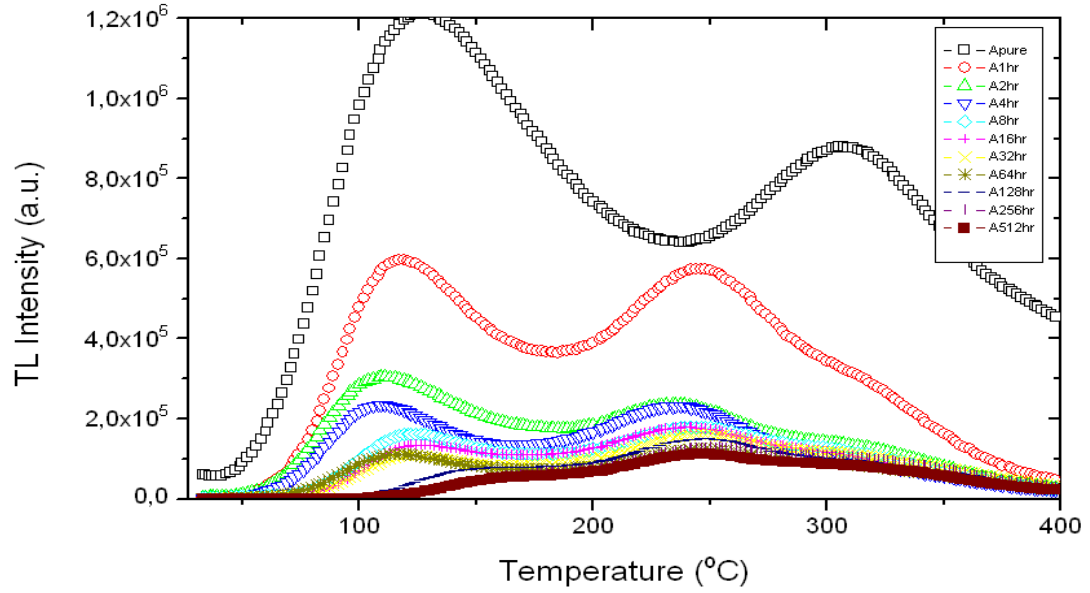

Figure 4.2A typical analyzed glow curve of Aldrich quartz crystal waiting in dark ambient, measured after ≈ 70 Gy irradiation at RT.

4.1.2 Samples waiting in fluorescent light

Figure 4.3 and 4.4 showa typical analyzed glow curve of quartz crystals waiting in fluorescent light for Fluka and Aldrich samples, respectively. In figure 4.3, maximumpeakintensitydecreaseswith increasing storage time for low and high temperature peaks but low temperature peaks reducedmore. Maximum peaktemperature increases with rising storage time for low temperature peaks but there is no significant change in high temperature peaks. High temperature peak showedan unexpectedeffect, after 64-hour waiting period while the fading time increases the maximum peak intensity also increases. In figure 4.2, maximumpeakintensitydecreaseswith increasing fading time for low and high temperature peaks but low temperature peaks reducedmore. After 512 hours for low temperature peak, TL glow curve of Fluka sample decreases about 90 % of its initial value, TL glow curve of Aldrich sample decreases about 95 % of its initial value and for TL glow curve of Aldrich sample.

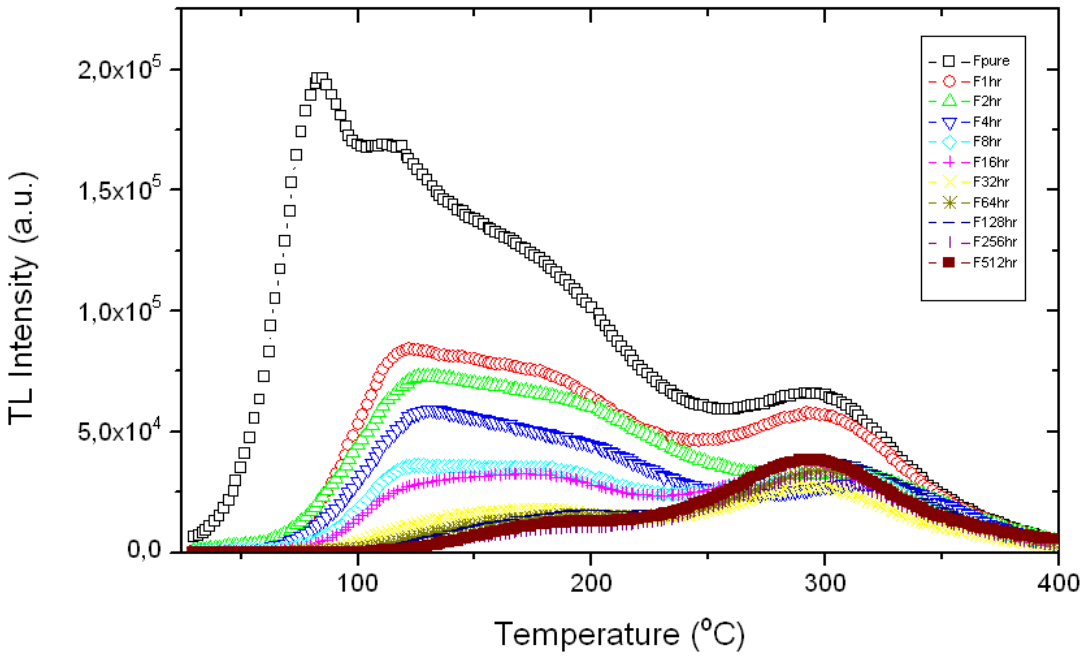

Figure 4.3A typical analyzed glow curve of Fluka quartz crystal waiting in fluorescent light, measured after ≈ 70 Gy irradiation at RT.

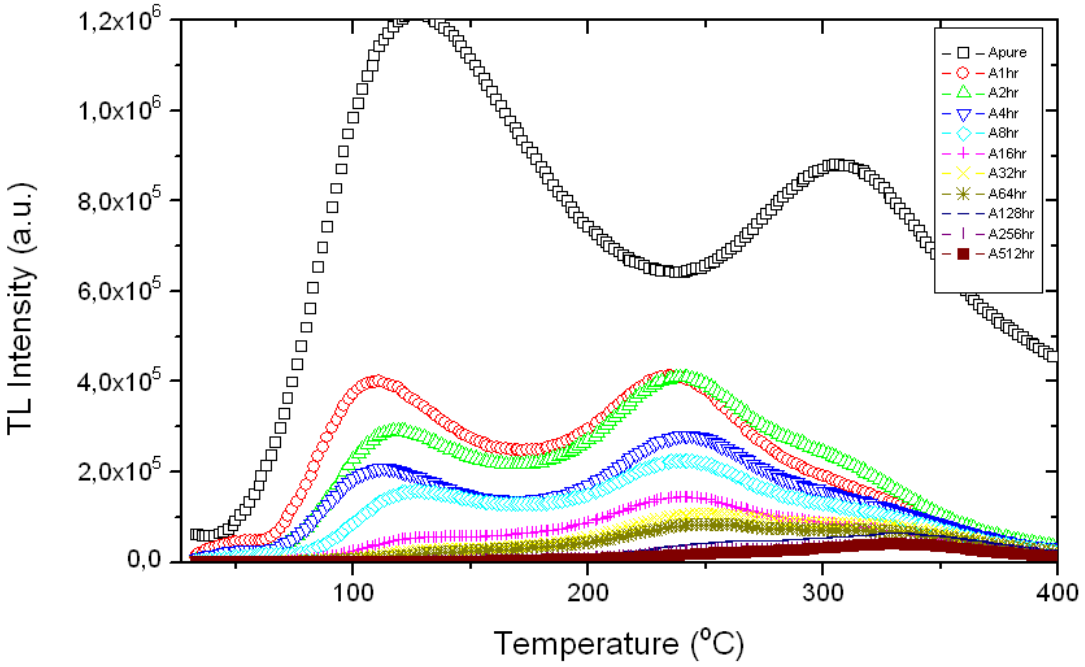

Figure 4.4 A typical analyzed glow curve of Aldrich quartz crystal waiting in fluorescent light, measured after ≈ 70 Gy irradiation at RT.

4.1.3 Samples waiting in tungsten light

Figure 4.5 and 4.6showa typical analyzed glow curve of quartz crystals waiting in tungsten light for Fluka and Aldrich samples, respectively. In figure 4.5, maximumpeakintensitydecreaseswith increasing fading time for low and high temperature peaks but low temperature peaks reducedmore. Maximum peaktemperature increases with rising storage time for low temperature peaks but there is no significant change in high temperature peaks. In figure 4.6, maximumpeakintensitydecreaseswith increasing storage time for low and high temperature peaks but low temperature peaks reducedmore. After 512 hours for low temperature peak, TL glow curve of Fluka sample decreases about 75 % of its initial value, TL glow curve of Aldrich sample decreases about 90 % of its initial value and for TL glow curve of Fluka sample, high temperature peak did not change so much.

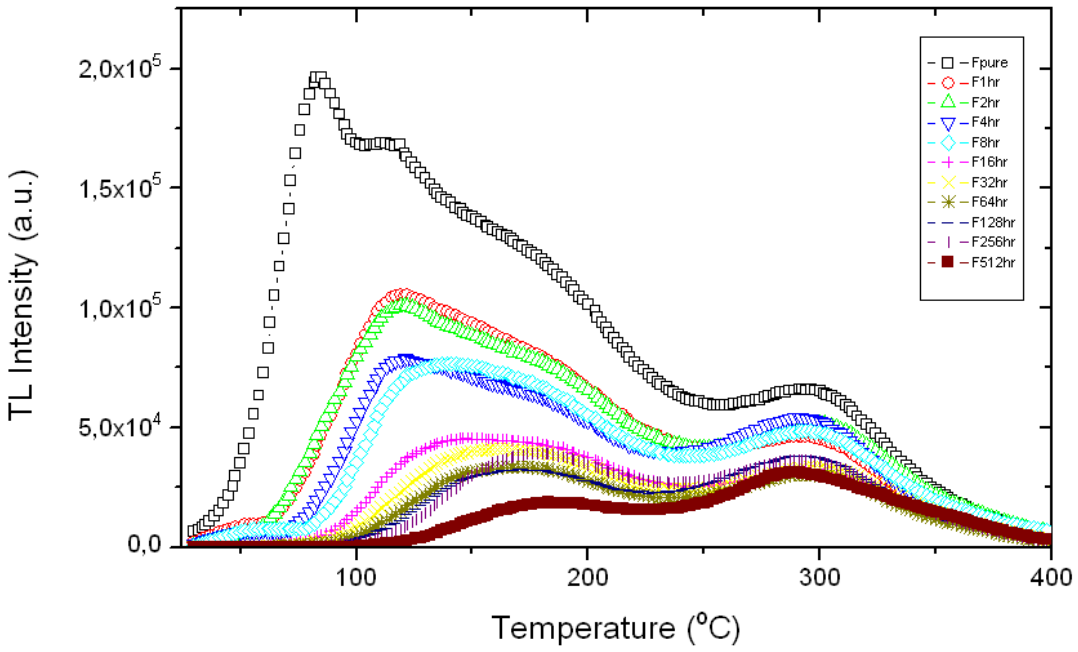

Figure 4.5A typical analyzed glow curve of Fluka quartz crystal waiting in tungsten light, measured after ≈ 70 Gy irradiation at RT.

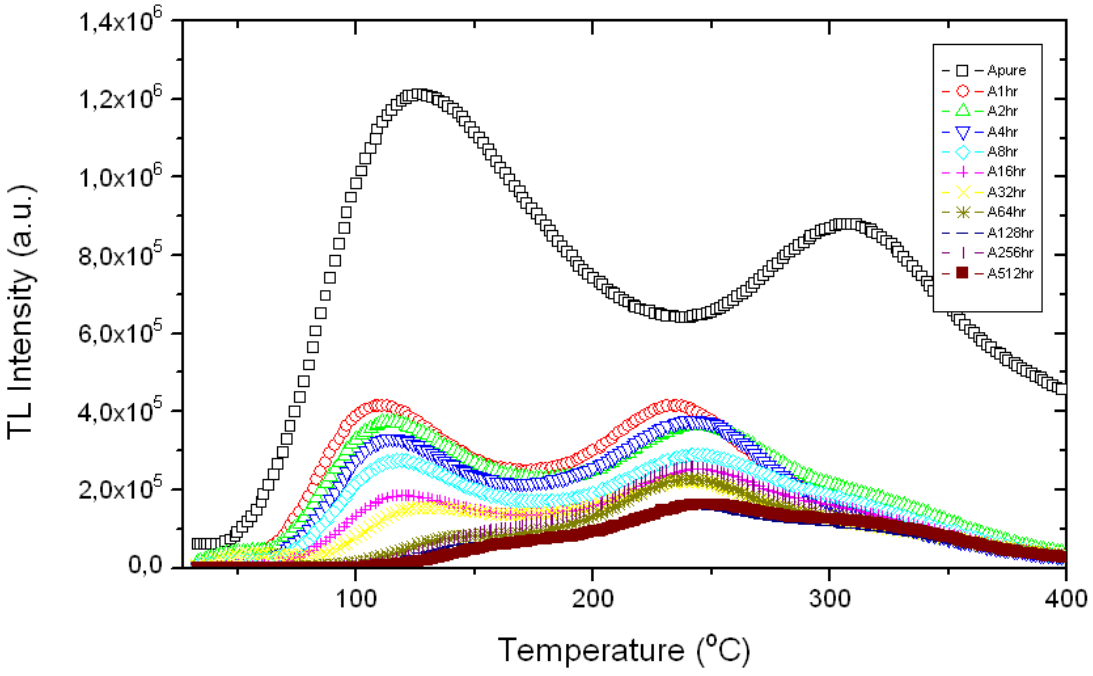

Figure 4.6A typical analyzed glow curve of Aldrich quartz crystal waiting in tungsten light, measured after ≈ 70 Gy irradiation at RT.

