DISCUSSION

Thermoluminescence is the property possessed by many materials, absorbing energy from a field of high energy radiation and being able to emit some of the energy as visible (near ultraviolet or infrared) radiation if subsequently heated with uniform heating rate. A measurement of the emitted light serve as a measure of absorbed dose in the radiation field. During the last fifteen years TL has attracted the attention of a large number of workers, particularly in the applied branches of research. The major applications of this phenomenon are in Radiation Dosimetry, Geology and Archaeology. Forensic scientists have attempted to use the technique in the identification of certain types of evidentiary materials.

The TL dosimetry TLD has become an accepted method for the measurement of absorbed dose resulting from the passage of ionizing radiations, (alpha, beta, gamma, and X-rays). The method is valuable particularly when the need is for a detector ; which is small, does not require connection by leads to other equipment, gives minimum disturbance to the radiation field and which is acceptable even when the measurement is not made for a little more time after the receipt of the dose.

In view of the NIOSH[22] report recommending standards for UV exposures and likely adoption of similar standards, it was expected[23] that new techniques and instruments would be needed to measure low level UV radiation. As a result of the persistence of large number of dosimetry workers, different techniques for the measurement of low level UV radiation are now available.[3-5, 24-29] According to their conclusions, TLD is by far the most suitable dosimetric system for UV dosimetry.[24-26] Many investigators in different radiation laboratories have undertaken and studied UV TL dosimetry through different aspects. From their experimental results, the essential basic requirements of an efficient UV TLD - material have been established. The basic conditions that TL phosphors must satisfy for its efficient performance as UV TLD - material are as follows.[24-26]

1) Direct response to UV light.
2) Simple trap distribution, high concentration of trapping sites and a long storage of trapped charges at normal working temperature (large trap depth)
3) High intrinsic TL efficiency
4) TL spectrum of wavelengths in the wavelength region 300 - 500 nm in which the photomultiplier tube responds well.

5) Large measurable dose range.
6) High storage stability or negligible fading.
7) Insensitive to room light.
8) Reporducibility, small size, low cost, easy availibility etc.

Thus, the TLD - material for UV dosimetry has been selected by trial and error method with the hope of combining as many of the above mentioned requirements of an efficdent TLD - material in a single material as far as possible. The UV dosimetry using intrinsic thermoluminescence is the most recent growing field. The dosimetry workers are actively engaged in exploring the better and better UV induced TL material for estimation of radiant exposure of UV radiation. In the present work attempt has been made to examine NaCl:Ca material as TLD - phosphor for UV dosimetry.

Apart from applied researchers a number of workers are studying the thermoluminescence phenomenon with a view to understand the mechanism of TL emission in different solids. As a result of an extensive work in this area, a lot of insight into these processes in various phosphor systems is now available. However, the understanding is by no means complete. The general outline of the understanding of this phenomenon is as follows. In the process of irradiation of an inorganic solid, electrons and holes are created. Most of them recombine and recombination energy is either emitted as fluorescence or is dissipated in the form of heat, Some of the electrons and holes are trapped at charge deficiency points, which are known as electron and hole traps. A fraction of the absorbed energy is thus stored in the material. These trapped charges are released in the process of heating. Trapped charges, depending on the environment around them are released at different temperatures. The released charge of one type moves freely in the crystal lattice and recombine with an opposite charge and the recombination energy appears in the form of luminescence in the case of thermoluminescent phosphors.

The trapping sites can be divided into two groups. In one type of trapping only the charge deficiencies because of negative or positive ion vacancies and interstitials or various combinations of these at various lattice sites are involved. In the other types of trapping, intentionally doped impurities, either anionic or cationic are involved. Normally, these impurities are so chosen as to provide a charge imbalance at the site of this impurity.

The discussion in the present thesis is divided into two parts. The first part contains the results of the examination of the TL characteristics of UV irradiated (253.7 nm), Ca^{++} doped NaCl specimens prepared under different physical conditions, the proposed TL mechanism and the interpretations of the TL behaviour of various glow peaks. NaCl:Ca (T) exhibits high intrinsic TL output with a well defined glow peak at 167° C, the intensity of which is found to be high compared with routine TLD - material, such as LiF TLD - 100. The study of dosimetry properties of this material with special reference to the peak at 167° C forms the second part. The utility of the NaCl:Ca (T) as a UV dosimetry material is discussed.

A. Thermoluminescence (TL)

The thermoluminescence phenomenon was known since long, but real interest in it started with the realisation of its usefulness in Radiation dosimetry. The phenomenon of TL is closely related with colour centre studies specially coloration due to irradiation with ionizing radiation (X-ray, α-, β-, γ-, radiations). In this respect alkali halides have been studied extensively. Some work on TL of alkali halides, other than LiF is also known but these phosphors did not find any place in radiation dosimetry, due to their low sensitivity. However, lot of study has gone into finalising the nature of the traps and various workers have come out with different models.[30,31] Knowledge of the nature of traps is useful for the understanding of the TL process. In what follows the TL processes in alkali halides as reported in the literature are presented in brief.

TL is comparatively weak in pure alkali halides. The study of F centre formation in these phosphors has shown presence of two stages. The first stage is suggested to be due to the trapping of electrons at already existing negative ion vacancies in the crystal. The second stage of F centre formation is attributed to the creating and filling of negative ion vacancies during irradiation with ionizing radiation. Correlated studies between F centres and the TL peaks in various alkali halides have shown clearly that two different peaks are associated with two stages of F centre formation. The hole trapping is normally explained to be due to the interstitials (alkali atoms at interstitial sites). The trapped holes are released in the TL reading process which combine with the electrons at the F centre sites giving rise to emission.[32-35]

It is normally observed that the activation energy is characteristic of a TL peak. From this activation energy study of various glow peaks in NaCl, Bonfiglioli[36] found that a number of peaks had the same activation energy. This he interpreted as due to varying capture cross-section of luminophore centres. These are the centres where F centre electron recombines after thermal release. Studies of activation energies of TL peaks in KBr crystals suggest a possibility of isoelectronic centres in different environments being responsible for various TL peaks.[37]

A lot of work on impurity doped alkali halides is also known. The most widely studied doping is that of thallium (Tl^{+}) in a number of alkali halides. Thermoluminescence process in Tl^{+} doped alkali halides is well understood due to the fact that Tl^{+} is known to exist in monovalent form (Tl^{+}) substitutionally. Characteristic absorption and emission bands of this impurity ion in these lattices are well known. On irradiation the monovalent Tl^{+} ion either gets reduced to Tl° atom or gets oxidised to a divalent Tl^{++} ion. Correspondingly, holes or electrons are trapped elsewhere in the crystal. On heating, the holes are released which combine with the trapped electrons at Tl°

sites. The resulting Tl^+ ion is left in a excited state. This excited Tl^+ ion relaxes giving its characteristic emission.[38,39] Work of Dutton and Maurer[40] shows association of various TL peak with hole centre.

