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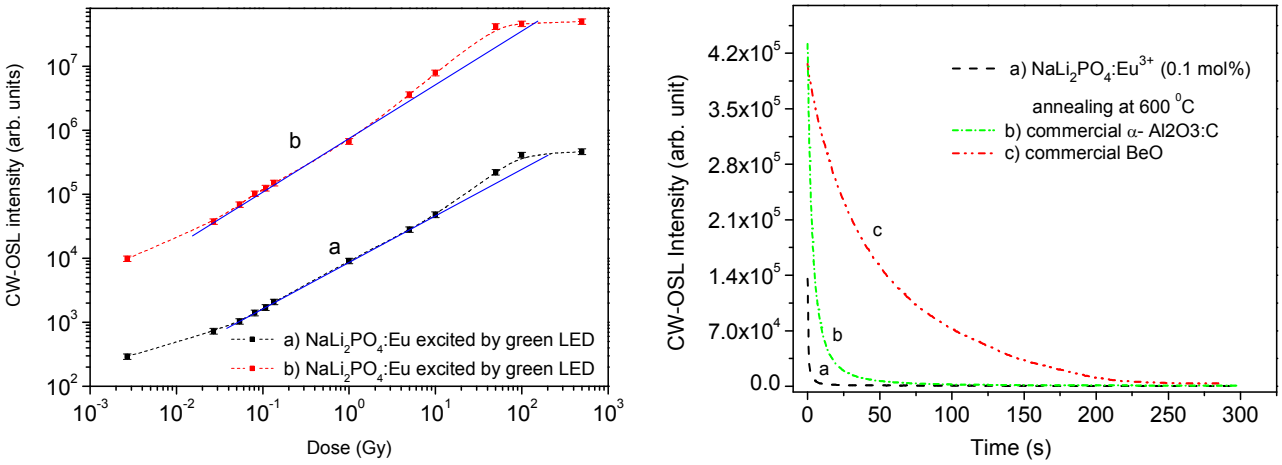
Graphical abstract:



A New High Sensitivity Na_2LiPO_4:Eu OSL Phosphor

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A New High Sensitivity Na_2LiPO_4:Eu optically stimulated luminescence dosimeter (OSLD) material was prepared by simple solid state diffusion method. The formation of the material was confirmed by comparing the experimental data with that of the available in the literature (JCPDF # 80-2110). Dosimetric properties of the phosphor material using continuous wave-optically stimulated luminescence (CW-OSL) technique have been studied. The material was studied for different concentration of the impurity and has also been given different heating treatments. The material doped with 1.0 mole% and annealed at 873 K is found to be the most sensitive. The phosphor has found to have all the good dosimetric characteristics, such as, tissue equivalent (low-Z, $Z_{eff.}$ ~10.8) high sensitivity (~3 times less than the commercially available Al_2O_3:C Landauer Inc., USA and BeO, Thermalox® 995, Materion INc., USA), low fading (~6.2% in 40 days), wide range of dose response (0.1–1.0 kGy), excellent reusability, easy optical bleaching (annealing) for its reuse, etc., which makes the material useful for dosimetry of high-energy radiations using OSL. The advantage of our OSLD phosphor is the easily available and inexpensive ingredients and a very simple method of preparation that makes it cost effective as compared to the commercially available OSLD phosphors. Also, it is easy to handle unlike that of the Thermalox® 995 (BeO) dosimeters which are very much toxic, requires special method of preparation and handling.

Introduction:

Optically stimulated luminescence (OSL) has established itself as an improved and more reliable technique for dosimetry of high-energy radiations. The technique is becoming more and more popular because of several advantages over thermoluminescence (TL) dosimetry, such as, completely optical nature of the instrumentation, possibility of online (in situ) measurements using optical fibre, low power consuming LED sources for stimulation, facility of reestimation of radiation doses in case of any doubts and over and above all no structural changes[1] unlike in some TLD phosphor materials due to heating that loses its reusability[2-5]. However, there is not much choice due to paucity of the commercially available OSL phosphors and high fading in others. The OSL phosphors available are also costly due to their difficult methods of synthesis. For example, for producing Al_2O_3:C[6,7], one needs to have very high temperature vacuum furnace as the doping of carbon is not possible in atmospheric environment; for producing another OSL phosphor BeO[8], needs special arrangements for its production and handling as it is very toxic to human beings.

The general requirement of a good OSL phosphor is that the emission should be between 350 and 425 nm (where most of the common detectors are most sensitive) and the defects (traps) should have a high photo-ionization cross section in blue–green region (450–550 nm) or IR region (650–800 nm). The

sensitivity of an OSLD phosphor depends on the kind of defects, stimulation sources and the availability of suitable filters and the detector (generally a wide band PMT). The tissue equivalent (low-Z) phosphors are better preferred due to their flat energy response and the suitability to use in a mixed radiation field. Attempts are, therefore, going on to study new (preferably low-Z) materials for their applications as OSL phosphors, such as, $LiMgPO_4$:Tb,B[9], Na_2SiF_6:Cu,P[10], Al_2O_3:B[11], $Y_3Al_5O_{12}$:C[12] Cu-doped quartz (SiO_2:Cu)[13], $LiAlO_2$[14], MgO:Tb[15], $NaMgF_3$:Eu[16], etc. However, all these phosphors are at the developmental level and the issues related to their sensitivity and fading need to be addressed before they are finally accepted as OSLD phosphors. More details and comparative study could be seen in some recent review papers[17-19].