4.2 The variation of TL peak temperature

In this part of our work, we investigated the variation of TL peak temperature and we examined this section under two different parts, one of them is low temperature peak and the other one is high temperature peak.

4.2.1 The variation of TL peak temperature of low temperature peak

The glow curves of Aldrich and Fluka samples are examined under two parts, in this section we analyzed low temperature part of glow curve. The samples were irradiated about 70 Gy and storage in different conditions and read out to obtain glow curve variations. The graphs are analyzed and data are used to draw temperature-storage time graphs. The variations and changes between Fluka and Aldrich samples and also between three different conditions are seen in below figures.

4.2.1.1 Samples waiting in dark room

In this section we investigated the variation of peak temperature on the TL intensity of low temperature peak andfigure 4.7 and 4.8 shows the variations of TL peak temperature of low temperature peak of Fluka and Aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT. In figure 4.7 and 4.8 if the storagetime increases the maximum peak temperature increases. The maximum peak temperature rises more for Fluka sample.

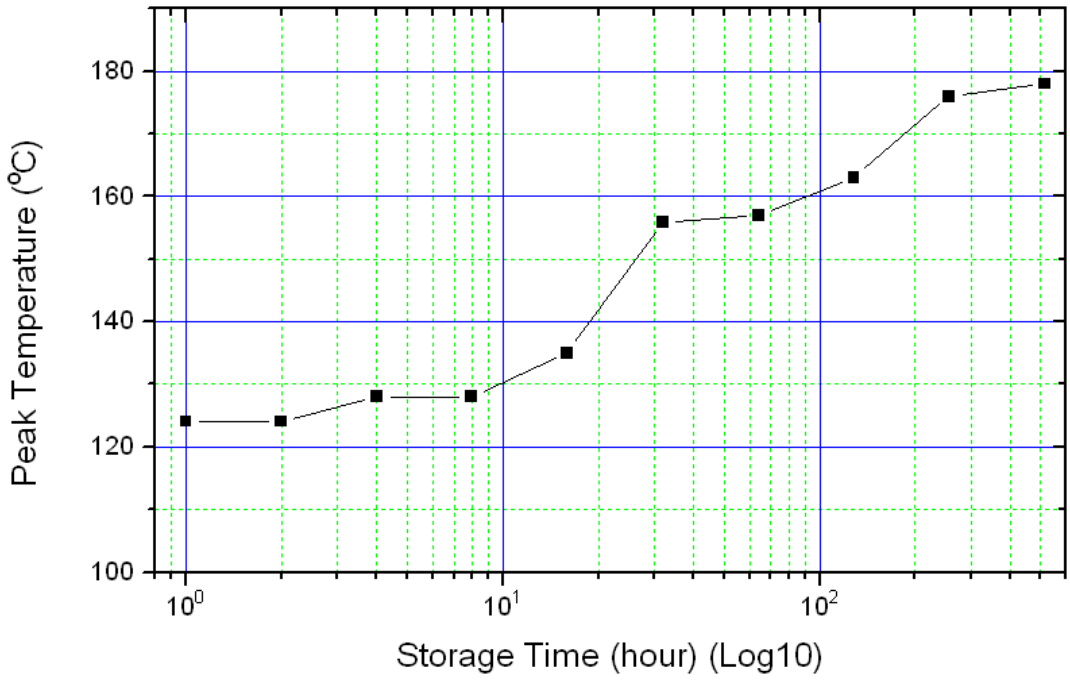

Figure 4.7 Thevariation of TL peak temperatureof Fluka quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT, low temperature peak.

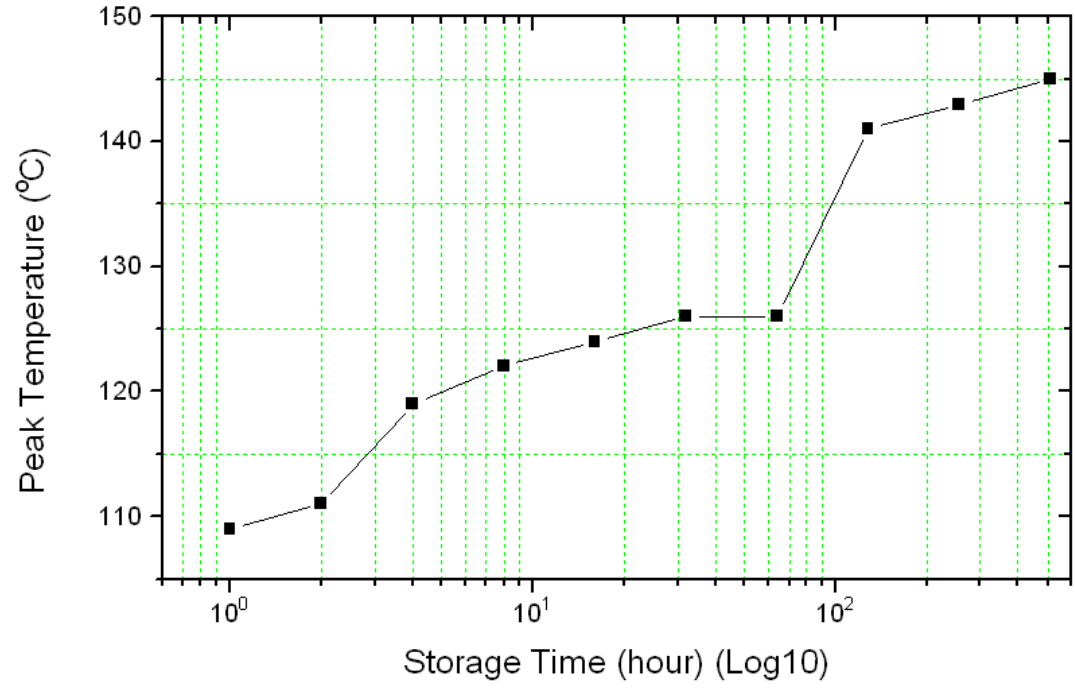

Figure 4.8Thevariation of TL peak temperatureof Aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT, low temperature peak.

4.2.1.2 Samples waiting in fluorescent light

We investigated the variation of TL peak temperature of low temperature peak and figure 4.9 and 4.10 show the variations of TL peak temperature of fluka and aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT. In figure 4.9 and 4.10 if the storage time is increased the maximum peak temperature is increased. The maximum peak temperature rises more for fluka sample.Samples waiting in thefluorescentlight of the rate of increase are more thansamples waiting in the dark room, for each of two samples.

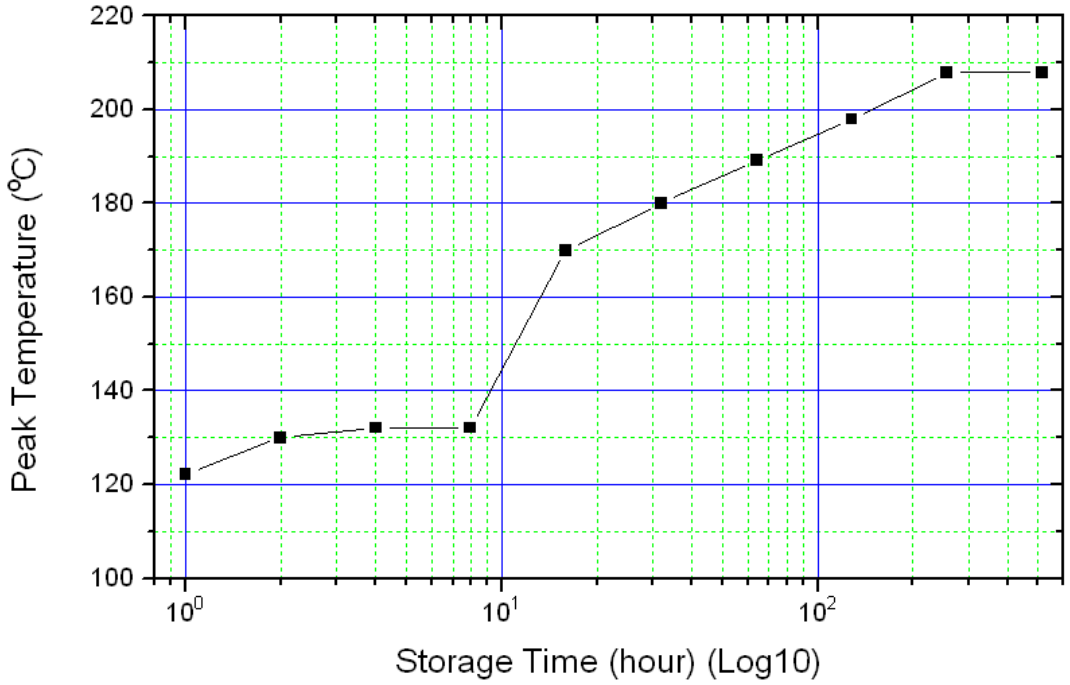

Figure 4.9 The variation of TL peak temperature of Fluka quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT, low temperature peak.

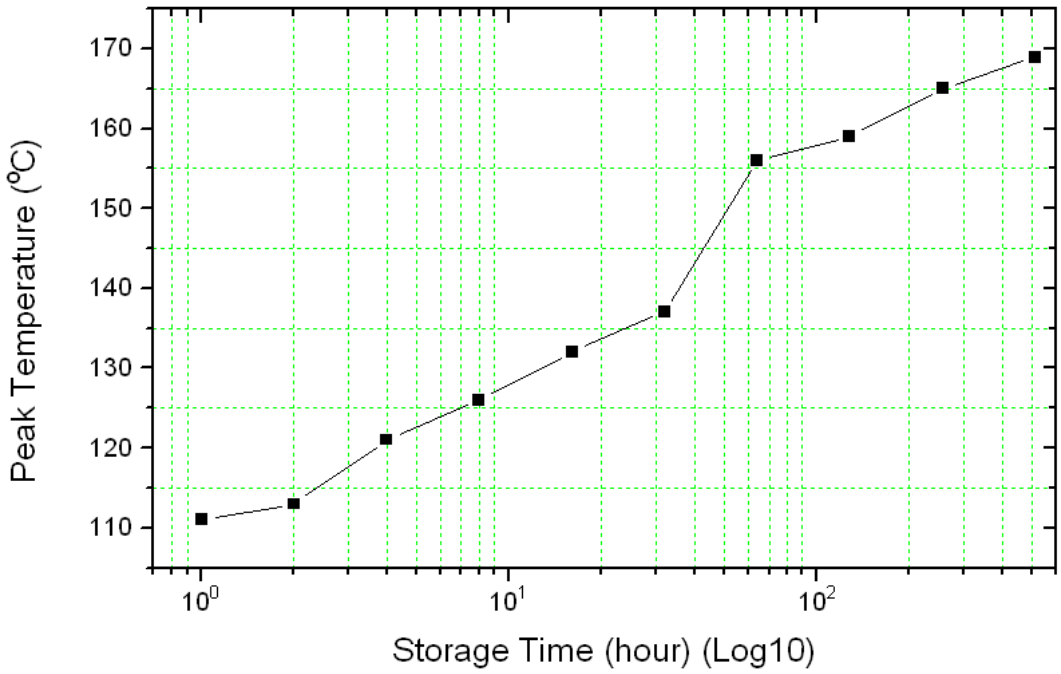

Figure 4.10The variation of TL peak temperature of Aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT, low temperature peak.

4.2.1.3 Samples waiting in tungsten light

In this section we investigated the variation of TL peak temperature of low temperature peak and figure 4.11 and 4.12 shows the variations of TL peak temperature of fluka and aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT. In figure 4.11and 4.12 if the storage time is increased the maximum peak temperature is increased. The maximum peak temperature rises more than for fluka sample.The rate of increase of samples waiting in thefluorescent and tungstenlight are more than the rate of increase of samples waiting in the dark room, for each of two samples.