Alkali halides with divalent impurity have also been studied. Work on Calcium doped alkali halides has shown association of certain TL peaks with the impurity.[41] Doping with other divalent ions in alkali halides has also revealed similar features.[42,43] As a result of divalent doping in alkali halides, defects known as Z centres are produced of which the divalent impurity is an integral part. Many workers have attributed the recombination sites to Z centres and the emission is ascribed to the impurity.[44,45] Though considerable work has been done on alkali halides, the TL mechanism in terms of creation and thermal bleaching of Z centres in divalent activated alkali halides is not so well understood.

Ionizing radiations are extensively used in coloration and thermoluminescence research work. Normally, the sources of ionizing radiation used are X - ray machines, accelerators, UV sources and radionuclides. In the present work the specimens were irradiated by ultraviolet rays to obtain TL from the material. UV radiation is one of the most common types of ionizing radiation that is used often in biochemical and other research work. Therefore, at this stage it is worthwhile to dwell on the present stage of understanding regarding UV induced generation of colour centres as well as thermoluminescence.

A survey of the literature shows that many types of electron - and hole - trapped centres are generated when alkali halide crystals are irradiated by highly energetic radiation like, X - rays or gamma - , beta - , and alpha - rays. Comparatively, little work on generation of colour centres using UV light has been reported. In 1930 Smakula[46] showed that F centres can be produced when alkali halide crystals are excited with light in their fundamental absorption called the exciton bands. Luschik and his co-workers[47] and Chiarotti and Inchauspe[48] observed F and V absorption bands by UV irradiation. Parker[49] repeated the smakula effect and concluded that the F - centres are produced by excitons. Johnson and Williams[50] used hydrogen discharge lamp for multiple excitation of KCl:Tl at 80° K and observed F and V centres. Thus UV coloration of alkali halides has been known for a long time.

However, it was generally considered to be the property of the impure crystal i.e. filling of existing vacancies rather than the creation of new ones. However, later it was demonstrated experimentally that nominally pure crystals can also be coloured by exposure to UV radiation.[51-54]

Widemann and Schmidt[55] in the year 1895 first observed the stimulated TL in virgin $CaSO_4$:Mn phosphor on exposure to radiations from a condensed spark in air. Lymen[56] later established the nature of these special radiations as UV component between 300 Å to 1300 Å of the spark spectrum to which air is partially transparent. Since then not much work[57-59] has been done on direct UV induced thermoluminescence compared to other ionizing radiation induced. TL. Several research workers[60 - 63] have studied the UV - transferred TL from partially annealed gamma irradiated phosphors. Direct UV - induced TL has not found much favour due to poor sensitivities of most of the well known TL phosphors. However, looking to the need of UV radiation users, TL workers concentrated their efforts to grow the materials such that they respond directly to UV light. Health physicists at BARC[64-66] developed the techniques to prepare the TL materials which are sensitive to UV radiation. They also compared the intrinsic TL sensitivities of different TL phosphors.

Considerable amount of experimental work has been done on UV - induced thermoluminescence in alkali halides in the author's laboratory during past two decades.[20, 67-74] Pure and monovalent Thallium activated Potassium and Sodium Chloride, and Potassium Bromide have been studied for their TL behaviours on direct UV excitation. TL characteristics of divalent Sr^{++} doped KCl and NaCl have also been investigated in detail after UV excitation. Examination of the UV - induced TL, exhibited by these phosphors, prepared under various physical conditions, lead to the following conclusions.

The room temperature excitation of Thallium activated alkali halides in general, creates the F centres under irradiation with UV light. Of course, they are produced in small number compared to other ionizing radiations like X - rays and gamma rays. Heating of the specimen thermally bleaches the F centres and the released electrons recombine with holes at TL centres emitting light in the visible range.

When the divalent metal impurity ions are incorporated into an alkali halide lattice, they go in substitutionally for alkali ions.[75,76] Because of the requirement of charge neutrality, the divalent cation addition is accompanied by the introduction of an equal number of positive ion vacancies. At low temperatures, a large number of divalent ion-positive ion vacancy pairs (dipoles) are found as their formation lowers the energy of the crystal.[77] The dipole association is optimum around 300° C and decreases with increase in temperature. Besides this, based on their experimental observations in different fields other investigators[75, 76, 78-85] have established the fact that at room temperature, most of the divalent cations and cation vacancies are present in the form of electric dipoles rather than free entities. Further, they reported that these impurity vacancy (I-V) dipoles form higher complexes under the different physical conditions.

It has also been suggested that the deliberate introduction of divalent cation in monovalent crystals of alkali halides, markedly influences the kinetics of TL which is different from that exhibited by monovalent impurity doped alkali halides after irradiation. The correlation between thermal annealing of

Z_1 centres and occurence of specific thermal glow peak has been reported in system NaCl:Ba, NaCl:Ca, KBr:Ca, KCl:Ba and KCl:Ca[86 - 89] systems. The suggested models for Z_1 centre was an F centre with I - V dipole in its vicinity[90]. It has been established that divalent impurity doped alkali halides Z_1 centre, a strongly perturbed F centre, play a role similar to that of F - centre in the TL processes[86-89] of monovalent impurity doped alkali halides.

On the basis of the above mentioned present understanding of TL in divalent impurity doped alkali halides, the following[91] mechanism in TL emission has been proposed. An exposure of divalent doped NaCl to ionizing radiation releases electrons in the lattice with simultaneous creation of Cl° atoms in the neighbourhood of the I-V dipole. An I-V dipole together with an adjacent negative ion vacancy is supposed to constitute a TL centre. The negative ion vacancy and the divalent impurity of the TL centre capture one electron each released in the lattice. Following Crawford and Nelson mechanism[92] one of the Cl° atom relaxes into the cation vacancy of the dipole forming a Cl_2 molecule oriented along $\langle 100 \rangle$ direction. The Cl_2 molecule is stable above room temperature[93]. Warming up of phosphor to higher temperature induces thermal bleaching of F centre which leads to electron-hole recombination at the hole site (Cl° atom). The recombination energy being very small, the excess energy is transferred to the adjacent divalent impurity ion raising it to the excited state. The characteristic TL emission of the impurity is displayed when the excited impurity ion returns to the ground state. The TL mechanism described above is for gamma irradiated divalent activated NaCl. The behaviours of the glow peaks observed in the present work and the models of the TL centres associated with them are discussed in the following sections.