In the present paper we report optically stimulated luminescence (OSL) and thermoluminescence (TL) studies of a new high sensitivity low-Z Na_2LiPO_4:Eu phosphor for its application for OSL dosimetry. Na_2LiPO_4:Eu is really a multifunctional advanced ceramic as it has already been proved to be a red phosphor for solid state lighting and display applications[20] and a high sensitivity TLD phosphor for dosimetry applications[21]. It was intuitive to study this material for its application as an OSL phosphor and it proved to be satisfying. The phosphor Na_2LiPO_4:Eu is found to have several 'good' characteristics, such as, Low-Z material, very easy method of preparation, nontoxic in nature, highly sensitive, linear OSL dose response over a wide range, low fading, excellent reusability, emission well separated (peaking at around 420 nm) from that of the excitation source (470 nm blue LEDs). The phenomenological studies have also been done to understand the process of OSL and a model for trapping and emptying and recombination of the traps with luminescence (hole) centres has also been proposed.

Result and discussions

XRD analysis

XRD patterns of the $NaLi_2PO_4:Eu^{3+}$ phosphor is as shown in Fig. 1. The peak positions in the diffraction pattern of the synthesized material were indexed by comparing them with the standard data available in the literature (JCPDF # 80-2110)[21] and found to be in agreement confirming the formation of the material. All the XRD peaks are indexed (h k l) for different lattice planes. The material is found to be in orthorhombic crystal system, with the space group Pmnb (62)[22]. Stick pattern of the standard data (JCPDF # 80-2110) along with the experimental one has also been given for a ready reference. No separate peaks corresponding to any impurity phase were observed at low concentrations (0.05 – 0.1 mole%) showing that the impurity has a good solubility in the matrix in this range. However, when the impurity concentration is increased beyond this range (< 0.2 mol%) new peaks corresponding to impurity clusters of monoclinic phase of Eu_2O_3 (JCPDF # 43-1009) were observed. This may be attributed to precipitation of the impurity ions forming clusters. Consequently, it has also been observed that the cell parameters and the cell volumes of the samples gradually decreased with the impurity concentration due to decrease in the crystallinity of the materials with addition of Eu_2O_3 phase[23]. This is very important from the application point of view as the precipitation of impurity clusters and/or the stress/strain developed due to changes in the cell volume could change the luminescence characteristics of the phosphor material[24]. The details of the study could be found in our earlier paper[25].

OSL measurements

Effect of excitation source

Two different excitation sources (~470 nm, 80 mW/cm^2, blue LED cluster and ~530 nm, 40 mW/cm^2, green LED cluster) were used for optical stimulation to see which one is more suitable. The results are as shown in Fig. 2. It could be seen that optical stimulation by blue LED yielded more (~3 times) OSL signal (intensity) as compared to that of the green LED for the samples irradiated for the nominal dose of 0.1 Gy. This shows that stimulation by blue light is more suitable than the green due to its photo-ionization cross section (as mentioned in Table 1). However, it is to be mentioned here that the power of the Green LED cluster at the sample is just half that of the blue LED cluster power at the samples. Therefore, it is difficult to conclude that the less OSL intensity in case the stimulation by green LEDs is due to the excitation energies as the power (excitation intensities) of the two different sources. However, further dosimetric studies were done using the blue LEDs only.

Effect of impurity concentration on the CW-OSL

Fig. 3 shows the effect of impurity concentration on the CW-OSL decay curves. From the figure it could be seen that the CW-OSL intensity is maximum for the impurity concentration (Eu ions) of 0.1 mol%. Doping the material with more Eu concentration shows quenching. It may be mentioned here that the same material when studied as a TLD phosphor showed maximum sensitivity for 0.5 mol% of the impurity concentration[21].

Effect of annealing temperature

The effect of annealing temperature was also studied. The results on CW-OSL measurements are as shown in Fig. 4. It could be observed from the figure that the material shows maximum CW-OSL sensitivity for the samples annealed at 873 K. The diffusion of environmental oxygen at higher temperatures[26-29] might be responsible for quenching at higher temperatures.

Dose response

Na_2LiPO_4:Eu samples annealed at 873 K for 1 h were irradiated for low doses (in the range of 0.003-0.14 Gy) from β rays from the ^{90}Sr-^{90}Yr source and the CW-OSL decay curves were recorded. The results are as shown in Fig. 5(a and b). For high doses, however, the samples were irradiated with different doses from γ rays from a ^{137}Cs source. No difference in the shape of the decay curve was observed except the increase in the intensity with the dose. The response curves both for stimulation by blue and green LED lights, i.e., 470 and 530 nm, respectively are as shown in Fig. 6. From the figure it could be seen that both the response curves are very much linear in the dose range (i.e., 0.05-10 Gy). However, beyond this range (10 Gy-100 Gy) they show supralinearity before saturation. No further studies, therefore, were done thereafter. These results show that there is not much effect of the different types of radiations (i.e. electrons and photons) and their energies due to low effective atomic number ($Z_{eff} \approx$ 10.8). The dose response is found to be within the same range as in case of the commercially available Al_2O_3:C (Landauer, USA) OSL phosphor. Several batches of the material for the optimized impurity concentration to see the batch to batch variation and were given proper annealing treatments. No appreciable variation was observed in their decay curves and dose response.