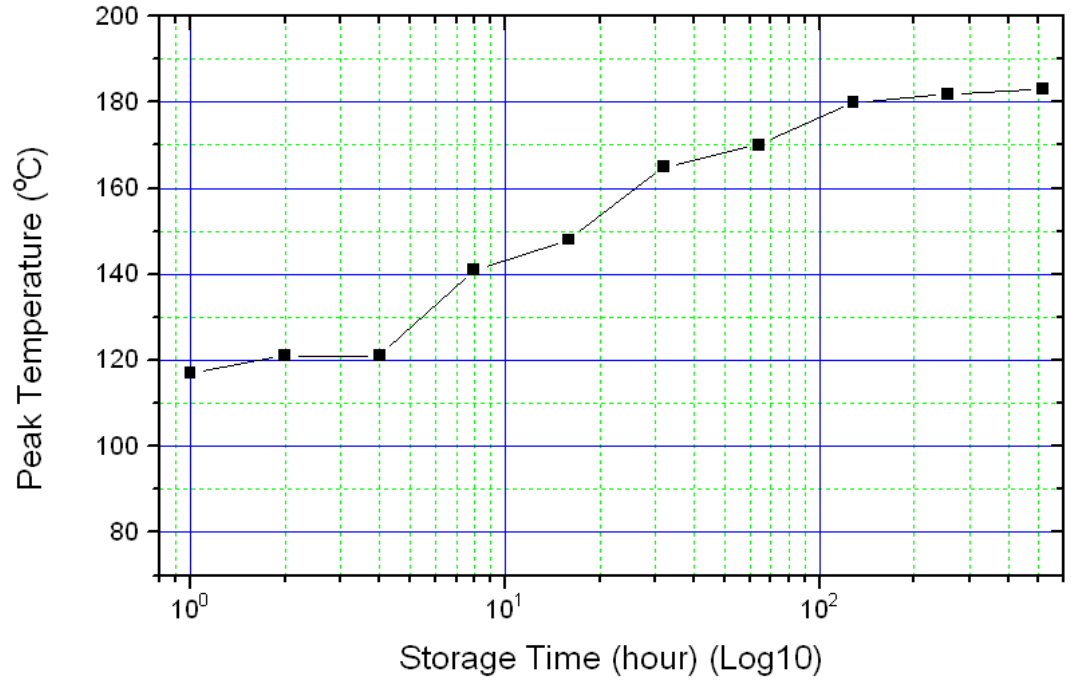

Figure 4.11The variation of TL peak temperature of Fluka quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT, low temperature peak.

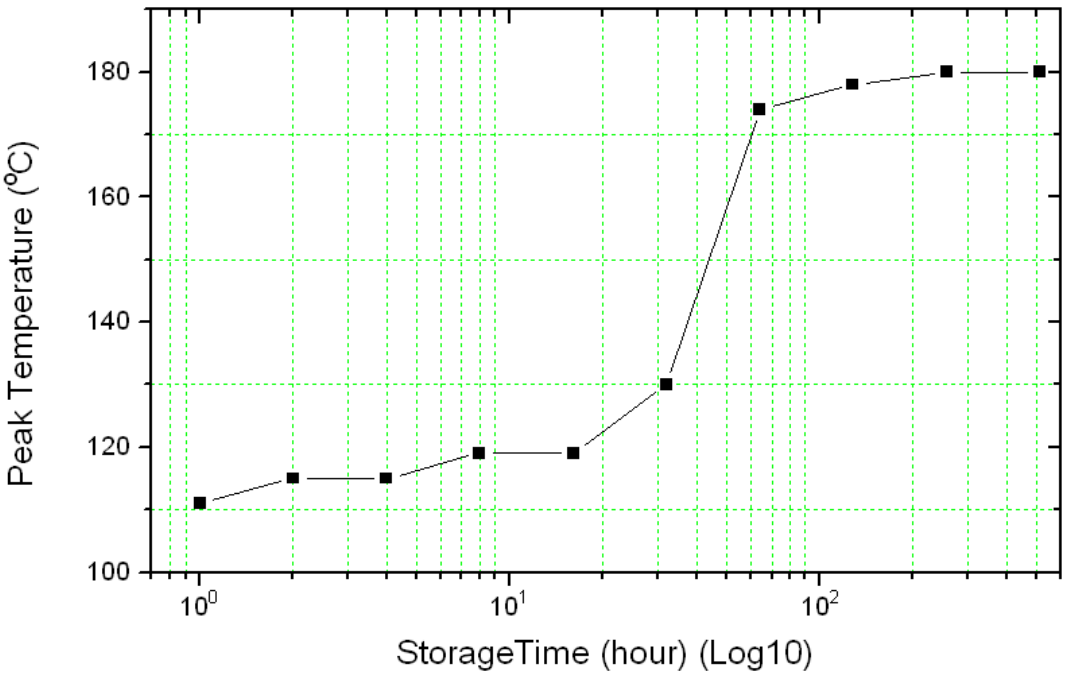

Figure 4.12Thevariation of TL peak temperature of Aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT, low temperature peak.

4.2.2The variation of TL peak temperature of high temperature peak

In this section we analyzed high temperature part of glow curve. The samples were irradiated about 70 Gy and stored in different conditions and read out to obtain glow curve variations. The graphs are analyzed and data are used to draw temperature-storage time graphs. The variations and changes between fluka and aldrich samples and also between three different conditions are seen in below figures.

4.2.2.1 Samples waiting in dark room

This section gave the variation of TL peak temperatureof high temperature peak and figure 4.13 and 4.14 shows the variations of TL peak temperature of fluka and aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT. In figure 4.13 there is no significant change and in figure 4.14 there isvery littlereduction.

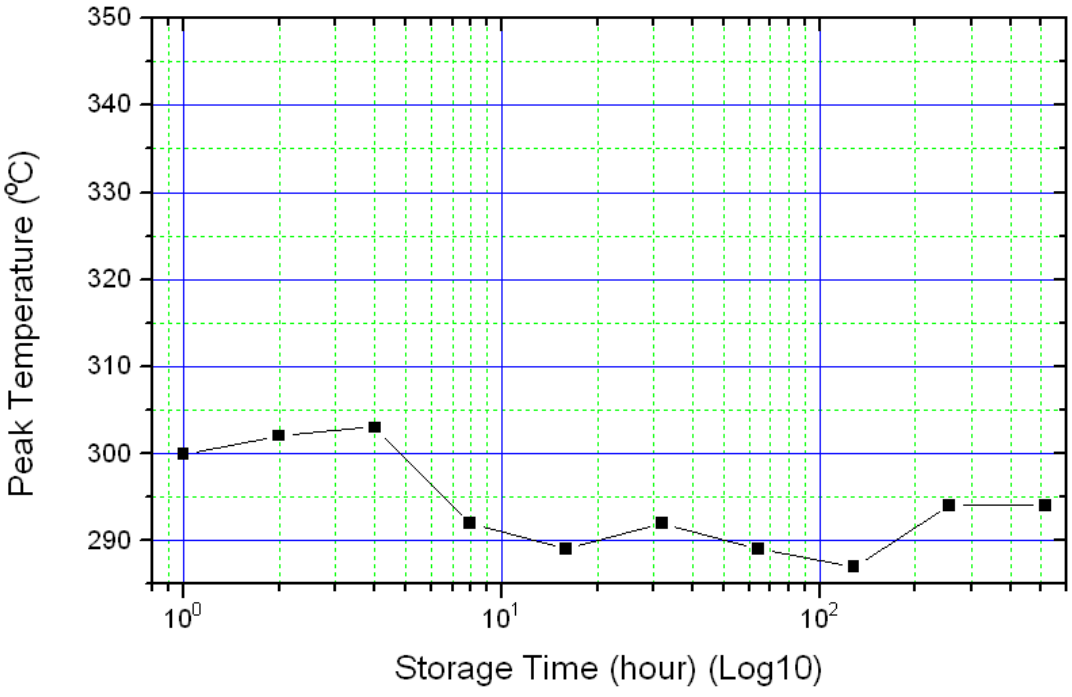

Figure 4.13Thevariation of TL peak temperatureof Fluka quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT, high temperature peak.

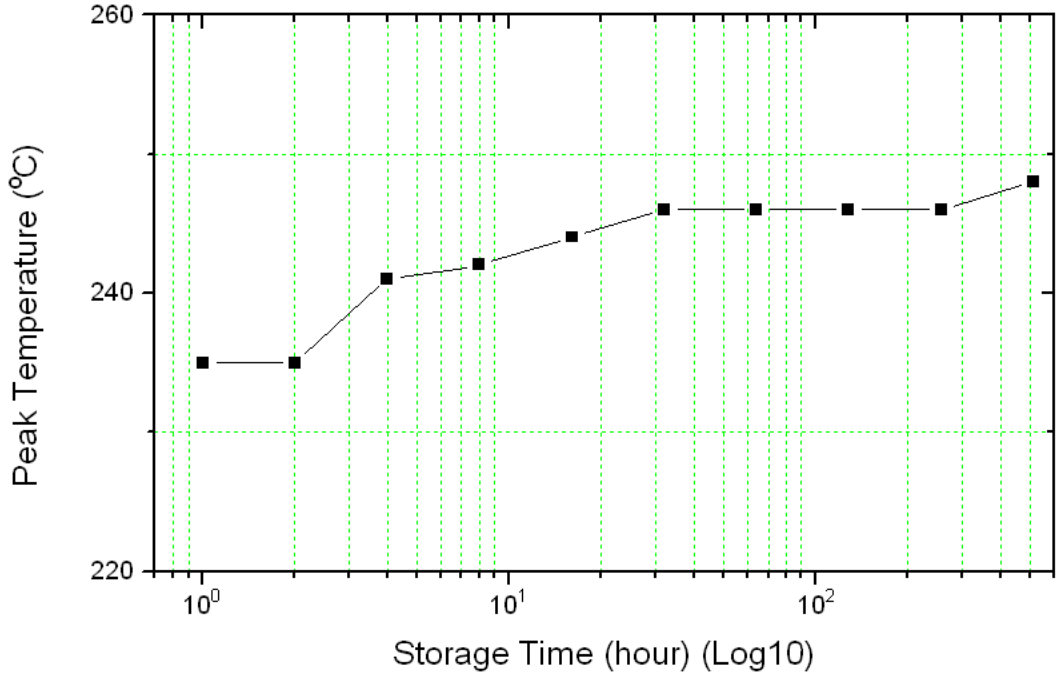

Figure 4.14Thevariation of TL peak temperatureof Aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT, high temperature peak.

4.2.2.2 Samples waiting in fluorescent light

In this section we investigated the variation of TL peak temperatureof high temperature peak and figure 4.15 and 4.16 show the variations of TL peak temperature of fluka and aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT. In figure 4.15 there is no significant change and there arefluctuations but in figure 4.14 there is an increaseof about 100 ^{o}C and there isa sharp increaseafter100 hours waiting time.

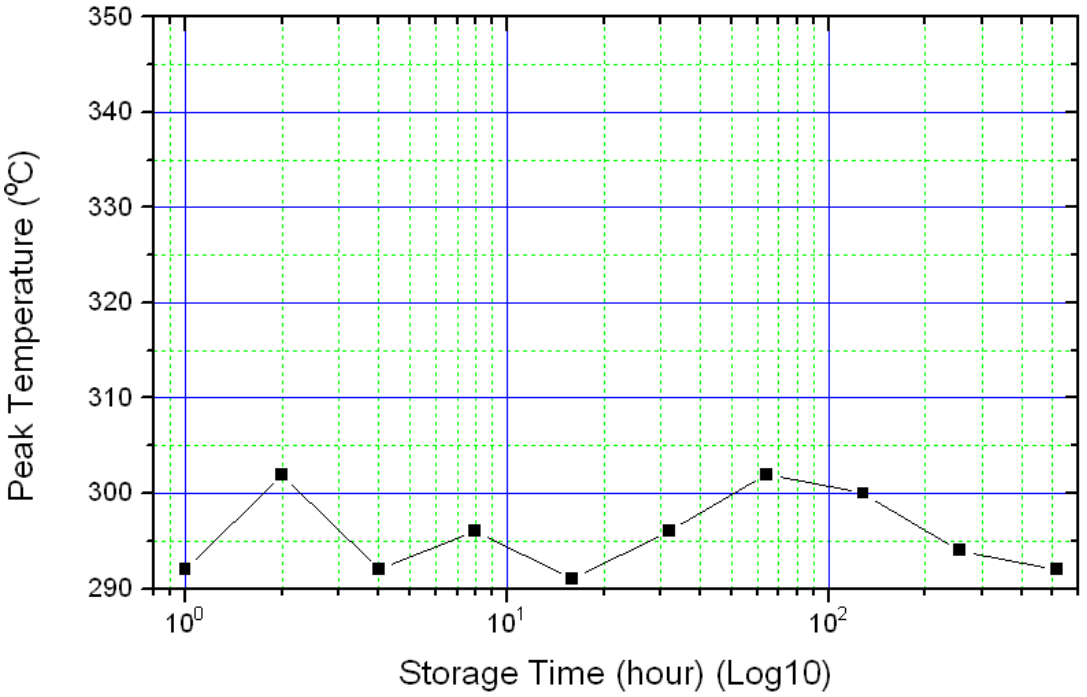

Figure 4.15Thevariation of TL peak temperature of Fluka quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT, high temperature peak.