1. 100° C Glow Peak :

It is clearly observed from Fig : 1 that virgin Sodium Chloride powder displays well defined peak at 100° C after a test UV dose of 2.4×10^4 Jm^{-2}. It is interesting to note that the peak does appear in as - obtained Ca^{++} doped NaCl specimen after a standard UV dose. However, its intensity decreases with the increase in the concentration of Ca^{++} (Figs : 1, 4, 7 and 10). It is believed that the 100° C peak is the characteristic of untreated or virgin NaCl. As per manufacturer's data, the unavoidably present impurities in NaCl base material are those of Ca^{++}

and Mg^{++} group. It is reasonable to presume that these inherent divalent impurities may be responsible for the occurrence of thermoluminescence (TL) in pure NaCl. It is proposed that the close association of an inherent impurity dipole (I - V) with an adjacent negative ion vacancy forms the TL centre responsible for 100° C glow peak. Further, since the material in the condition as - obtained from the manufacturers is supposed to have been annealed and cooled slowly, it may be inferred that the dislocation content in such a material is low. It is therefore suggested that a complex formed by a dipole adjacent to a negative ion vacancy in the dislocation - free region acts as TL centre for 100° C glow peak in the virgin NaCl powder. The association of the vacancy with the dipole is presumed on the basis of the volume consideration to reduce the strain energy in the lattice.

The TL glow curves were recorded for the virgin NaCl after a standard test dose (2.4×10^4 Jm^{-2}) in the consecutive heating runs. It is seen that the intensity of 100° C glow peak increases with the successive heating runs. It may be noted that unlike in virgin NaCl, the intensity of 100° C peak decreases in the subsequent heating runs in the case of thermally treated NaCl (Fig. 2). This feature can be explained on the basis of the proposed model for 100° C peak. It is an accepted fact that in virgin NaCl specimen large content of the inherent impurity remains in a precipitated phase. During first thermal cycle the specimen is heated to 400° C and then rapidly cooled to room temperature to record the subsequent TL glow curve. This thermal treatment appears to dissolve the precipitated impurity in the base material. The dissolution and redistribution of the impurity is presumed to be responsible for the enhancement of the intensity of 100° C glow peak due to thermal cycling in virgin specimen. Obviously, the same is not the situation in the heat treated NaCl specimen, because the thermal pretreatment would have already redissolved the precipitated inherent impurity in the specimen. In addition to this, the thermal treatment would increase the dislocation content in the crystal. Under such condition it is believed that thermal cycling will induce migration of either a component or components of the TL centre to the dislocation sites and thereby reduce the number of TL centres situated in the dislocation - free region of the lattice. This decreases the intensity of 100° C glow peak in the subsequent heating runs.

In order to investigate the behaviour of 100°C glow peak under different physical conditions of preparation, the TL glow curves were recorded for 550 and 750°C annealed and quenched NaCl specimens after 2.4×10^{4} Jm^{-2} UV dose under identical experimental conditions. The data for the specimen quenched from 550°C is presented in Fig. 2. It is observed that the peak intensity is enhanced due to the thermal treatment. When the specimen is quenched from 750°C (Fig. 3), the peak is found to be absent probably because it is overshadowed by the neighbouring higher temperature peak. This feature namely, 100°C peak is favoured by thermal pretreatment, is also observed in the case of thermally treated NaCl:Ca specimens containing different Ca^{++} - concentrations (Fig. 4 - 12). This result can be explained on the basis of the redistribution of the impurities and change in the defect pattern of the host material (NaCl) due to thermal treatment. It is natural to presume that in the samples quenched from higher temperature the impurity would be distributed uniformly in the volume of the specimen. Correspondingly the number of the TL centres responsible for 100°C peak will increase with the increase in the quenching temperature.

On the basis of the data available one can also explain the effect of thermal cycling on various samples examined. It is seen that the thermal cycling induces increase in the strength of 100°C peak in the glow curve of as-obtained NaCl:Ca specimen. On the other hand, the height of the 100°C peak decreases with thermal cycling in the case of specimens quenched either from 550 or 750°C . In as-obtained specimen there will be precipitated impurity which is redissolved during successive heating runs and hence the 100°C peak grows in intensity. In the case of quenched specimens, besides the uniform distribution of the impurity there will also be "forzen -- in" vacancies in the specimen. The presence of excess vacancies will enhance the diffusion of impurities leading to their condensation on the dislocation or precipitation out of the lattice. As a result, the number of TL centres will decrease due to thermal cycling and consequently the 100°C glow peak will be suppressed.

Examination of the TL glow curves of plastically deformed pure and Ca^{++} doped Sodium Chloride (Figs. 13 - 15) clearly indicates that the peak at 100°C is absent in such specimens. This data is in accord with the proposed model for the 100°C

TL centres namely, the TL centres are situated in the perfect regions of the specimen. Since the TL emission spectra of UV irradiated 750°C air - quenched NaCl could not be recorded on account of poor intensity, the inference regarding the TL centre associated with the glow peak in 100°C region, in UV and gamma irradiated NaCl specimens, is drawn from the glow curve studies of gamma irradiated specimen. Correlated measurements on the TL emission and thermal glow curves of gamma irradiated (saturated dose 2.1×10^4 rad) thermally pretreated pure NaCl material Fig. 21 A; C_1, C_2 and C_3) indicate that observed weak glow peaks at 90°, and 147°C and dominant peak at 235°C are associated with two emission bands at 425 and 475 nm. On the basis of spectroscopic data these two bands can be ascribed to the presence of inherent divalent Mg^{++} or Ca^{++} impurities. It is suggested that the emission sites for 90°C TL centres could be either Mg^{++} or Ca^{++} ions. It may be noted that in 100°C region the peak at 90°C in gamma irradiated NaCl appears at 100°C in UV irradiated NaCl. In sum, it is believed that in UV irradiated NaCl the inherent impurities Mg^{++} or Ca^{++} could be one of the constituents of the TL centre associated with 100°C glow peak.

The examination of the behaviour of 100°C peak in the glow curves of 750°C quenched NaCl:Ca specimens under excitation with different doses of UV as well as gamma radiation shows that the strength of this peak increases with the increase of radiation dose. The experimental results for only 750°C quenched NaCl:Ca (10^{-3} m.f.) are presented in the thesis (Fig. 16 - 19). Fig. 20 depicts the saturation effect in the growth of 100°C at higher doses. The data concerning 100°C peak shown in Figs. 16 - 19 for UV irradiation are together presented in Fig.28. It can be inferred that the incorporated Ca^{++} impurity forms component of the 100°C TL centre. The increase in the dose increases the number of excited 100°C TL Centre which reaches saturation for an optimum dose.