Correlation of CW-OSL with TL peaks and Supralinearity of the dose response

The CW-OSL dose response of Na_2LiPO_4:Eu phosphor as shown in Fig. 6. It could be seen in the figure that the dose response is supralinear in the dose range 10.0 Gy to 100.0 Gy. To understand the phenomenon further in more details some more experiments were performed. It was found that in CW-OSL the intensity is reduced by almost three orders of magnitude after the first readout (Fig. 7). However, it could be seen (in the inset of Fig. 7) that the CW-OSL intensity does not get completely diminished even after repeated readouts or by optical annealing. This indicates some optically sensitive traps (though negligibly small in numbers) still remain inside of the material and get depleted on subsequent readouts. The material was optically annealed for half an hour but still some (though very weak) OSL signal was observed. In order to investigate which of the TL peaks are contributing to the CW-OSL in in our material, the irradiated sample was subjected to thermal bleaching at different temperatures. For this, the $NaLi_2PO_4$:Eu sample was irradiated with beta radiation for 0.1 Gy each time and heated with the heating rate 5 Ks^{-1} on metal strip (in the Riso TL/OSL Reader) up to 373, 423, 463, 505, 560, 603, 663 and 698 K, held for 30s, cooled to room temperature rapidly by switching off the heater and then the CW-OSL was recorded[30]. These results are plotted and are shown in Fig. 8. The results show that all the peaks are OSL sensitive. To confirm these results further, the phosphor material was irradiated to β rays, different TL peaks were cleaned by thermal cleaning method and the intensity of the CW-OSL decay curves was plotted with the temperature up to which the TL glow curves were recorded before taking the CW-OSL. The results are as shown in Fig. 9. It could be seen that OSL intensity was observed even after cleaning the first two peaks and even the third peak partially. It seems that some of the deeper traps were transferred to the vacancies created by thermal cleaning on subsequent illumination of the blue light during CW-OSL readout. This also indicates that all the TL peaks are contributing in OSL one way or the other. Finally, TL glow curves were recorded each time after subsequent CW-OSL readouts for a number of times (Fig. 10). It was surprising to note that there was no decrease in the TL intensity as compared to the subsequent OSL readouts. This might be occurring due less probability of transitions of the deeper traps to the conduction band and the subsequent recombinations. From all the above discussion it seems that even after optical annealing or thermal cleaning a small fraction of the deep traps still remain inside the material which could be responsible for the supralinearity of the dose response. The amount of these reminiscent traps may depend up on the total number of traps created during irradiation (dose). This amount would be negligibly small for low doses and won't be that prominent but at higher doses the effect is seen prominently till the saturation occurs.

Comparison of OSL sensitivity of Na_2LiPO_4:Eu with that of Al_2O_3:C and BeO dosimeters

The CW-OSL intensity of the newly developed homemade Na_2LiPO_4:Eu OSLD phosphor was compared with that of commercially available Al_2O_3:C OSL dosimeters (Landauer, USA) and that of the BeO hot pressed chips (Thermalox® 995, Materion, USA). The results are as shown in Fig. 11. It could be seen from the figure that the intensity of our phosphor was found to be approximately 3 times less than that of the commercially available phosphors in the linear dose response range (i.e. 0.05–10.0 Gy). However, the advantage of our OSLD phosphor is the very easily available and inexpensive ingredients and a very simple method of preparation that would make it cost effective as compared to the commercially available ones. Also, there is ease of handling

unlike that of the Thermalox® 995 (BeO) dosimeters which are very much toxic.

Fading

For studying fading, the samples irradiated were irradiated to 1.0 Gy of γ rays from a ^{137}Cs source. The samples were stored at room temperature (~300 K) in dark and CW-OSL was taken at different intervals of time. The results are as shown in Fig. 11 (inset). A few CW-OSL decay curves recorded initially and after 3 h and 20 h are also given. Other decay curves are not given due to clarity of the figure. It could be seen from Fig. 12 that ~ 6.2% fading of the OSL signal was observed in 40 days. This is very much comparable with that of the commercially available phosphors, i.e., Al_2O_3:C (Luxel^{TM}, Landauer Inc., USA) and BeO (Thermalox® 995, Meterion Inc., USA). This has also been accepted for medical and personnel dosimetry.

Optical annealing (bleaching) and Reusability

Several batches of the newly developed $NaLi_2PO_4$:Eu OSLD phosphor were prepared and used for OSL studies. The phosphors were also irradiated to various test doses; OSL was taken and optically annealed using an annealing system consisting of 8 high output T5 fluorescent lamps (Annealing System, Model No.: GS-00004, Gammasonics, Australia). The system can remove a dose of a few mGy in a few minutes[31]. The samples were optically annealed for different times after the OSL readouts till the entire OSL signal was erased. After the first CW-OSL, the left over signal is of the order of only a few mGy. The moderate time for annealing/bleaching was found to be around half an hour. The OSL was again taken to see that no OSL signal is left inside the material. Several samples were irradiated for different test doses and the procedure was repeated several times. Few results have been shown in Fig. 13 below. The material has shown excellent reusability.

Theoretical fitting of the CW-OSL decay curve and photo-ionization cross-sections

Figures 14 and 15 show theoretical curve fittings of typical CW-OSL decay curves for the OSL stimulated by the blue (470 nm) and green (530 nm) light. The figure of merit (FOM) for both the curve fittings was approx. 2%. It could be observed from the figure that the blue light stimulated decay curve consists of two components, the fast component and a slow component, while that of the green light stimulated consists of three components fast, medium and slow. The sum of these components has also been shown as theoretically fitted curves (curves with symbols). The curve stimulated by blue light curve could be represented by the following equation (Eq. 1),

$$I_{OSL(Blue)} = A_1 \, exp\frac{-t}{\tau_1} + A_2 exp\frac{-t}{\tau_2} \quad \text{--- (1)}$$

where, A_1 = 391734.5, τ_1 = 3.45, A_2 = 4440293.7, τ_2 = 0.50 and the other one (by stimulated by green light) by another equation as given below (Eq. 2),

$$I_{OSL(Green)} = A_1 \, exp\frac{-t}{\tau_1} + A_2 exp\frac{-t}{\tau_2} + A_3 exp\frac{-t}{\tau_3} \quad \text{--- (2)}$$

where, A_1 = 75656.8, τ_1 = 1.14, A_2 = 107279.3, τ_2 = 0.10, A_3 = 34103.1, τ_3 = 11.7.