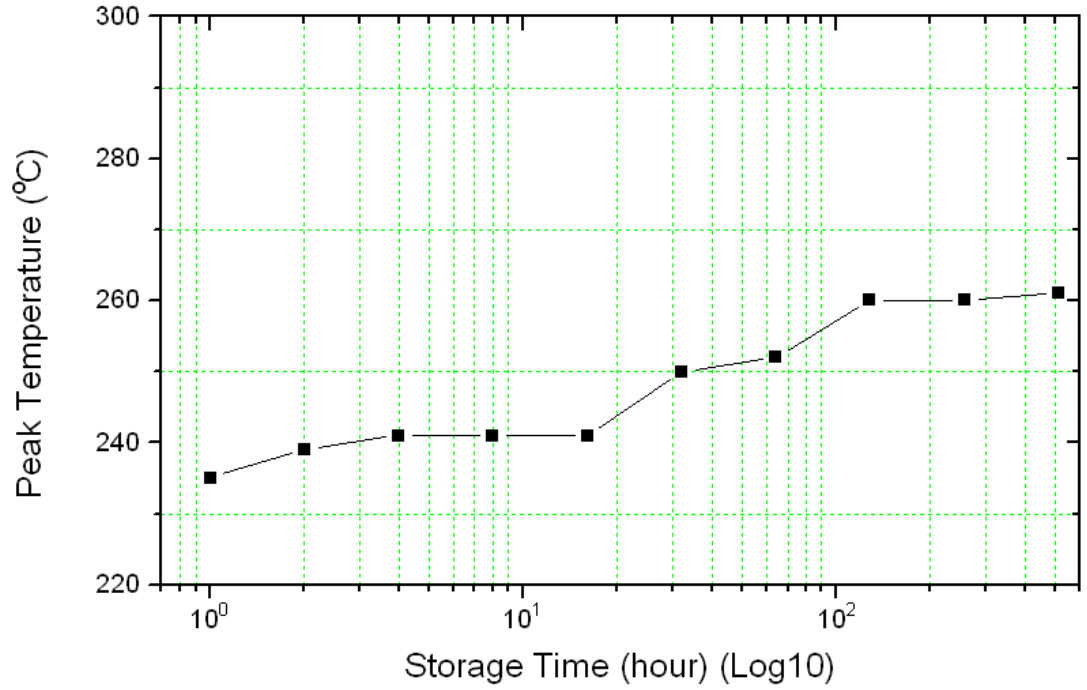

Figure 4.16 Thevariation of TL peak temperatureof Aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT, high temperature peak.

4.2.2.3 Samples waiting in tungsten light

In this section we investigated the variation of TL peak temperature of high temperature peak and figure 4.17 and 4.18 show the variations of TL peak temperature of fluka and aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT. In figure 4.17 there is no significant changeand in figure 4.18 there is an increaseof about 20 ^{o}C.

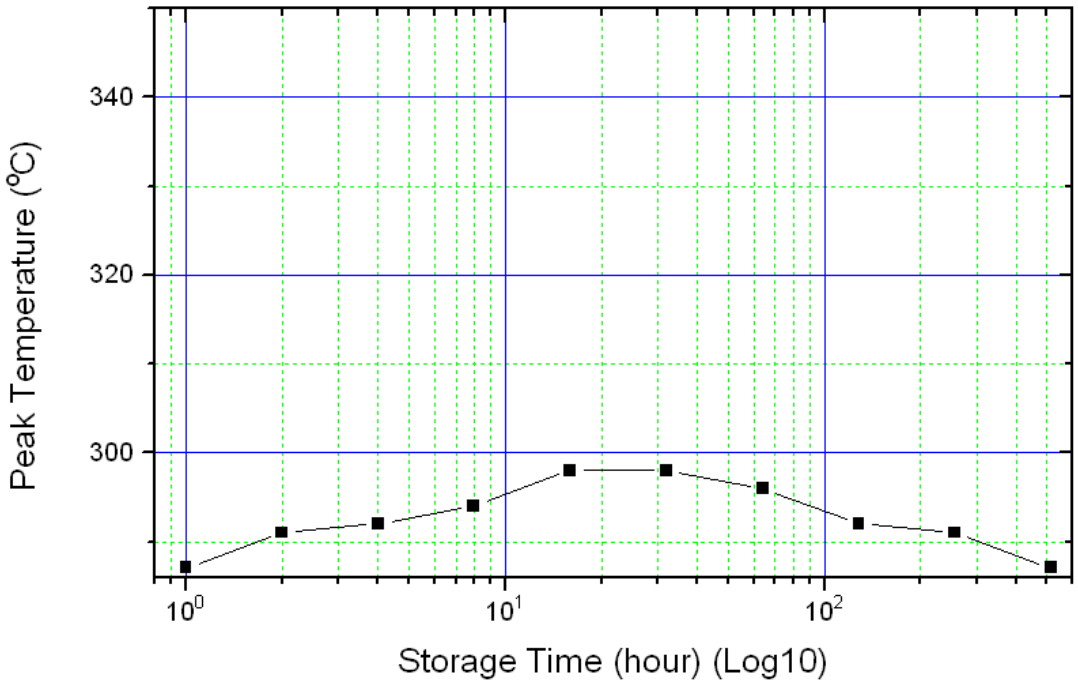

Figure 4.17Thevariation of TL peak temperatureof Fluka quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT, high temperature peak.

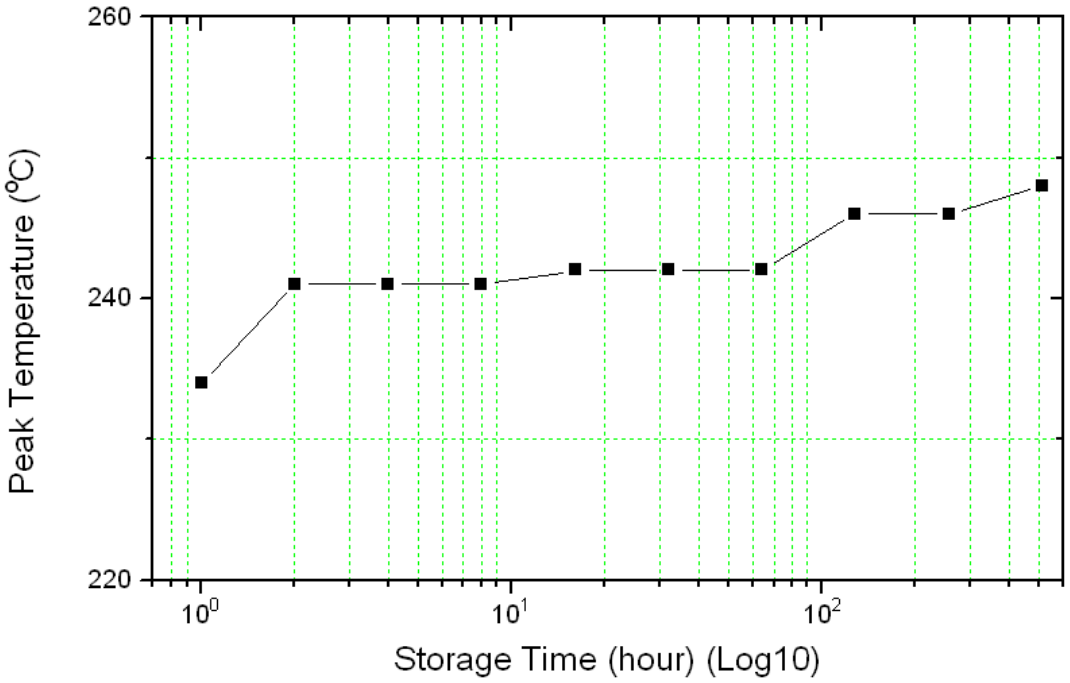

Figure 4.18 Thevariation of TL peak temperatureof Aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT, high temperature peak.

4.3 The effect of storage time on maximum TL peak intensity

In this part of our work, we investigated the effectof storage timeon maximumTL peak intensity. Our glow curve graphics have two distinguish peaks so we divided these graphs in two parts.The glow curve of Aldrich and Fluka samples are examined under two parts, one of them is low temperature peak and the other one is high temperature peak.This studywas also performedforeachsample which heldin three different conditions.

4.3.1 The effect of storage time onmaximum TL peak intensity of low temperature peak

Low temperature peaks appeared between 100 ^{o}C and 200 ^{o}C and these peaks showed different react for different conditions. We can see clearly the changes in below figures, storage time affected to TL intensity. For Fluka andAldrich quartz crystal, we obtained the graphics and we observed the differences.

4.3.1.1 Samples waiting in dark room

In this part of work, we examined the effect of storage time on maximum TL peak intensity of low temperature peak of Fluka and Aldrich quartz crystals, respectively. Figure 4.19 and 4.20 show the variations of storage time on maximum TL peak intensity of low temperature peak ofFluka quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT. TLintensitydecreases approximately fifty percent intwo charts.

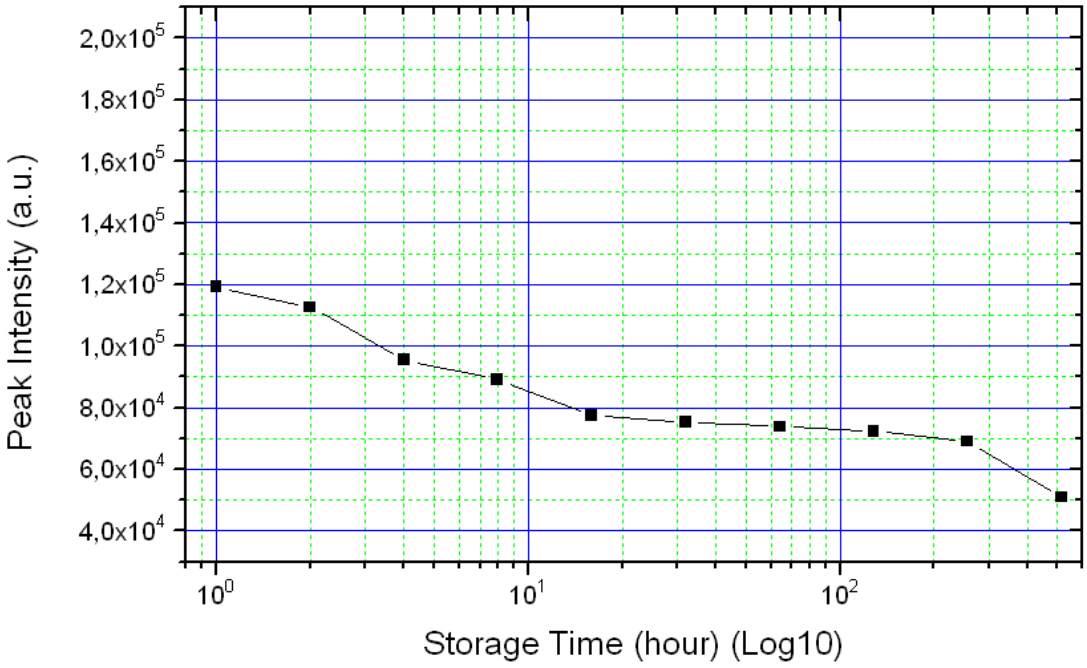

Figure 4.19Thevariation ofstorage time on maximum TL peak intensityof low temperature peak of Fluka quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT.