2. 340°C Glow Peak :

It is observed that the dominant peak at 340°C appears in almost all untreated and pre-heat-treated pure and Ca^{++} doped NaCl after UV irradiation (Figs. 2 - 12). Its strength is maximum when the given specimen is air-quenched from 750°C. It is significant to note that this peak also occurs without irradiation in the glow curves for pure and Ca^{++} doped

NaCl specimens air-quenched from 750°C (Figs. 22 - 23).

The luminescence emission from annealed and non-irradiated phosphor during warm up of the specimen using uniform heating rate is known as Tribo or spurious thermoluminescence. The phenomenon has been studied in detail in the case of ceramics. Kathuria et al[93] examined the spurious TL in commonly used TLD - materials like LiF, CaF_2, $CaSO_4$ and $Li_2B_4O_7$: Mn . Since in the present work, 340°C glow peak occurs in NaCl and NaCl:Ca specimens air-quenched from 750°C without irradiation, it is inferred that the peak at 340°C is a spurious TL glow peak. The excitation of the centres responsible for this peak is probably initiated by non-radiative means which could be mechanical pressure during handling of the specimens. Compression, grinding, rapid crystallization, mechanical disturbances during stirring and spreading of the phosphor on the heater plate have been reported to excite the TL centres[93-95]. The mechanism for the occurrence of 340°C spurious glow peak is given below.

It is presumed that the mechanical excitation of the quenched NaCl or NaCl:Ca phosphors at room temperature involves production of electron - hole pairs which remain trapped at defect centres. When the temperature of the phosphor is raised the charge carriers are released from the trapping sites by thermal ionization which subsequently recombine at the recombination centres with the emission of photons. It is proposed that during heating of the specimen for the record of the TL glow curve, at about 300°C the oxygen present in the atmosphere begins to interact with the surface ions forming new recombination sites which results in the occurrence of the spurious TL glow peak around 340°C.

It is worth noting that in almost all irradiated as well as unirradiated specimens, the peak at 340°C disappears after the completion of first heating run (Figs. 2 - 12, 22, 23). It is believed that heating of the specimen to 400°C in the first thermal cycle results in the thermal release of the trapped charges and their destruction by recombination. No spurious TL is therefore expected in the subsequent heating run.

It is also observed (Figs. 1 - 12) that the intensity of the 340°C glow peak is more in Ca^{++} doped phosphor. Further, the intensity rises with increase in Ca^{++} concentration upto 10^{-3} m.f. and then drops down with further increase in Ca^{++} concentration.

The increase in the intensity of the spurious glow peak (340°C) in heat - treated NaCl:Ca compared to NaCl may be the result of the formation of additional recombination centres favoured by the distortion produced in the lattice due to the presence of impurity ions.

Figs. 28 and 41 clearly indicate that the spurious glow peak (340°C) is prominently seen under UV irradiation or exposure to low gamma doses. It is absent or suppressed under exposure to higher gamma dose (Fig. 20). It is believed that the nonoccurrence of 340°C glow peak in gamma irradiated air-quenched NaCl:Ca phosphors is due to overshadowing of the peak by the neighbouring dominant 147°C glow peak. Further, the strength of the peak for different UV or low gamma doses reaches saturation at the height which is comparable with that obtained for non - irradiated Ca^{++} doped specimen (Fig. 23). This suggests that the intensity of 340°C peak does not depend on the quantity of the radiation dose. This corroborates the nondependence of the occurrence of 340°C glow peak on irradiation.

The effect of deliberate plastic deformation on the behaviour of spurious peak has also been examined

(Figs. 13 - 15). It is found that the peak is highly sensitive to mechanical pressure. Plastic deformation enhances the intensity of 340°C glow peak substantially in both 'pure' and Ca^{++} doped NaCl specimens. The most important feature is that the peak recurs in second and third cycles in the cases of compressed tablets which is not so in powder specimens. This feature is also observed in unirradiated NaCl or NaCl:Ca tablets. Ofcourse, the intensity was found less compared to that for UV or gamma irradiated specimens. These results are not presented in the thesis. At this stage it is difficult to offer explanation to these experimental results. It is obvious that mechanical compression plays an important role in the occurrence of 340°C glow peak. Further study would shed more light on the above mentioned feature.

3. 137 and 230°C Glow Peaks :

In the glow curves of NaCl:Ca a well defined peak at 137°C appears only when the specimen is lightly doped (Ca^{++} concentration $\simeq 10^{-4}$ m.f. , Fig. 4). The peak is not favoured in specimens with higher Ca^{++} concentration. This suggests that the 137°C glow peak is a characteristic of lightly doped

NaCl material. The occurrence of 137°C peak alongwith 230°C peak also takes place in thermally treated undoped NaCl (Figs. 2 and 3). It may be noted that a broad peak at 167°C developes alongwith shoulders at 137 and 230°C in the first thermal cycle of 750°C quenched NaCl material (Fig. 3). The peak at 167°C disappears in the second heating run and instead the peaks at 137 and 230°C show up as well defined peaks. Since the peak at 137°C is observed with enhanced intensity in Ca^{++} doped NaCl (Fig. 6), it appears that the generation of the peak may be associated with the presence of Ca^{++} impurity. It is not possible to state the type of impurity responsible for the occurrence of 230°C peak. The 230°C peak does not seem to depend directly on the incorporation of Ca^{++} impurity in NaCl. However, generation of 137 and 230°C peak at the cost of 167°C peak in undoped NaCl leads one to believe that like 137°C peak, the 230°C peak may also be associated with inherently present Ca^{++} impurity. In the discussion that follows it is shown that the 167°C peak is the property of Ca^{++} impurity.

Since the peak at 137 and 230°C grow at the cost of 167°C it can be concluded that there is generic relationship between these three glow peaks.

It is proposed that the three peaks result from the electronic transitions in the TL centre which is a complex formed by the association of an impurity with a single negative ion vacancy. The difference in the three TL centres lies in the configuration of the components. It is seen from Fig. 3 that the generation of glow peak at 167° C is favoured in 750° C air - quenched NaCl specimen. In such a specimen the dislocation content will be enhanced by resulting thermal strains. It is presumed that 167° C glow peak is due to TL centre located in the dislocation region with negative ion vacancy component occupying the nearest neighbour (nn) position to the Ca^{++} dipole. It should be mentioned that there are evidences[80, 81, 96, 97] to believe that in the temperature range of extrinsic conductivity (i.e. below about 500° C) the dislocation cores in alkali halides are negatively charged. The negative charge on the dislocation is supposed to be induced by the surrounding cloud of negative ion vacancies. Because of the proposed presence of the negative ion vacancies in the neighbourhood of dislocation one may reasonably presume the dipole in the vicinity of the dislocation to have a negative ion vacancy as its nearest neighbour. At the end of the first thermal cycle the dipole may diffuse in the interior of the specimen either away from dislocation or may precipitate out at the dislocation site. In the former case the statistical probability for the negative ion vacancy to be positioned as a nearest neighbour (nn) to the dipole will be reduced. In such a situation, the dipoles which move away from the dislocation may locate themselves as the next - nearest - neighbours (nnn) or third - nearest - neighbours (tnn) of the single negative ion vacancies. Such centres are suggested to be responsible for the occurrence of 137 and 230° C glow peak respectively.