From the above discussion, it is clear that the decay curve stimulated by green light is more complicated than that stimulated by blue light. Therefore, the stimulation by blue light is preferred. It may also be inferred that different

kinds of traps might have been involved in two different stimulation processes.

The photo-ionization cross-section was determined by using the following formula photoionization cross-section, $\sigma = 1/(\varphi \times \tau)$, where, τ decay constant (in seconds)and φ is the incident photon flux (photons incident per cm^2 per second). The corresponding values of decay constants and photo-ionization cross-sections are as given in Table 1. It could be seen from this table that the photoionization cross-sections depends not only on the stimulating wavelength (energy) but also the total incident photon flux at the sample. In the present case, large differences in the photo-ionization cross sections may also be attributed to different incident photon flux due to different powers of the stimulating sources.

Experimental

Material and the method

Eu^{3+} doped orthophosphate $NaLi_2PO_4$ phosphor was synthesized by a simple solid state diffusion method[20]. This has also been described here briefly. The starting materials LiOH, NaH_2PO_4 (CDH, 99.5%) and the impurity salt $EuCl_3$ (Alfa Aesar, 99.9%) were used to synthesize the material. All the chemicals were used as received without any further purification as they were of high purity. The samples were prepared by considering the following chemical reaction:

$$2LiOH + NaH_2PO_4 + xEuCl_3\ (x = 0.01\text{-}0.3\ mol\%) + O_2(atmospheric) \longrightarrow NaLi_2PO_4{:}\ Eu^{3+}\ (x\ mol\%) + 2H_2O + 3x/2\ Cl_2\uparrow.$$

The impurity (in appropriate amounts, i.e., 0.05–3.0 mole%) was firstly dissolved in LiOH water solution and the solvent was evaporated slowly in a vacuum oven. The Eu doped LiOH (thus obtained) and $NaH_2(PO)_4$ (in 2:1 molar ratio) were mixed thoroughly, using agate mortar and pestle, in the presence of ethanol for better mixing. A temperature controlled programmable furnace having temperature stability better than ±1 K was used for synthesis of the material. The mixture was heated initially at 673 K for 12 h in air and then cooled slowly to room temperature, crushed again to fine powder and reheated at 1073 K for the same period. The ingots thus obtained were finally crushed and sieved to get particle size in the range of 100-200 μm, given proper heat treatments and were used for further characterizations.

Characterization

The powder X-ray diffraction (XRD) patterns were recorded on a high-resolution D8 Discover Bruker X-ray diffractometer using a monochromatic Cu-$K_{\alpha 1}$ line obtained through a pair of Göbel mirrors. The scan rate was kept as 1.0 s/step and step size of 0.02 s. The XRD recording was done at room temperature. The CW-OSL decay curves were recorded on the Risø TL/OSL Reader Model TL/OSL-DA-20TL (Risø, DTU, Radiation Research Division, Denmark) available at AIIMS, New Delhi, India. The decay curves were recorded for 300 s using blue (470 nm, FWHM ≈ 20 nm) and green (530 nm FWHM ≈ 20 nm) LED lights (variable from 50 – 100 mW/cm^2) at the sample position for stimulation and a wide band photomultiplier tube (EMI 9235QB15 PMT, ET Enterprises Ltd, UK) for detection of light. UV transmitting broad-band glass filter (Hoya U-340, 7.5 mm total thickness, transmission between 270 nm and 380 nm, Hoya Corporation, Japan) was used (across the PMT) to prevent stimulation signal from reaching it and a long pass green filter GG-420 (3.0 mm thickness, Schott, Germany) was used (across the LED) to cut off the stimulation wavelengths below 420 nm. The samples were exposed in situ by the ^{90}Sr-^{90}Yr β rays source (dose

rate 0.16 Gy/min) attached to the main reader unit for low doses (~ 3.0 mGy – 140 mGy). However, for higher doses ^{137}Cs γ rays source (dose rate 0.6 Gy/min) was used for higher doses (1.0 Gy-1kGy). Every time ~10 mg preirradiated sample was used for the CW-OSL decay curve recordings. For comparative and other studies, some TL measurements were also carried out using the same TL/OSL set up. Recording of the TL glow curves and CW-OSL decay curves after partial thermal cleaning were also done to study whether all the traps take part in the OSL. All the samples were protected from sun/room light during irradiation as well as during storage and measurements.

Figures

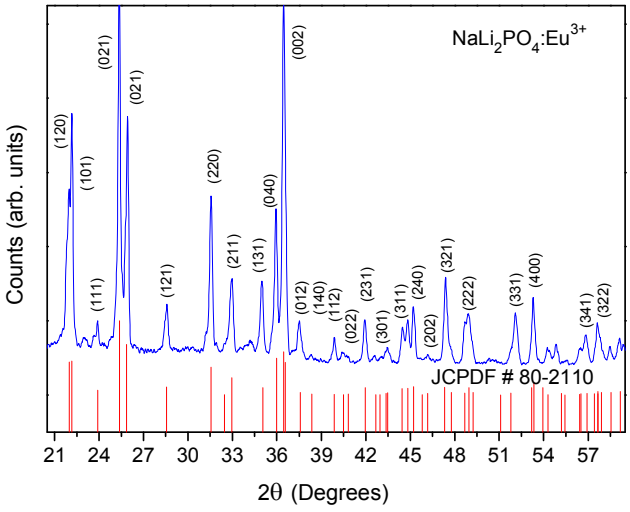

Fig. 1: XRD pattern of NaLi2PO4:Eu based on our experimental data. The stick pattern of the XRD pattern plotted using the data available in the literature (JCPDF file # 80-2110) [21] is also given for comparison.