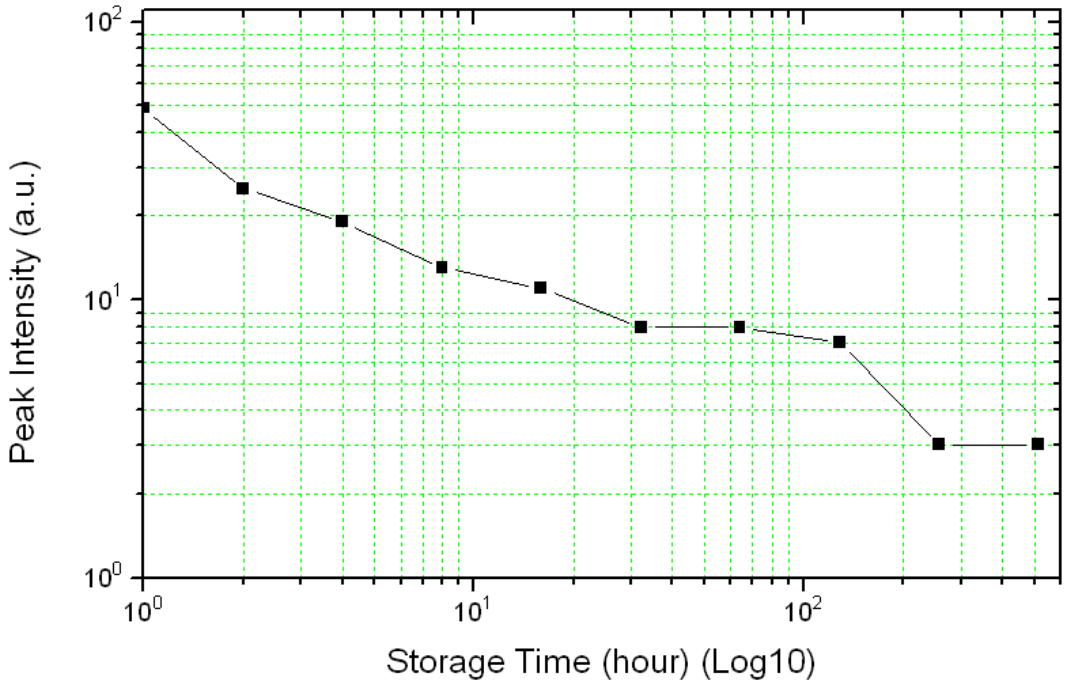

Figure 4.20Thevariation of storage time on maximum TL peak intensity of low temperature peak of Aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT.

4.3.1.2 Samples waiting in fluorescent light

This part of work gave the effect of storage time on maximum TL peak intensity of low temperature peak of Fluka and Aldrich quartz crystals. Figure 4.21 and 4.22 show the variations of storage time on maximum TL peak intensity of low temperature peak of Fluka and Aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT. TLintensitydecreases approximately one hundredpercent inbothtwo charts. Samples waiting in fluorescent light have more changes than the samples waiting in dark room.

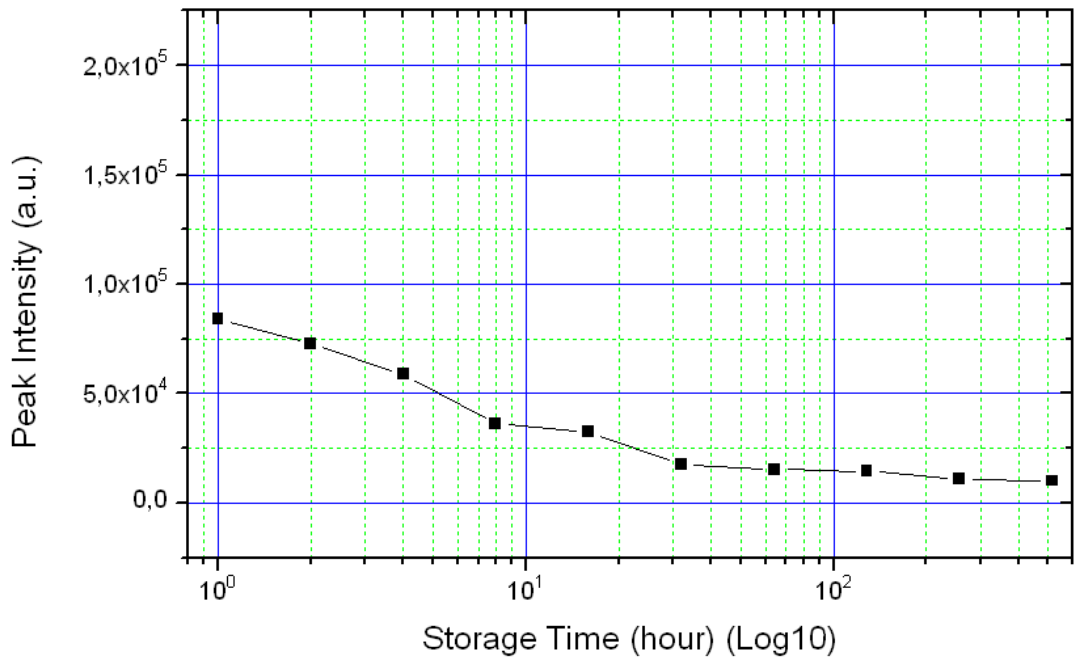

Figure 4.21Thevariation of storage time on maximum TL peak intensity of low temperature peak of Fluka quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT.

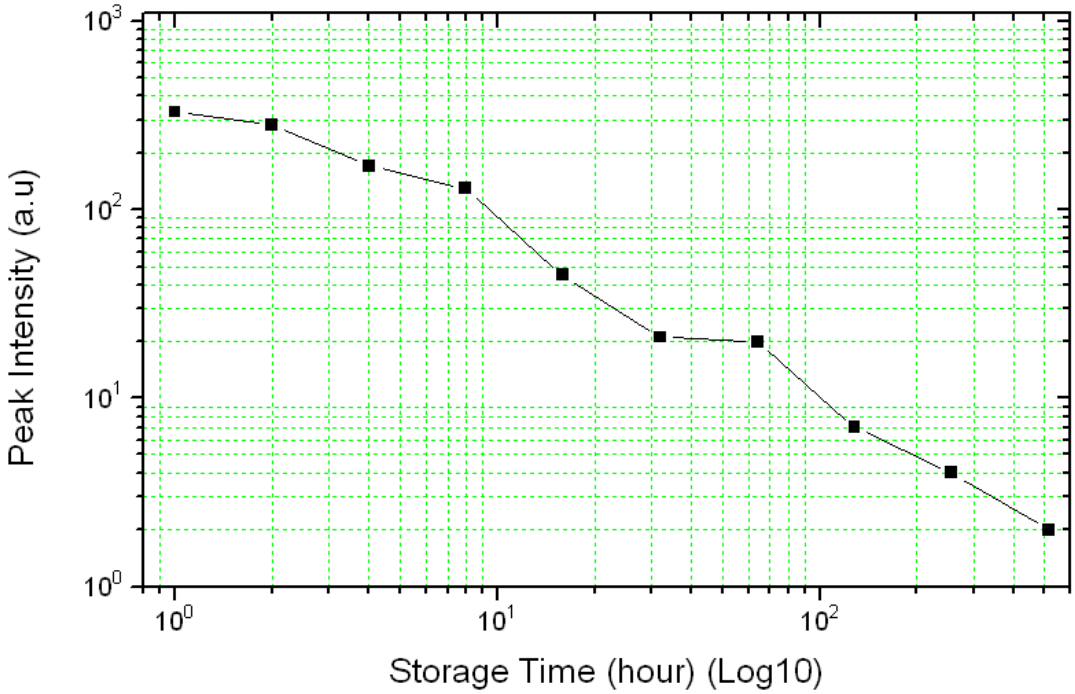

Figure 4.22 Thevariation of storage time on maximum TL peak intensity of low temperature peak of Aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT.

4.3.1.3 Samples waiting in tungsten light

In this part of work, we got the effect of storage time on the TL intensity of low temperature peak of Fluka and Aldrich quartz crystals. Figure 4.23 and 4.24 show the variations of storage time on the TL intensity of Fluka quartz crystal waiting in tungsten lightand irradiated ≈ 70 Gy at RT, low temperature peak. TLintensitydecreases approximately one hundredpercent inbothtwo charts. Samples waiting in fluorescent light have more changes than the samples waiting in dark room. Samples waiting in fluorescent light have least maximum TL intensity andsamples waiting in dark room have the most maximum TL intensity because ofthe light.

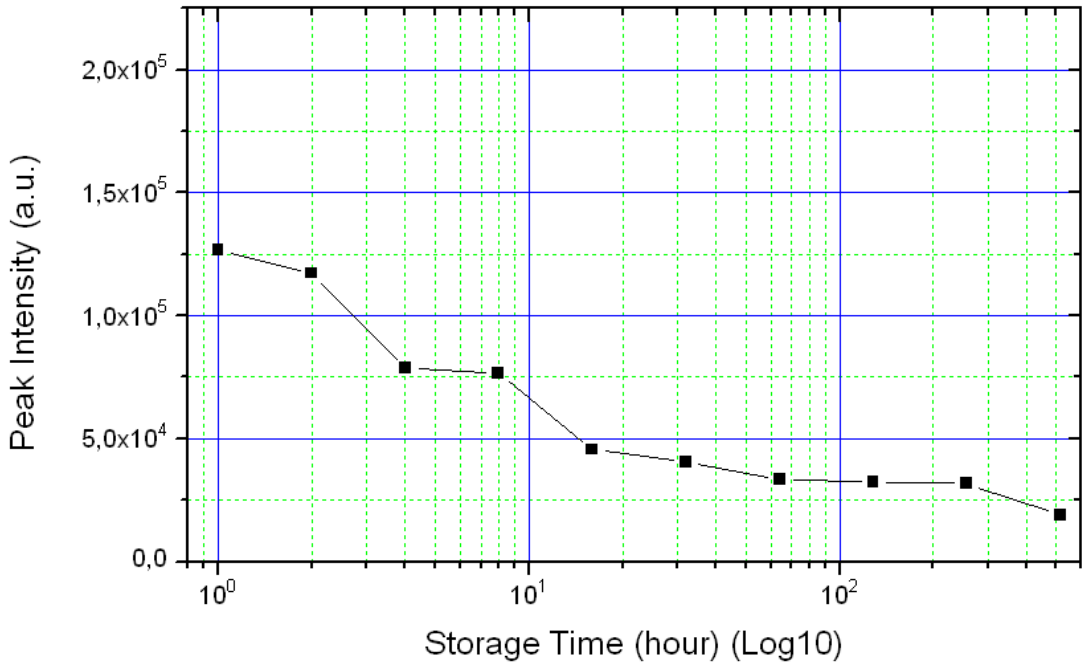

Figure 4.23 Thevariation of storage time on maximum TL peak intensity of low temperature peak of Fluka quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT.

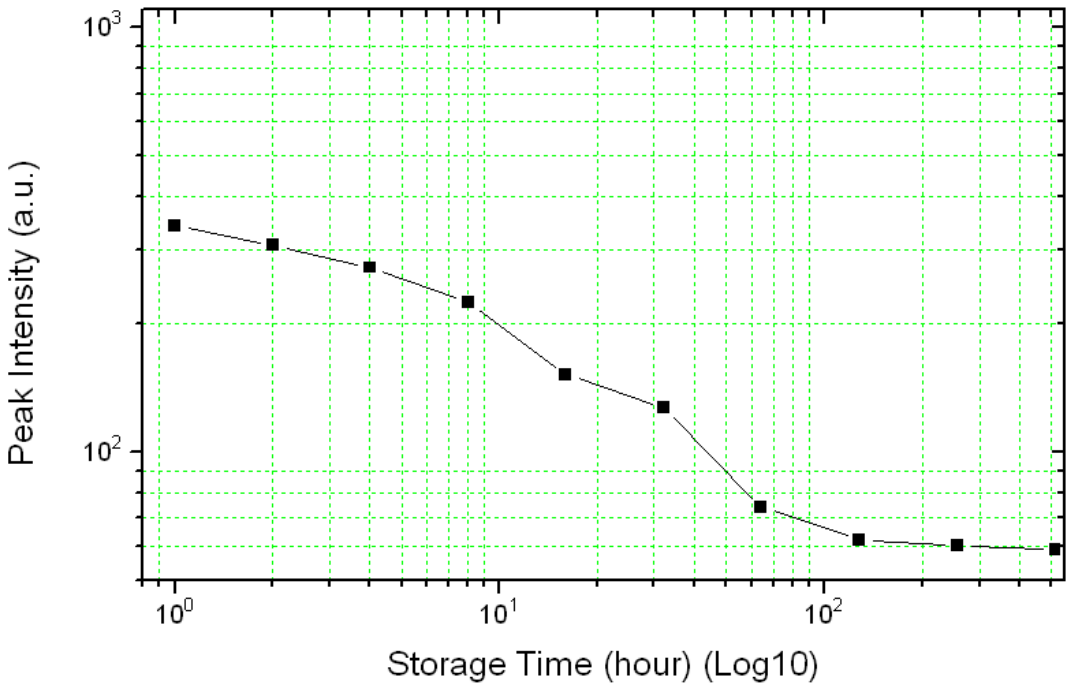

Figure 4.24Thevariation of storage time on maximum TL peak intensity of low temperature peak of Aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT.

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4.3.2 The effect of storage time on maximum TL peak intensityof high temperature peak

High temperature peaks appeared between 200 ^{o}C and 300 ^{o}C and these peaks showed different react for different conditions. We can see clearly the changes in figures. For both Fluka quartz crystal and Aldrich quartz crystal, we obtained the graphics and we observed the differences.