Thermal glow curves of lightly doped NaCl:Ca specimens quenched from 550 and 750° C (Fig. 5 and 6) indicate that the strength of 137° C glow peak increases with thermal pre-treatment. The intensity of the peak depends on the quenching temperature. The enhancement in the intensity of the peak with quenching temperature is understandable on the basis of the increase in the dislocation density and in the Ca^{++} content resulting from the heat treatment. The preferential increase in the intensity of 137° C peak due to thermal cycling for 750° C quenched specimen (Fig. 6) takes place because of the easy diffusion of the dipoles to dislocation region due to presence of excess "quenched-in" positive ion vacancies.

The data presented in Fig. 4 to 6 indicate the effect of thermal cycling on as - obtained and heat-treated NaCl:Ca (10^{-4} m.f.) specimens. It is easily discernible that the effect is pronounced in the case of 750° C quenched specimen. In such a specimen the dipoles and vacancies will be uniformly dispersed in the volume of the specimen, ofcourse, much in excess of the equilibrium concentration at room temperature. The increase in the strength of the peak in successive heating runs can as before, be explained on the basis of significant dipole diffusion to dislocation sites due to large number of "frozen-in" positive ion vacancies. In the glow curves for as-obtained and 550° C quenched specimens (Fig. 4 and 5) one observes reduction in the height of 137° C peak and appearance of 100° C peak in the second and subsequent heating runs. As discussed earlier the 100° C peak is the property of the dipoles in the dislocation - free region of the specimen. Hence it is believed that due to thermal cycling there is a significant tendency to push the dipoles in the perfect regions of the lattice in the case of as-obtained specimen and to a smaller degree in 550° C quenched specimen. In both these specimens the removal of the strain and equilibrium concentration of the defects is attained rather quickly compared to that in 750° C quenched specimen. This may account for the stabilisation of the glow curve pattern after first heating run.

4. 185 and 260° C Glow Peaks :

Examination of TL glow curves presented in Figs. 4 to 12 for various specimens under exposure to UV radiation (2.4×10^4 Jm^{-2}) indicates that pretreated NaCl:Ca specimens in general exhibit a glow peak at 185° C. The increase in Ca^{++} concentration enhances the intensity of the peak. It is known that the incorporation of divalent cation impurity such as Ca^{++} produces isolated Ca^{++} ions, Ca^{++} dipoles either single or in clusters in solid solution in the specimen. Physical conditions of the preparation of the specimen markedly influence the strength of these entities present in the specimen. For instance, the process of aggregation of the dipoles will be more pronounced in a heavily-doped thermally quenched specimen. Since with the increase in Ca^{++} concentration, other conditions of preparation remaining identical, the intensity of 185°C glow peak increases, it is believed that the process of dipole aggregation may be associated with the generation of this peak. The hypothesis of the aggregation of dipoles in divalent impurity doped alkali halides has been corroborated by the work of Cook and Dryden.[79,80] Data presented in figs. 10 to 12 clearly demonstrate that for a given Ca^{++} concentration, the intensity of 185° C peak is lower for as - obtained specimen compared to that for thermally pretreated specimens. Further, between thermally quenched specimens (Fig. 11 and 12), the strength of the peak is higher for the specimen quenched from higher temperature. This is consistent with the concept of the aggregation of dipoles being associated with the occurrence of the peak. Because in a specimen quenched from higher temperature there will be more number of "quenched-in" dipoles alongwith isolated Ca^{++} ions and vacancies. The higher concentration of positive ion vacancies in the specimen will enhance the diffusion rate of the dipoles leading to significant aggregation in the bulk of the specimen. It has been reported in the literature that in divalent impurity doped alkali halides, dipoles develop metastable plate-like aggregates, stable beyond 150° C (Miyake and Suzuki).[98] Metastable aggregates of this nature may be responsible for the generation of 185° C peak.

The effect of thermal cycling on the behaviour of this peak was examined. It is observed from Figs. 10 to 12 that the change induced by thermal cycling involves marked decrease in the intensity of 185°C glow peak at the end of the first heating run. Since in each heating run the specimen is heated to around 400°C in the record of the glow curve, it is to be expected that the metastable aggregates associated with the 185°C peak will break-up into their constituents in the first thermal cycle. This obviously will lead to the suppression of 185°C peak in the second heating run. It is plausible that the dipole content in the specimen also attains equilibrium concentration at the end of the first thermal cycle in which the number of single dipoles and their aggregates remain in equilibrium with each other. As a result, the strength of the 185°C peak is not significantly affected in the subsequent heating runs.

The data presented in Figs. 14 and 15 exhibit the effect of deformation on the 185°C peak. It is seen that alongwith 185°C peak the plastic deformation also generates a glow peak at 260°C. The intensity of 185°C peak relative to 260°C peak is more for specimen with higher Ca^{++} concentration. Further it is of significance to note that the intensity of 185°C peak for deformed specimen shows a marked increase compared to that for undeformed specimen. It is therefore inferred that the 185°C TL centre presumed to be metastable dipole aggregates, are located in the distorted or dislocation regions of the specimen. Appearance of 260°C peak with 185°C peak in the glow curves for deformed specimen suggests that it may be the product of dislocation debris, created due to dislocation motion and dislocation multiplication, involving dislocations, impurity ions and vacancies.

It is seen from Figs. 14 and 15 that the deformation induced TL is considerably suppressed on the completion of the first heating run and the glow peak at 167°C becomes easily discernible in the second and subsequent heating runs (Fig. 15). It has been mentioned before that the TL centres responsible for 185°C peak are metastable dipole aggregates which break-up during thermal cycling. In the same way, the TL centres associated with 260°C glow peak also appear to be some type of metastable clusters, created from dislocation debris, which disintegrate on thermal cycling. The occurrence of 167°C peak in the second heating run (Fig. 15) is understandable on the basis of the break-up of dipole aggregates into constituent (single) dipoles. Creation of single dipoles in the dislocation region has been earlier suggested to be conducive to the generation of 167°C TL centres.