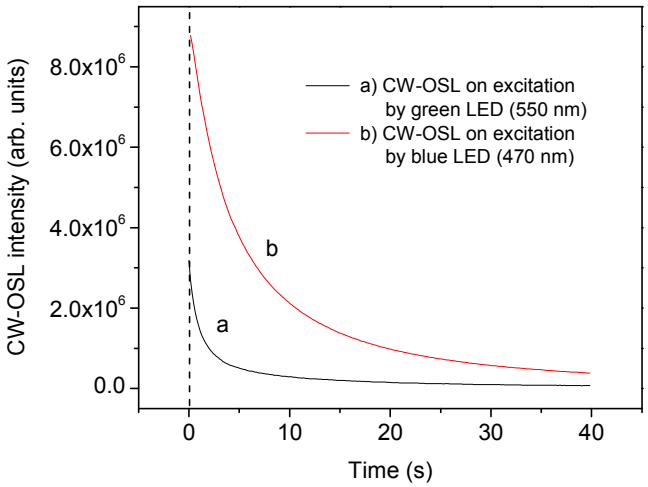

Fig. 2: Effect of stimulating source on the CW-OSL decay curves of $NaLi_2PO_4$:Eu, a) decay curve stimulated by blue LED light (470 nm) and b) decay curve stimulated by green LED light (530 nm). The material was irradiated for 10.0 Gy of γ rays from ^{137}Cs source. The samples were annealed at 873 K for 1 h before irradiation.

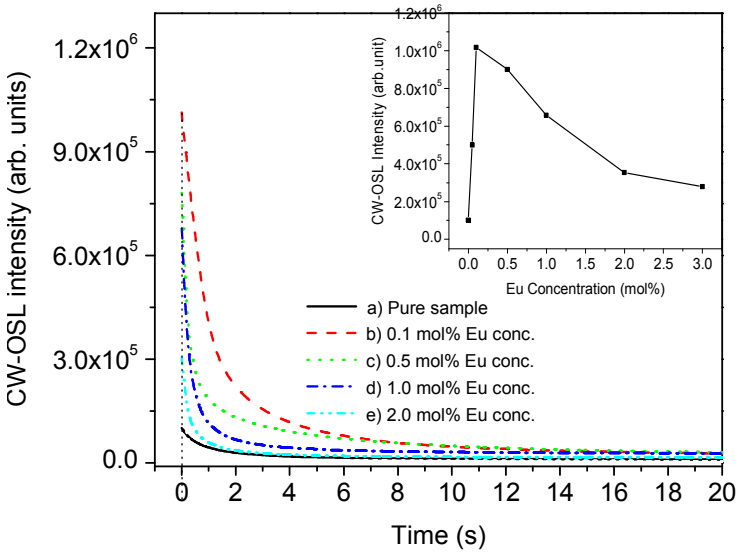

Fig. 3: Effect of Eu-impurity concentration on the CW-OSL decay curves: a) pure sample, b) 0.1 mol%, c) 0.5 mol%, d) 1.0 mol% and e) 2.0 mol%. The variation of the CW-OSL intensity with impurity concentration has also been shown in the inset. The samples were annealed at 873 K for 1 h and irradiated for 1.0 Gy of γ rays from ^{137}Cs source. The samples were annealed at 873 K for 1 h before irradiation.

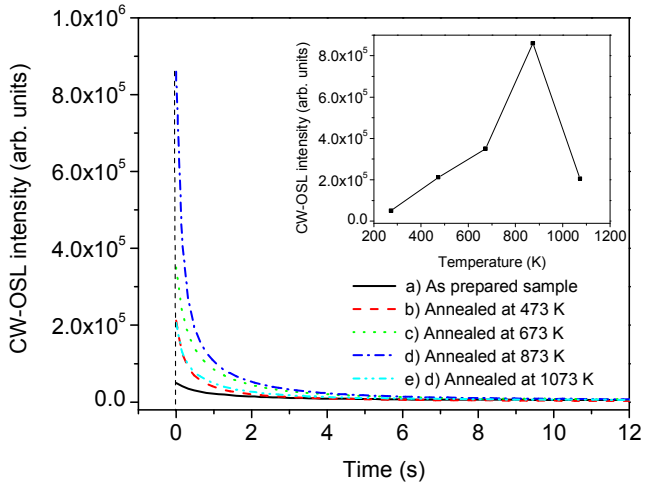

Fig. 4: Effect of annealing temperatures on the CW-OSL decay curves: a) as prepared sample, b) annealed at 473 K, c) annealed at 673 K, d) annealed at 873 K and e) annealed at 1073 K. The variation of the CW-OSL intensity with annealing temperatures is also shown in the inset. The samples used for these studies are doped with 0.1 mol% Eu concentration (which shows maximum CW-OSL sensitivity) and were irradiated for 1.0 Gy of γ rays from ^{137}Cs source.