4.3.2.1 Samples waiting in dark room

We observed the effect of storage time on maximum TL peak intensity of high temperature peakof Fluka and Aldrich quartz crystals, respectively. Figure 4.25 and 4.26 show the variations of storage time on the maximum TL peak intensity of Fluka quartz crystal waiting dark room lightand irradiated ≈ 70 Gy at RT, high temperaturepeak. TLintensitydecreases approximately one hundredpercent infigure 4.26 but in figure 4.25 there is no significantchange.

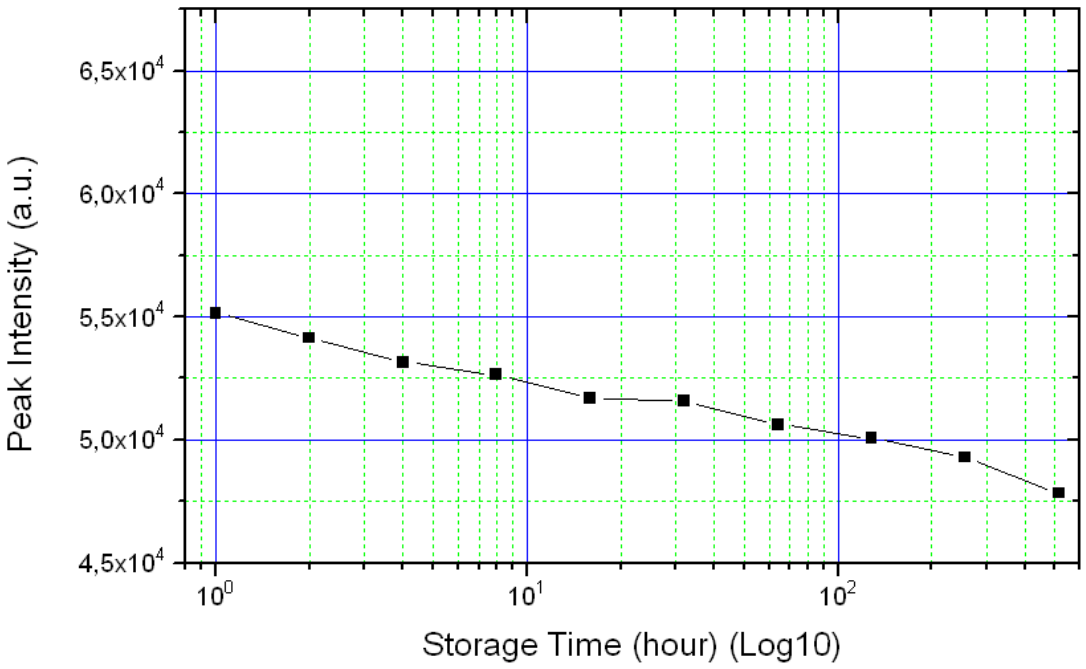

Figure 4.25Thevariation of storage time on maximum TL peak intensity of high temperature peakofFluka quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT.

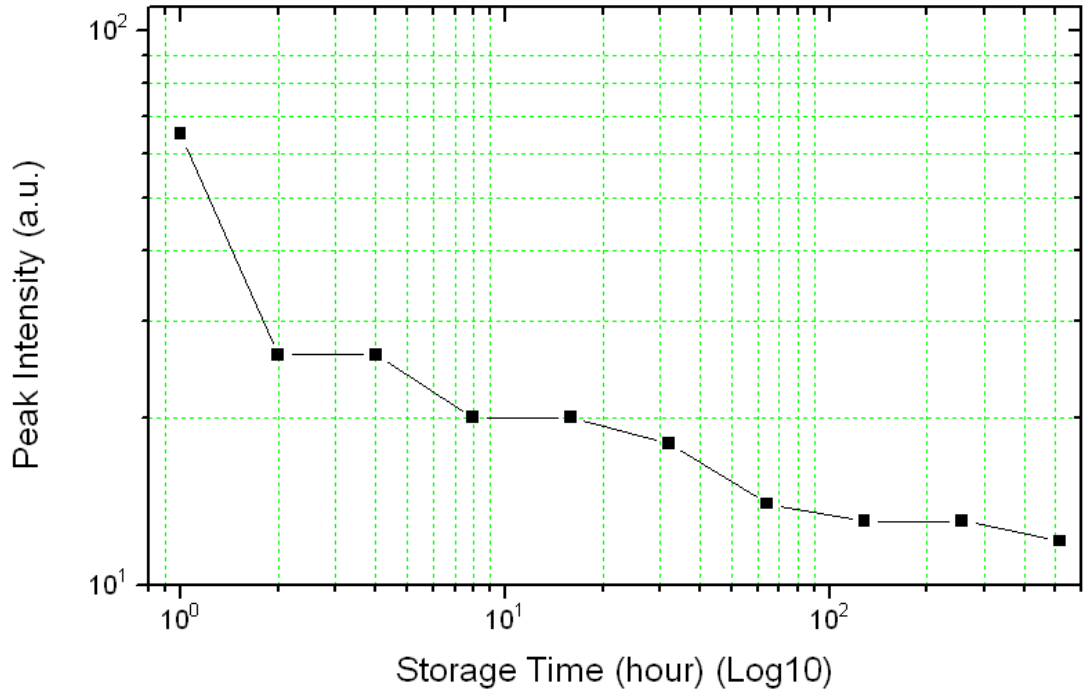

Figure 4.26Thevariation of storage time on maximum TL peak intensity of high temperature peakof Aldrich quartz crystal waiting in dark room and irradiated ≈ 70 Gy at RT.

4.3.2.2 Samples waiting in fluorescent light

In this section, we surveyed the effect of storage time on maximum TL peak intensity of high temperature peakofFluka and Aldrich quartz crystals, respectively. Figure 4.27 and 4.28 show the variations of storage time on maximum TL peak intensity of high temperature peakof Fluka quartz crystal waiting in fluorescent lightand irradiated ≈ 70 Gy at RT. TLintensitydecreases approximately one hundredpercent in figure 4.28 whilein figure 4.27 there is no significant change.Samples waiting in fluorescent light have more changes than the samples waiting in dark room.Maximum TL peak intensity of samples waiting in fluorescent light have thelowest value and maximum TL peak intensityof samples waiting in dark room have the highest value because ofthe light.

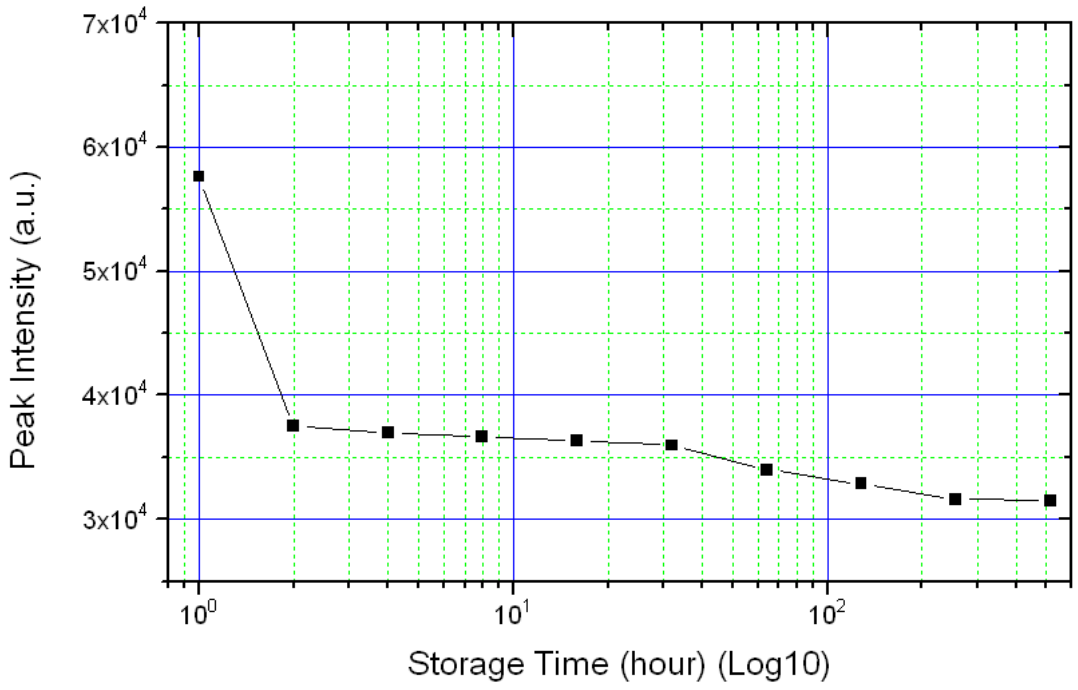

Figure 4.27Thevariation of storage time on the TL intensity of Fluka quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT, high temperature peak.

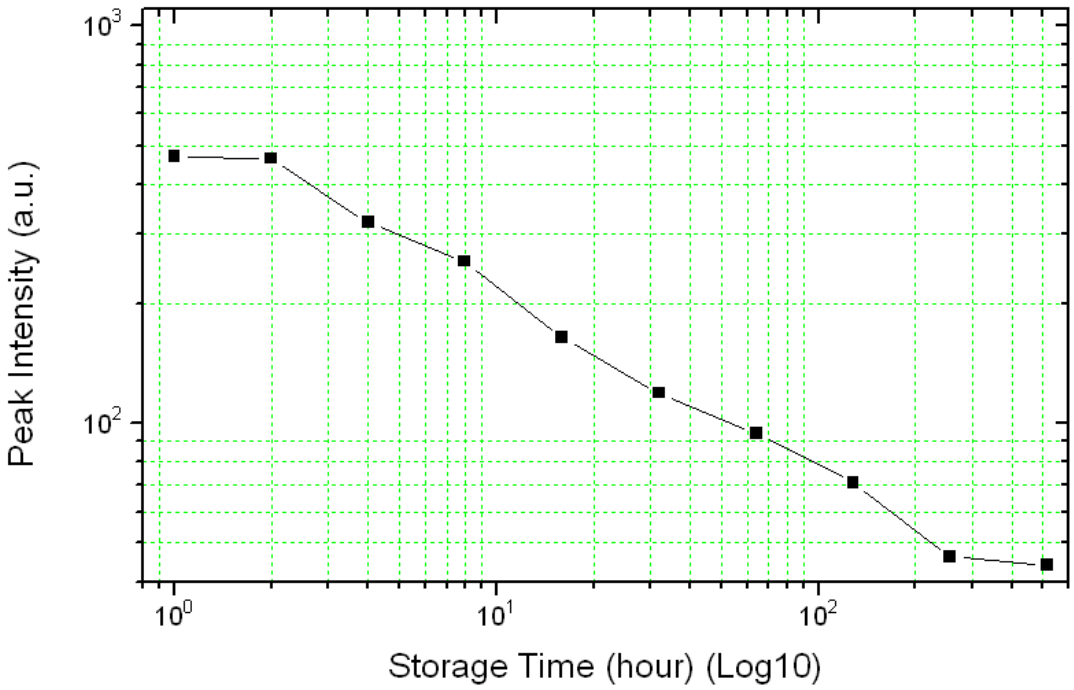

Figure 4.28Thevariation of storage time on maximum TL peak intensity of high temperature peakof Aldrich quartz crystal waiting in fluorescent light and irradiated ≈ 70 Gy at RT.

4.3.2.3Samples waiting in tungsten light

In this part of study, we surveyed the effect of storage time on maximum TL peak intensity of high temperature peakof Fluka and Aldrich quartz crystals. Figure 4.29 and 4.30 show the variations of storage time on maximum TL peak intensity of high temperature peakof Fluka quartz crystal waiting in fluorescent lightand irradiated ≈ 70 Gy at RT. TLintensitydecreases approximately one hundredpercent in figure 4.29 but TLintensitydecreases approximately fiftypercent in figure 4.30. Samples waiting in fluorescent light have more changes than the samples waiting in dark room. Maximum TL peak intensity of samples waiting in fluorescent light have the lowest value and maximum TL peak intensity of samples waiting in dark room have the highest value because ofthe light.