5. 167°C Glow Peak :

It is seen in Fig. 7 that the NaCl:Ca specimen as-obtained from aqueous solution with optimum concentration of impurity (Ca^{++} concentration $\simeq 10^{-3}$ m.f.) display a glow peak at 167°C on the ascending slope of the prominent peak at 340°C. The thermal annealing of the specimen at 550°C followed by rapid quenching to room temperature increases the overall emission under the glow curve (Fig.8). The emission under the glow peak at 167°C is further enhanced with the increase in quenching temperature to 750°C (Fig. 9). The distinguishing feature of the introduction of Ca^{++} at concentration 10^{-3} m.f. is the occurrence of a prominent glow peak at 167°C. It may be noted that the previously reported peaks attributable to the presence of Ca^{++}, at 137 and 230°C, are observed only in the glow curve for specimen quenched from 550°C (Fig. 8). It is mentioned before that the three peaks at 137, 167 and 230°C, are due to TL centres involving a dipole and a negative ion vacancy in proximity to each other however, differing in their configuration. It is of special significance to note that the 167°C peak is preferentially favoured when the specimen is quenched from 750°C (Fig. 9). This specimen with Ca^{++} concentration 10^{-3} m.f. quenched from 750°C is referred in the thesis as NaCl:Ca(T). The TL centre for 167°C peak is proposed to be a Ca^{++} dipole with a negative ion vacancy as its nearest neighbour both situated in the region close to the dislocation core. Genetically related TL centres attributable to 137, 167 and 230°C glow peaks will naturally appear more in number for any one peak at the cost of TL centres for other two peaks. In the specimen quenched from 750°C there will be dipoles, negative ion vacancies and dislocations more numerous in number compared to that in the specimen quenched from 550°C. Hence statistically it is more probable for a dipole and a negative ion vacancy to be nearest neighbour in the dislocation region.

The thermoluminescence mechanism associated with the occurrence of 167°C glow peak in NaCl:Ca(T) is suggested to be due to the removal of an electron from the Ca^{++} ion by multiple UV excitation. The freed electron gets trapped at the nearby negative ion vacancy in the proposed complex TL centre. After warming the specimen to around 167°C, the electron is released from its trap. The released electron then returns to its parent Ca^{++} ion in which process it first drops to the emission level of Ca^{++} ion and finally returns to the ground state with the emission of a photon.

The study of the influence of thermal cycling on the intensity of the 167°C peak shows that the peak height substantially decreases in the second heating run. Subsequent thermal cycling does not affect the intensity of the peak. As mentioned earlier, the variation in the intensity of the glow peak is suggested to be due to the change in the defect pattern leading to the lowering of strain energy in the lattice. The change in the pattern which involves annihilation as well as redistribution of the defects appears to have reached equilibrium situation at the end of first heating run. Hence there is no significant change in the glow curve pattern after second and subsequent thermal cycles.

The glow curves of 750°C annealed and air-quenched NaCl:Ca (10^{-3} m.f.) specimens exposed to varying UV and gamma doses were recorded (Figs.16-20) to compare the glow curve pattern and to estimate the measure of the radiation dose sufficient to record the TL emission. It is found that the glow peaks are at 100 and 167°C for UV irradiated specimens while at 100 and 147°C for gamma irradiated specimen. The intensities of these peaks are comparable upto 14 rad (gamma) and 9.6×10^{4} Jm^{-2} (UV) doses. It was not possible to record the TL emission spectra of the specimen for such low doses because of insufficient TL intensity. The gamma dose around 2.1×10^{4} rad for which the overall glow curve pattern is similar to that for gamma dose of 14 rad was found suitable to record the TL emission spectra. Hence the TL glow curves and the corresponding TL emission spectra of 750°C quenched pure NaCl and NaCl:Ca (10^{-3} m.f.) specimens were examined and the data obtained are presented in Fig. 21. It is clear from the figure that 100 and 235°C glow peaks in pure NaCl are associated with 425 and 475 nm emission which are characteristic of inherent impurities. The peak at 147°C in the glow curve of 750°C air - quenched NaCl:Ca (10^{-3} m.f.) specimen seems to be related to 375 nm emission. Since the TL emission at 375 nm observed in the present experiments can be identified with the characteristic Ca^{++} emission[13, 99] it is believed that the Ca^{++} impurity plays role as an emitter in the TL centre responsible for 147° C peak. As inferred earlier by comparison from Figs. 16 - 20, the glow peak at 167° C for UV irradiated specimen can be identified with glow peak at 147° C for gamma irradiated specimen. Hence the TL centre associated with 167° C glow peak is also presumed to have Ca^{++} impurity as one of its components acting as an emission centre.

B. Application of Intrinsic TL of NaCl:Ca (T) Radiation Dosimetry

Generally any TL phosphor which satisfies the fundamental requirements of an efficient TL dosimetric material (enumerated earlier), is standardised and then recommended for dosimetry work in radiation applications. The commercially available materials are not equally sensitive to different types of radiations viz., alpha, beta, gamma, X-rays and ultraviolet (UV). LiF is one of the popular present day dosimeter materials. Its responses to alpha, beta and gamma radiations have been reported to be excellent. The TL glow curves exhibited by commercially available LiF TLD - 100 under identical experimental conditions after standard UV (2.4×10^4 Jm^{-2}) and gamma

(6.5 x 10^2 rad) doses are presented in Fig. 30. The figure indicates that LiF TLD - 100 is not sensitive to UV radiation. Ofcourse, the material can be made sensitive to UV radiation by subjecting it to gamma irradiation and subsequently partially annealing it at elevated temperature[6-8,60-63]. This means that the material does not exhibit thermoluminescence by direct interaction with UV radiation. Thus the LiF TLD-100 material is not found to be suitable for use in UV dosimetry.

Recently, the work on pure and divalent impurity doped NaCl materials has been found useful in gamma and beta dosimetry[13,91,102]. The results and their analysis presented in part 'A' of the present thesis clearly suggest that the undoped NaCl material is quite sensitive to UV radiation. Fig. 31 represents the TL glow curves of undoped NaCl in as-obtained condition and after quenching from 550 and 750°C when subjected to standard UV dose (2.4 x 10^4 Jm^{-2}). It is seen that the TL output for 750°C air quenched NaCl is significant compared to the TL output for other two specimens. Incorporation of Ca^{++} in NaCl enhances the overall TL output (Fig. 32) and as mentioned earlier, the optimum TL output is obtained when the Ca^{++} content of the specimen is of the order of 10^{-3} m.f. Further, it is observed that between the specimens with 10^{-3} m.f. Ca^{++} concentration the one quenched from 750°C showed maximum TL output. This specimen therefore attracted special attention from UV dosimetry point of view. The dosimetric properties of this specimen were therefore examined in greater details. The observed dosimetric properties of the specimen, referred as NaCl:Ca (T), are described below.