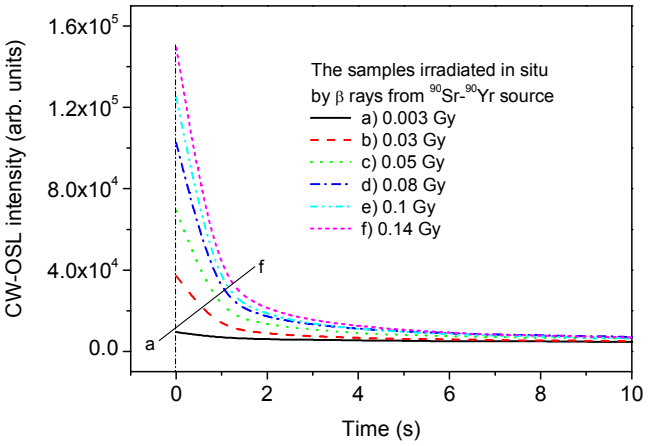

Fig. 5(a): CW-OSL decay curves for Na_2LiPO_4:Eu (0.1 mol%) samples irradiated in situ with β rays from a ^{90}Sr-^{90}Yr source for different doses: a) 0.003 Gy, b) 0.03 Gy, c) 0.05 Gy, d) 0.08 Gy, e) 0.1 Gy and f) 0.14 Gy. The samples were annealed at 873 K for 1 h before irradiation.

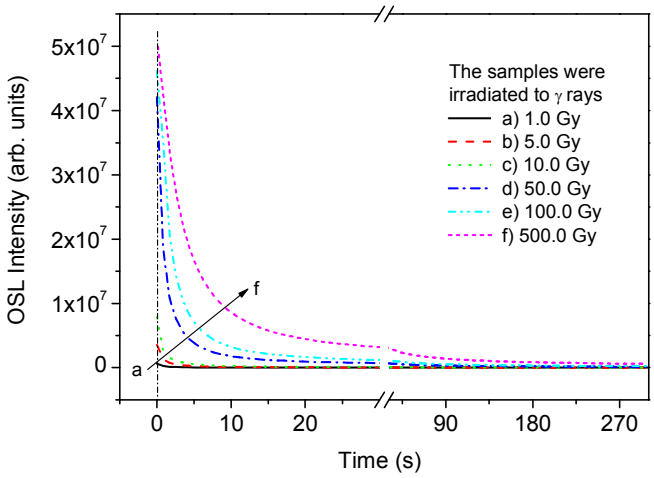

Figure 5(b) **Fig. 5(b):** CW-OSL decay curves for Na_2LiPO_4:Eu (0.1 mol%) samples irradiated with γ rays from a ^{137}Cs source for different doses: a) 1.0 Gy, b) 5.0 Gy, c) 10.0 Gy, d) 50 Gy, e) 100.0 Gy and f) 500.0 Gy. The samples were annealed at 873 K for 1 h before irradiation.

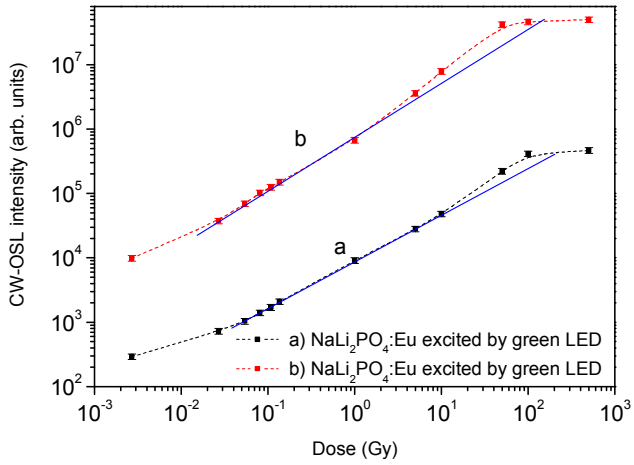

Fig. 6: CW-OSL dose response curves of Na_2LiPO_4:Eu phosphor material: a) stimulated by green LED light (530 nm) and b) stimulated by blue LED light (470 nm). Theoretical linear fittings of the curves (solid lines) are also shown in the figure. The dotted curves are guides for eyes.

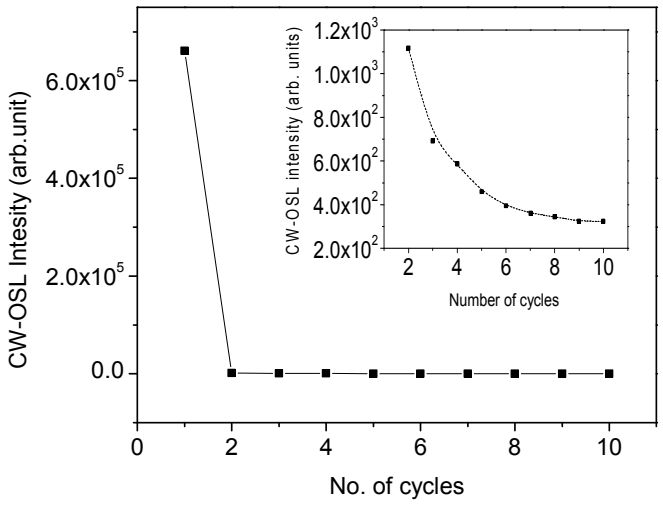

Fig. 7: Plot of the CW-OSL intensity with number of readout cycles. It could be seen in the figure that more than 99.8% intensity is lost during the first readout itself. The enlarged view of the intensity after the successive readouts has also been shown in the inset.