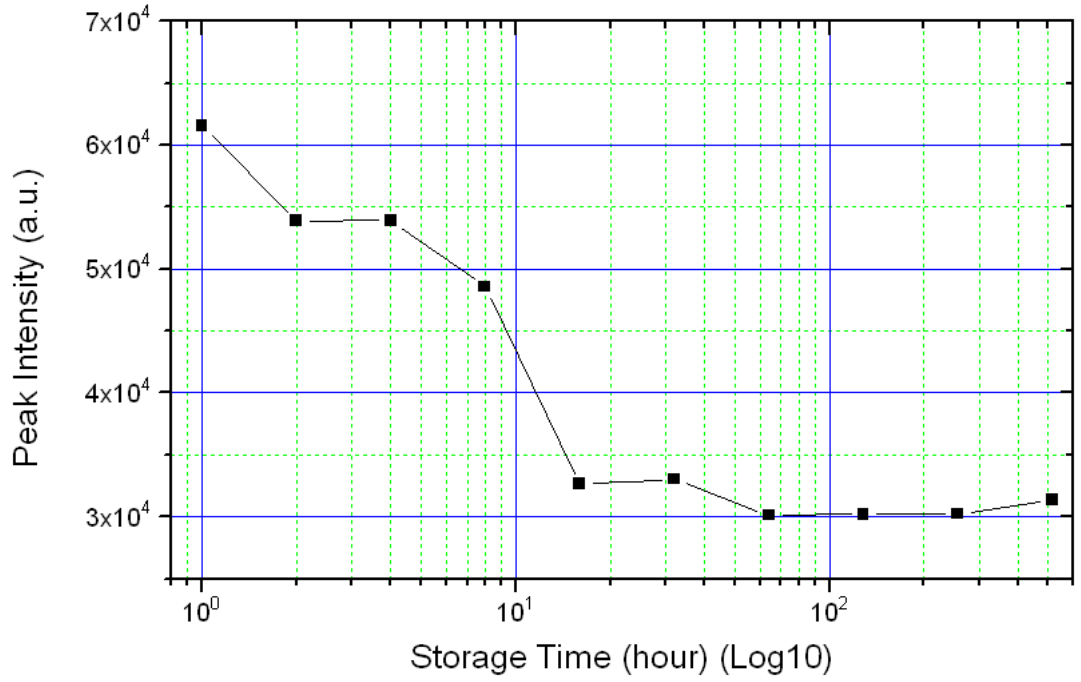

Figure 4.29 Thevariation of storage time on maximum TL peak intensity of high temperature peakofFluka quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT.

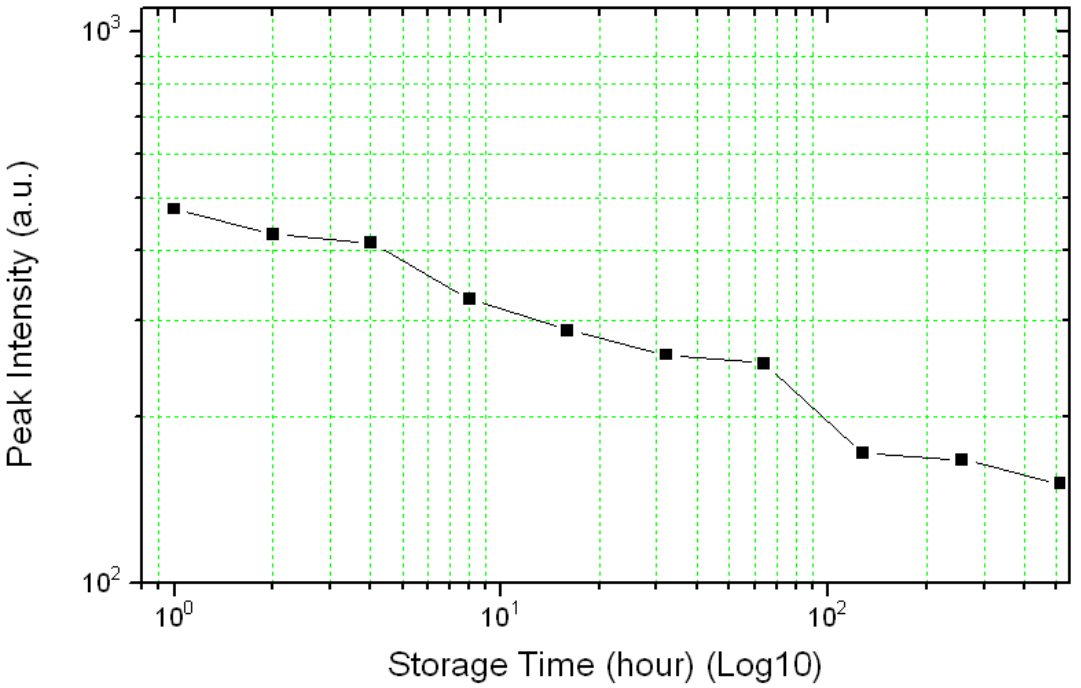

Figure 4.30 Thevariation of storage time on maximum TL peak intensity of high temperature peakof Aldrich quartz crystal waiting in tungsten light and irradiated ≈ 70 Gy at RT.

4.4 The investigation of kinetic parameters

In this part of examination we obtained the kinetic parameters of Fluka and Aldrich quartz crystals which were waited in three different conditions. We just analyzed some samples which were waited 512 hours in dark room, fluorescent light and tungsten light. We used CGCD program, which is based on the least square minimization procedure, was developed at the Reactor Institute at Delft, The detail results of thesemodels were given in an IRI-CIMAT Report [15] to get these parameters and we observed carrier population in a trap (n_0), trap depth (E_a), frequency factor (s) and kinetic order (b) by using this program. We investigated this part of work under two main folders which are kinetic parameters of Fluka and Aldrich samples.

4.4.1 Kinetic parameters of Fluka sample

In this analysis, it is veryimportant to decide correctly how many glow peaks there are in the glow curve and which of them have first or general-kinetics to obtain results. All our glow peaks were fitted to two peaks which are first order kinetics given infigure 4.30, 4.31 and 4.32 and two of them (peak1 and peak2) are low temperature peaks, two of them (peak3 and peak4) are high temperature peaks.

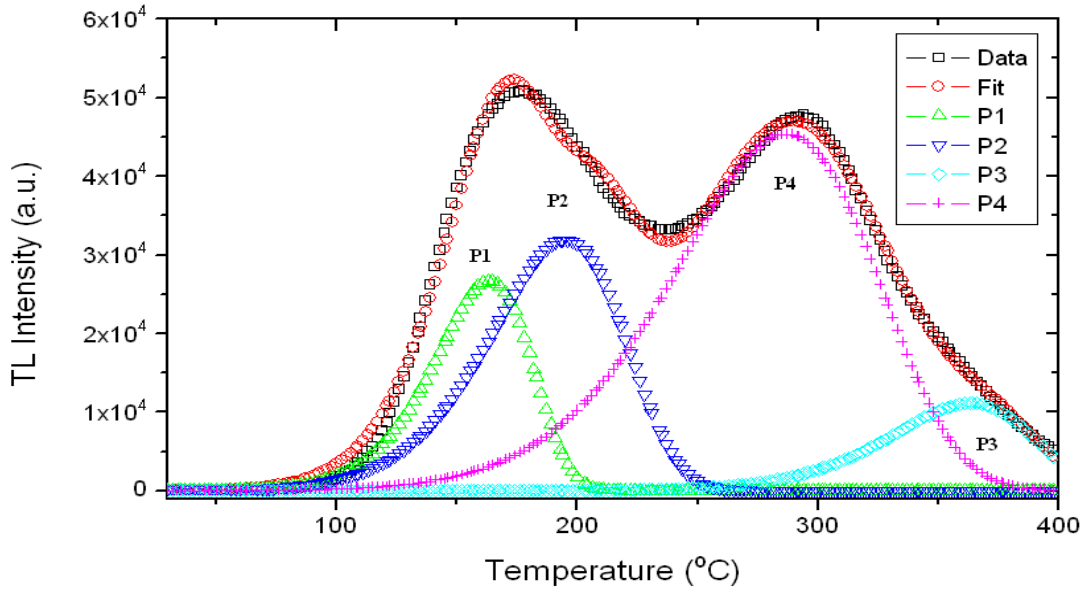

Figure 4.31A typical analyzed glow curve of Fluka quartz crystal waiting 512 hours in dark room, measured after ≈ 70 Gy irradiation at RT.

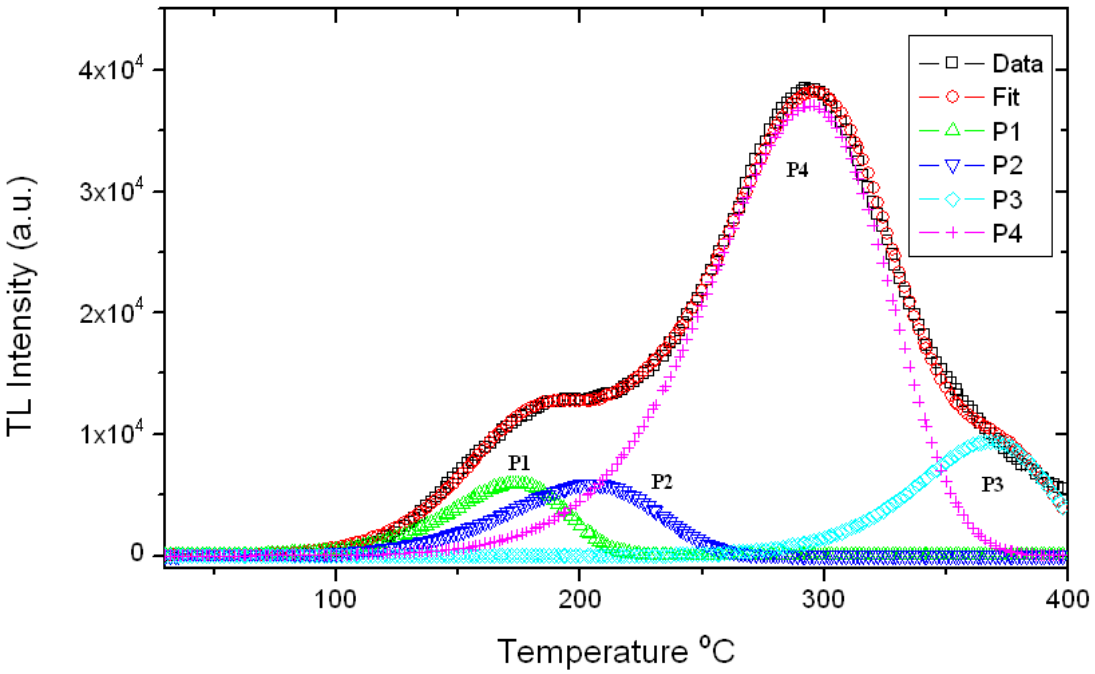

Figure 4.32 A typical analyzed glow curve of Fluka quartz crystal waiting 512 hours in fluorescent light, measured after ≈ 70 Gy irradiation at RT.

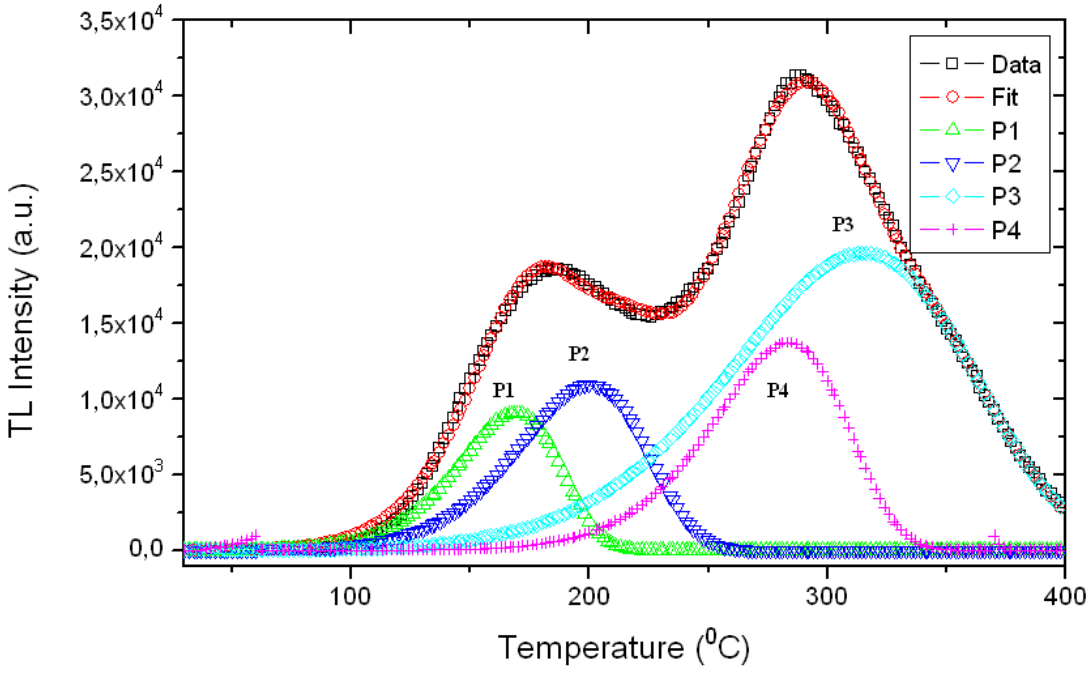

Figure 4.33 A typical analyzed glow curve of Fluka quartz crystal waiting 512 hours in tungsten light, measured after ≈ 70 Gy irradiation at RT.