The direct response to UV radiation (requirement No. 1) and high intrinsic TL efficiency (requirement No. 2) are essentially the basic requirements to be satisfied by any UV dosimeter material. The glow curves observed for untreated and pre-heattreated specimens (Fig. 32) clearly demonstrate that the thermal glow results from the direct interaction of the UV radiation with the phosphor.

Fig. 33 shows the intrinsic TL glow curves of standard dosimeter material LiF TLD-100 and the material being examined namely NaCl:Ca (T) under identical conditions after the standard UV dose of 6×10^{3} Jm^{-2}. The comparison of glow curves for the two phosphors obviously shows that the intrinsic

TL output in 167° C region for NaCl:Ca (T) is ten times more than that of LiF TLD - 100. This is equally true when the TL output of NaCl:Ca (T) is compared with that of another extensively studied dosimeter material namely, CaF_2. Thus the intrinsic TL sensitivity of the material examined is markedly higher compared to that of LiF TLD - 100 and also the material is quite suitable for use in UV dosimetric applications. The fulfilment of the condition of high intrinsic TL efficiency satisfies the requirement No. 2 of an efficient UV TLD material.

In part 'A', it is proposed that in NaCl:Ca (T) the centre responsible for peak-II (167° C) is a complex formed by the association of a Ca^{++} dipole with a nearest - neighbour negative ion vacancy in the dislocation region. Because of thermal shock due to quenching, these centres in NaCl:Ca (T) are expected to be more numerous in number which in consequence leads to the enhanced TL output at 167°C. The occurrence of single isolated peak II at higher temperature (above 150° C) with substantial TL output after UV irradiation (Fig. 9) suggests that the traps involved in the generation of peak - II (167° C) are single valued, larger in number and of considerable depth. Under such conditions the UV radiant exposure once registered will not be lost under normal working temperature, i.e. the storage stability of trapped charges is high. Further high intensity of the 167° C glow peak indicates significant intrinsic TL efficiency. Thus another important basic condition, namely, simple trap distribution with high concentration of trapping sites and significant storage of trapped charges at normal working temperature (requirement No. 3) is very well satisfied in the case of NaCl:Ca (T) .

It is observed from Fig. 33 that NaCl:Ca (T) displays a well defined peak at 167° C (peak II) alongwith a weaker and a stronger peak respectively at 100 and 340° C. Peak I (100° C peak) is not considered for dosimetry purposes due to its occurrence at lower temperature and variation in its position and intensity observed under normal changes in climate and/or room temperature. The higher temperature peak at 340° C is well defined and strong in intensity. Being at higher temperature it is expected to be thermally more stable than dosimetry peak (167° C). Therefore, it has higher application potential for dosimetric purposes. However, it is reported earlier that the peak at 340° C is a tribo or a spurious TL peak.

It is proposed to have its origin in mechanical excitation. Besides this, it reaches early saturation after which its intensity is not affected by the increase in the magnitude of the incident UV dose (Fig. 28). Therefore, in spite of being thermally more stable, the 340° C glow peak is not selected for dosimetric applications. The presence of spurious TL in a TL phosphor can cause a serious error in the evaluation of low doses. Fortunately, in NaCl:Ca (T) phosphor under study the UV radiation-induced glow peak (167° C dosimetry peak) and spurious TL glow peak (340° C) appear much apart on the temperature scale. Therefore, the presence of spurious peak does not significantly influence the UV radiation induced changes in the dosimetry peak.

The TL emission spectra of gamma irradiated NaCl:Ca (T), Fig. 21, brings out the fact that the TL emission in the temperature region around 130°C is at 375 nm, (147° C peak after gamma irradiation is identical with 167° C peak after UV irradiation), the characteristic emission of Ca^{++}. It is therefore presumed that the TL emission at peak II (167° C) is around 375 nm which falls in the sensitive region of the photomultiplier (300 - 500 nm) used as detector in the present measurements. Thus, the matching of the spectral distribution of TL emission from the phosphor with the spectral sensitivity of the photomultiplier, the requirement No.4 is fulfilled by the TL material under investigation.

For the selection of an efficient TLD material, direct response to UV radiation, high intrinsic TL efficiency, thermal stability and matching of the wavelength region of the TL emission and the sensitive region of the spectral response of the detector are not the only requirements. The exact and precise relationship between the TL output at dosimetry peak and the incident radiant exposure (dose) is the most important factor that mainly decides the use of TL material in radiation estimation and other applications. According to current understanding, the linear TL response i.e. TL intensity versus dose response is one of the chief requirements to be satisfied by the phosphor for its suitability as an efficient TLD material. Slight deviation from this linear TL response disqualifies the phosphor to act as an efficient TLD material. Figs.34 and 36 show the systematic growth of TL intensity of 167°C glow peak in NaCl:Ca(T) for UV dose in the range

10^2 to 10^4 and 10^3 to 10^5 Jm^{-2} respectively. The TL sensitivity of peak II (167°C) versus the UV dose (Jm^{-2}) is linear in both lower and higher dose ranges (Figs. 35 and 37). The overall TL response is linear up to 3×10^3 Jm^{-2} (Fig. 38). It is important to note that the TL response of the material being examined covers the large dose range of $10 - 10^4$ Jm^{-2} like other commercially available TL materials in use. The present material NaCl:Ca(T) gives linear TL response upto 10^4 Jm^{-2} (Fig. 38), which is high enough to cover most of the range of exposure of interest to UV radiation users. This complies with the requirement No.5 which makes NaCl:Ca (T) a suitable TLD material in UV dosimetry.

Since under the influence of different UV radiant exposures the shape of the glow curve remains same, it is natural to believe that the material does not undergo radiation damage. This is ofcourse understable because the UV photon has much low energy and consequently the material damage by exposure to UV radiation is ruled out.

An additional established fact that disqualifies any material for dosimetric uses is the decrease in the intensity of the dosimetry peak with decay time, a time gap between stopping of excitation and starting of TL recording. In radiation application this is referred to as fading. For an ideal dosimeter the TL intensity of dosimetry peak must remain constant over longer duration of decay. It is known that the thermal energy available at room temperature is responsible for such fading. The fading is more when the traps are shallower and less when the traps are deeper. Since the fading depends on the distribution of the traps which can be controlled through pre-heatreatment, it is possible to minimize the fading effect by adopting a suitable preheat - treatment.