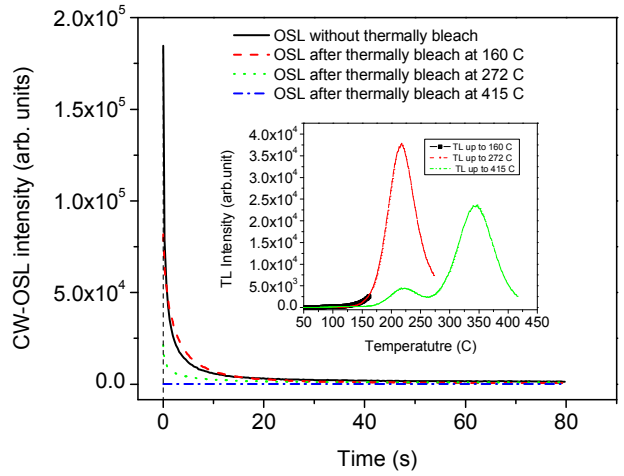

Fig. 8: Effect of thermal cleaning of the TL glow curve on the CW-OSL curves of Na_2LiPO_4:Eu phosphor. The phosphor was stimulated by blue LED light (470 nm). The samples were annealed at 873 K for 1 h and irradiated for 1.0 Gy of γ rays from ^{137}Cs source. Glow curves taken after the thermal cleaning have also been shown in the inset.

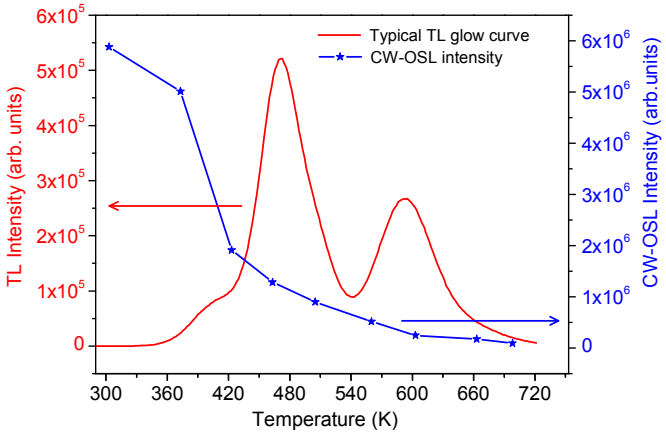

Fig. 9: The plot of CW-OSL intensity of Na_2LiPO_4:Eu phosphor with the temperatures up to which the TL glow curves were taken before the CW-OSL. A typical glow curve before taking the CW-OSL is also shown in the figure. The samples were annealed at 873 K for 1 h and irradiated for 1.0 Gy of γ rays from ^{137}Cs source.

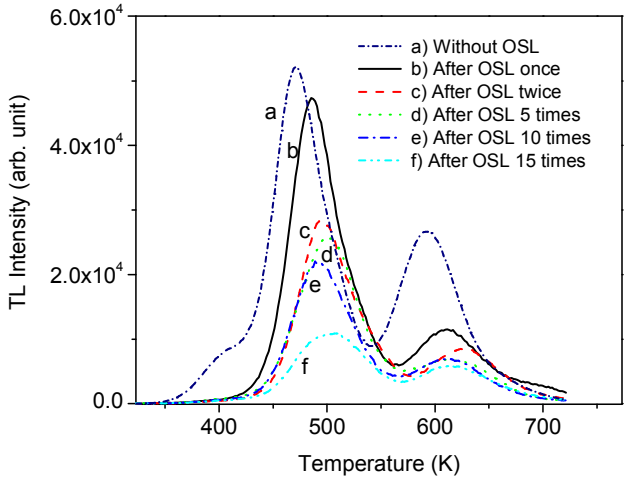

Fig. 10: TL glow curves recorded after successive CW-OSL decay curve readouts. The samples were annealed at 873 K for 1 h and irradiated for 1.0 Gy of γ rays from ^{137}Cs source.

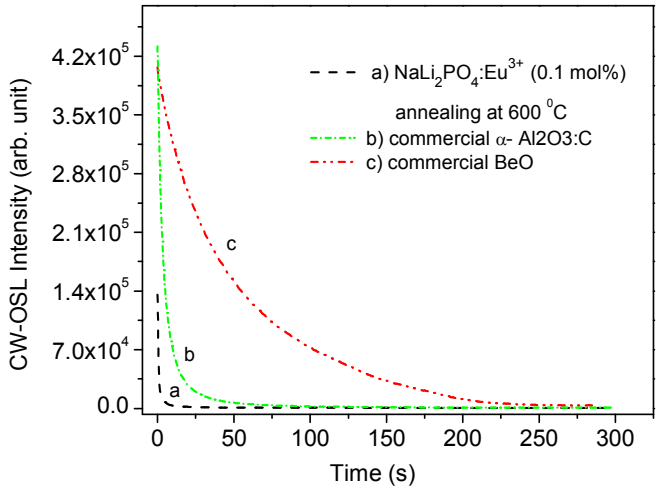

Fig 11: Comparison of the OSL sensitivity of Na_2LiPO_4:Eu phosphor material with that of the commercially available Al_2O_3:C (Luxel™, Landauer Inc., USA) and BeO (Thermalox® 995, Meterion Inc., USA) phosphors.