The kinetic parameters of Fluka samples are shown in table 4.1, 4.2 and 4.3. Each table shows differentkinetic parameter values, table 4.1 shows the carrier population values in the traps (n_0) and we gave n_0 values for low and high temperature peaks for three conditions, figure 4.2 shows the trap depth (E_a) values and figure 4.3 shows the frequency factor (s) values.

Table 4.1 The values of the carrier population in traps ($\mathbf{n_0}$) of Fluka samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	0.1393×10^7	0.3250×10^6	0.5051×10^6
P_2	0.2279×10^7	0.4201×10^6	0.7556×10^6
P_3	0.8580×10^6	0.1906×10^7	0.2481×10^7
P_4	0.4793×10^7	0.2250×10^7	0.9941×10^6

Table 4.2 The values of the activation energy $\mathbf{E_a}$ (eV) of Fluka samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	0.7843	0.7283	0.7542
P_2	0.6438	0.6962	0.6844
P_3	1.1270	0.5246	0.5462
P_4	0.6051	0.7896	0.9122

Table 4.3 The values of the frequency factor s ($\mathbf{s^{-1}}$) of Fluka samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	0.1780×10^2	0.1589×10^2	0.1668×10^2
P_2	0.1258×10^2	0.1366×10^2	0.1344×10^2
P_3	0.1712×10^2	0.6068×10^1	0.6793×10^1
P_4	0.8749×10^1	0.1274×10^2	0.1564×10^2

4.4.2 Kinetic parameters of Aldrich sample

In this analysis,all our glow peaks were fitted to two peaks which are first order kinetics given in figure 4.34and 4.36 and two of them (peak1 and peak2) are low temperature peaks, third of them (peak3, peak4 and peak5) are high temperature

peaks but figure 4.35 have two peaks one of them is low temperature peak and the other one is high temperature peak.

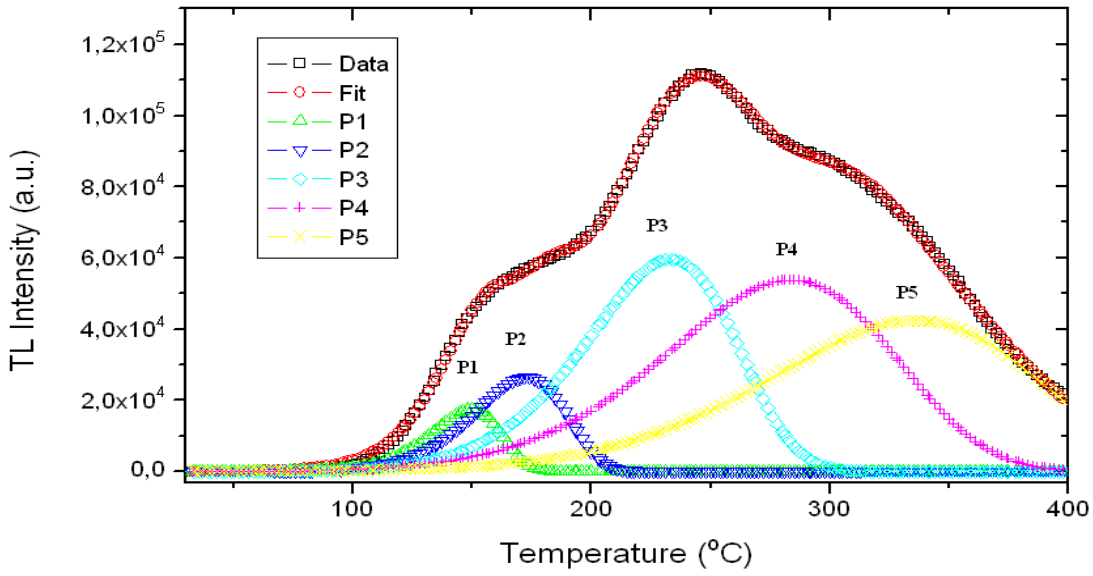

Figure 4.34 A typical analyzed glow curve of Aldrich quartz crystal waiting 512 hours in dark room, measured after ≈ 70 Gy irradiation at RT.

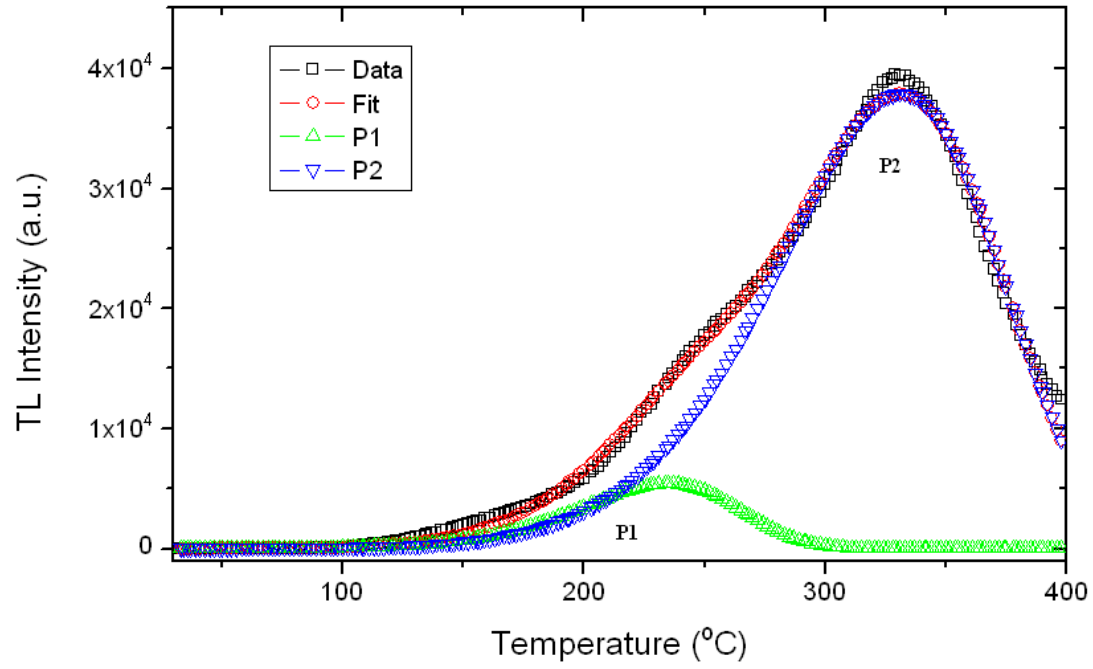

Figure 4.35 A typical analyzed glow curve of Aldrich quartz crystal waiting 512 hours in fluorescent light, measured after ≈ 70 Gy irradiation at RT.

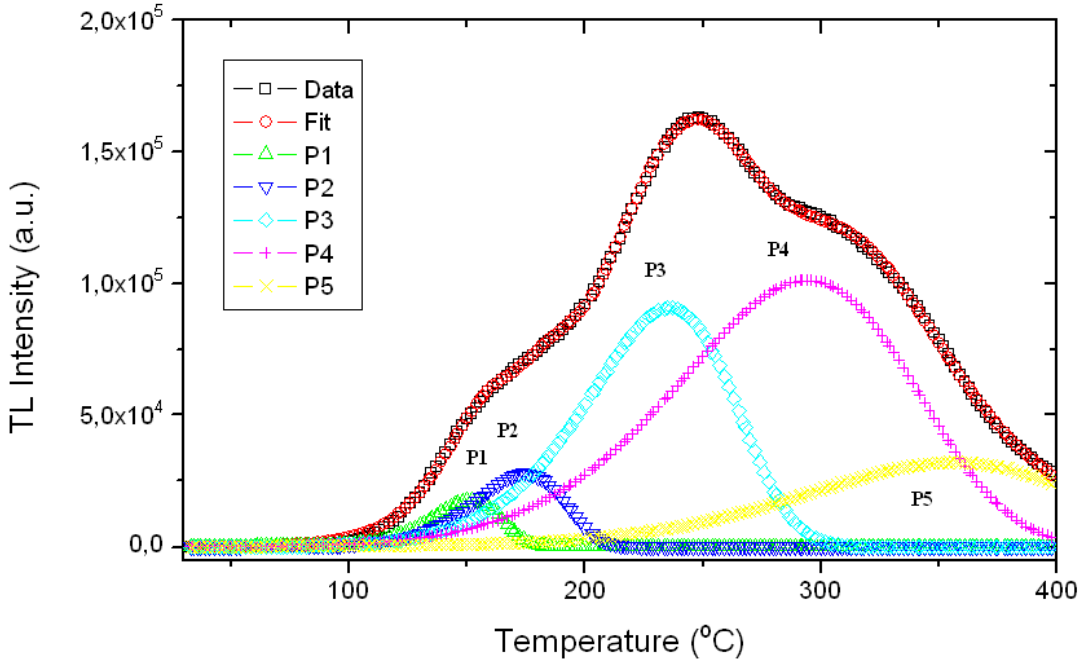

Figure 4.36 A typical analyzed glow curve of Aldrich quartz crystal waiting 512 hours in tungsten light, measured after ≈ 70 Gy irradiation at RT.

The kinetic parameters of Aldrich samples are shown in table 4.4, 4.5 and 4.6. Each table shows different kinetic parameter values, table 4.4 shows the carrier population values in the traps (n_0) and we gave n_0 values for low and high temperature peaks for three conditions, figure 4.5 shows the trap depth (E_a) values and figure 4.6 shows the frequency factor (s) values.

Table 4.4The values of the carrier population in traps ($\mathbf{n_0}$) of Aldrich samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	0.6555×10^6	-	0.6658×10^6
P_2	0.1318×10^7	-	0.1359×10^7
P_3	0.4778×10^7	-	0.7250×10^7
P_4	0.6430×10^7	0.4505×10^6	0.1261×10^8
P_5	0.5930×10^7	0.4446×10^7	0.4636×10^7

Table 4.5The values of the activation energy $\mathbf{E_a}$(eV) of Aldrich samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	1.0420	-	1.0540
P_2	0.8608	-	0.8863
P_3	0.6684	-	0.6776
P_4	0.5171	0.6396	0.5128
P_5	0.5202	0.6303	0.5337

Table 4.6The values of the frequency factor s ($\mathbf{s^{-1}}$) of Aldrich samples which were waited 512 hours.

PEAK NUMBER	DARK ROOM	FLUORESCENT LIGHT	TUNGSTEN LIGHT
P_1	0.2291×10^2	-	0.2608×10^2
P_2	0.1941×10^2	-	0.1999×10^2
P_3	0.1183×10^2	-	0.1196×10^2
P_4	0.6844×10^1	0.1107×10^2	0.6514×10^1
P_5	0.5813×10^1	0.8203×10^1	0.5697×10^1

CHAPTER 5

CONCLUSION

Fading is the process in which there is unintentional loss of the latent information, that is, its response. The TL-signal decreases, or fades, over time. Inthis work the glow curves of Fluka and Aldrich samples, which were kept in three different conditions, after β irradiation about 70 Gyat room temperature were investigated and two main peaks were studied between 100 ^{o}C and 200 ^{o}C and between 200 ^{o}C and 300 ^{o}C. It is well known that the thermal treatment highly affects the intensity of TL glow curves and for fading the storage time also affects the intensity of TL glow curves. We observed the effect of storage time and light on TL glow curves. We used three different conditions, each of the threemediaaffectedin different ways.

In dark room there is no light to affect the fading time so fading proceededmore slowly and samples waiting in fluorescent light faded more than samples waiting in tungsten light so we can understand easily light is the effected way for fading.

For Fluka samples, we observed that the fading of thermoluminescence peaks had changed depending on time and the effect of environment like light.For two samples which were waited in fluorescent and tungsten light, we observed that the peak intensities were decreased faster than the samples waiting in dark room (see figure 4.1-6).If the storage time was increased, the maximum peak temperature was also increased but the intensity was decreased and the peaks at low temperature were close to each other.All these observations are valid for three mediums.

For Aldrich samples, if the storage time was increased the maximum peak temperature was not changed so much but the intensity was decreased.If the storage time was512 hours the low energy traps were faded all of their electrons, these cases were observed for three medium (see figure 4.1-6). The TL peak intensity value of Aldrich samples were higher than the TL peak intensity value of Fluka samples and

the rate of decreases of Aldrich samples were also higher than the rate of decreases of fluka samples. Kinetic parameters were observed for Fluka and Aldrich samples which were waited 512 hours in three different conditions and n_0 value of Aldrich samples were higher than n_0 value of Fluka samples for three conditions.

In this thesis the fading of thermoluminescence peak intensities were surveyed in three different environments which are dark ambient, tungsten light and fluorescent light by using two different synthetic quartz crystals. We sawan expectedeffect and light is effective way for fading of TL peak.

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