The TL decay for peak II was examined for the UV irradiated NaCl:Ca (T) with a test dose 2.4×10^{4} Jm^{-2} stored at room temperature. Fig. 40 exhibit the plot of the decay time versus TL intensity of peak II. The decay time ranges from an hour to few weeks. It is clearly observed that the room temperature fading of TL output at peak II is negligible even after the post-irradiation period of one week. Obviously no anomalous fading is seen. This establishes the NaCl:Ca (T) as material of high storage capability with negligible fading which satisfies yet another fundamental condition (requirement No.6) of an efficient

TLD material.

Additional complications that have been considered in radiation dosimetry are the nature of detector and black body radiation signals. In the cases of UV dosimetry and low level gamma dosimetry, these two factors play important role in deciding the lowest detectable dose. The present experimental measurement involved highly sensitive standard TL reader whose different characteristics are well known[100]. There are no changes in the present measurements of any restriction due to detector unit on the recording of the TL signal from NaCl:Ca (T) phosphor. The black body radiation signals emanating from the sample and heating pan alongwith factual. TL from material during heating have been reported to be negligible below 250°C. In NaCl:Ca (T) material presently being examined dosimetry peak is at 167°C. This peak temperature is sufficiently high for the adequate stability, yet low enough to be free from black body radiation during heating. Besides this, black body radiations are also found to be minimized by recording them in oxygen free nitrogen gas. In the present experiments, the TL glow curves were recorded in nitrogen atmosphere and hence the black body radiation influence in the detection of UV dose is eliminated.

Yet another point to be examined precisely for the successful use of phosphor as TLD material is the energy dependence or the tissue equivalent. The number of photons absorbed in a given material depends on the incident energy. Further, it has been reported that the most convenient dosimeter is the one which absorbs radiation similar to a tissue. The energy responses for different standard materials have been studied by the health physicists. They concluded that for the determination of the dose of radiations at high or low energy, the energy responses of the phosphor must be considered for the proper estimation of exposure. Heywood studied this dosimetric property for NaCl. He reported that NaCl is not soft tissue equivalent and if used to measure absorbed dose in soft tissue with low energy radiation, careful calibration is necessary. However, NaCl dosimetrically is quite similar to bone and there will be situations in which this property can be turned to advantage. Thus the results reported also favour the use of NaCl:Ca (T) material in UV dosimetry.

The effect of daylight on the behaviour of dosimetry peak (167° C) was examined in the case of NaCl:Ca (T). It was observed that daylight exposure decreases the TL signal. Exposure to the light before UV irradiation has not resulted in any effect. In the present experiments the measurements were made in the dark. In a particular case, for instance, while examining the fading effect, the specimen was covered in a dark paper after UV exposure till its TL was recorded. This helped in satisfying the requirement No. 7.

The typical TL glow curves of NaCl:Ca (T) after irradiation with UV (6×10^3 Jm^{-2}) and gamma (1 rad) radiations are also recorded under same EHT setting of the recorder (Fig. 39). The figure clearly shows that the TL sensitivities for gamma and UV radiation are more or less identical. This suggests that with proper calibration it should be possible to express the UV sensitivity of NaCl:Ca(T) in an equivalent gamma dose (rad). The related calibration technique is described below.

Thermally stimulated luminescence (TSL) response of 147° C peak as a function of ^{226}Ra gamma exposure dose (low dose 500 m rad to 3 rad) in the case of NaCl:Ca (T) phosphor is shown in Fig. 41. It is clearly observed that the dominant peak at 147°C increases in intensity with the increase in gamma dose.

The TL intensity versus gamma dose is shown in Fig. 42. The same in Gy units is presented in Fig. 43. The TL response is observed to be linear in both the cases which justifies the use of NaCl:Ca (T) material in low level gamma dosimetry.

The data presented in Fig. 44 gives the TL sensitivity (dosimetry peak height) of NaCl:Ca (T) as a function of UV (Jm^{-2}) and ^{226}Ra gamma (Gy) dose. It is observed that both responses are linear. Fig. 45 represents the UV response of NaCl:Ca (T) in equivalent gamma dose (Gy). The estimation of UV exposure in Jm^{-2} can thus be made by simply knowing the TL signal in ^{226}Ra equivalent Gy. The above calibration measurement should prove very useful in the employment of NaCl:Ca (T) as a routine UV dosimetry material.

Examination of the different dosimetric characteristics of NaCl:Ca (T) material suggests that it fulfils the requirements of a good TLD material for UV dosimetry. The characteristics are : direct response to UV, high intrinsic TL efficiency, simple trap distribution, high concentration of trapping sites with deep traps, matching of TL emission wavelength from the phosphor with sensitive region of the detector, large measurable dose range, tissue equivalence and low fading. Additionally, reproducibility, easy availability at low cost, desired size and shape, ease of handling and reusability of the phosphor under study enhances its claim for use in UV dosimetry at 253.7 nm. The drawback of the material is its high hygroscopy which can easily be eliminated by preventing the atmospheric contact using sealed transperant PVC bags as enclosures.

The black body radiation and spurious TL are found to be important factors restricting the lowest detectable exposure. In some cases they are higher in powder samples. It is reported that the use of a single-piece dosimeter material and/or readout in an inert atmosphere, such as nitrogen, has been found to alleviate the contributions of the above factors in the total TL output.[102] In order to investigate this dosimetric characteristic of NaCl(T) and NaCl:Ca (T), the TL behaviours of the materials in the tabletted form were examined. They were subjected to a standard UV dose 2.4×10^4 Jm^{-2} under identical geometrical conditions in the experimental set-up. The experimental results are presented in Fig. 46. The comparison of TL behaviours of these specimens indicate that the tablets of lightly doped NaCl:Ca (10^{-4} m.f.) annealed and quenched from 750° C display isolated and prominent glow peak at 260° C. The pellets of NaCl annealed and quenched from 750° C exhibit broad peak around 340° C while those of NaCl:Ca (T) (10^{-3} m.f.) exhibit closely spaced peaks with maxima at 185 and 260° C.

The data presented clearly demonstrate that the use of NaCl:Ca (T) material in pellet form has certain advantages over its use in powder form. The specimen in pellet form exhibits enhancement in TL emission besides shift of the glow peak to higher temperature side. Thus both intensity of emission and thermal stability of the material increase if it is used in pellet form. It is of special significance to note that in NaCl:Ca(T) material concentration of Ca^{++} also plays an important role in deciding the suitability of the material for dosimetry purpose. The material with Ca^{++} concentration 10^{-4} m.f. only shows well defined dominant glow peak at 260° C. In view of high TL efficiency, thermal stability, ease of handling and negligible spurious TL as well as black body radiation, the pellets instead of powder of heat treated NaCl:Ca (10^{-4} m.f.) are suggested to be the suitable form of the material for UV dosimetry. Further work in detail is essential to standardise the use of NaCl;Ca tablets instead of powder as routine TLD material. Investigation of this aspect is contemplated in the future work.