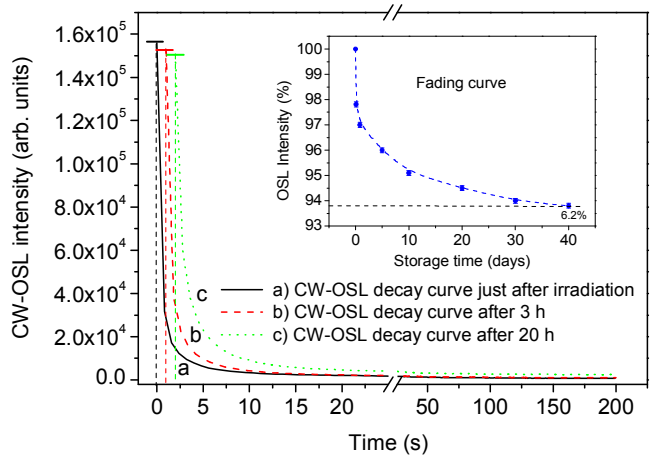

Fig. 12: Typical CW-OSL decay curves just after irradiation and after storing in dark at room temperature: a) at 0 h, b) after 3 h and c) after 20 h. The decay curves recorded after 20 h are not shown in the figure for better clarity. The fading curve has also been shown in the inset. Around 6.2% fading was observed in 40 days.

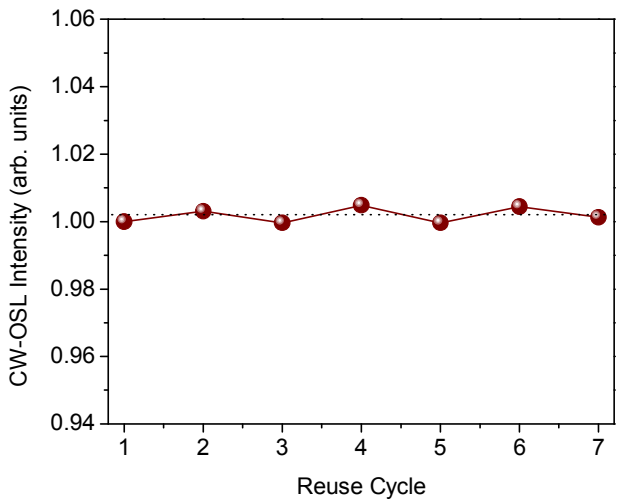

Fig. 13: Normalized intensity curve for repeated reusability of the Na_2LiPO_4:Eu phosphor material. The material was irradiated for 1.0 Gy of γ rays from ^{137}Cs source and CW-OSL was taken. The material was optically annealed for half an hour; OSL was taken before irradiation to see that no OSL signal is left after the annealing. The material was irradiated again for the same dose for taking CW-OSL. The process is repeated several times. The dotted line shows the least square fitting.

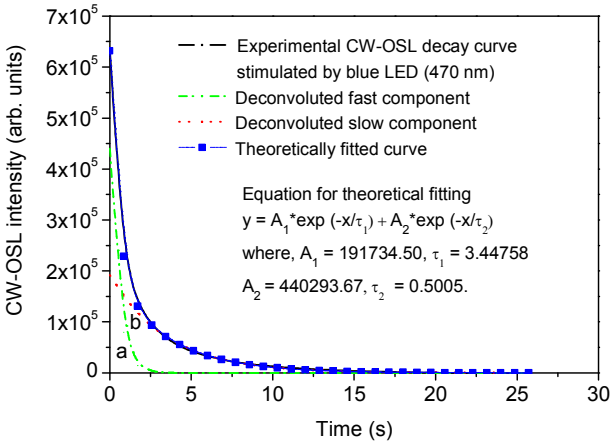

Fig. 14: Theoretical fitting of a typical CW-OSL decay curve stimulated by blue LED light (470 nm). The theoretically fitted curve is shown in symbols, experimental (solid curve). The components are: a) fast component (dash dot curve) and b) slow component (dot dot curve).

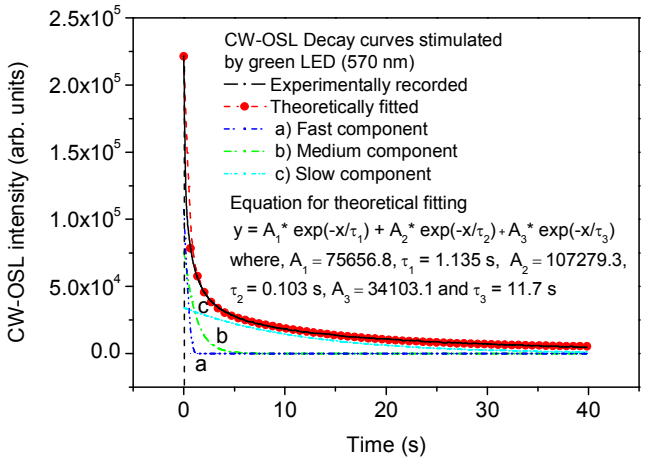

Fig. 15: Theoretical fitting of a typical CW-OSL decay curve stimulated by green LED light (530 nm). The theoretically fitted curve is shown in symbols, experimental (solid curve). The components are: a) fast component (dash dot dot curve), b) medium component (dash dot) and c) slow component (short dash dot curve).

Table 1

OSL component	OSL response stimulated by green LED (570 nm)			OSL response stimulated by blue LED (470 nm)		
	Coefficients	Decay constant (s)	Photo-ionization cross section σ (cm^2)	Coefficients	Decay constant (s)	Photo-ionization cross section σ (cm^2)
Fast	75656.8 (A_1)	1.13 (τ_1)	0.82×10^{-17}	191734.5 (A_1)	3.45 (τ_1)	0.15×10^{-17}
Medium	107279.3 (A_2)	0.10 (τ_2)	0.91×10^{-16}	---	---	---
Slow	34103.1 (A_3)	11.69 (τ_3)	0.8×10^{-18}	440293.7 (A_2)	0.50 (τ_2)	0.11×10^{-16}

Conclusions

The newly developed $NaLi_2PO_4$:Eu phosphor material shows good OSL characteristics useful for the dosimetry of high-energy radiations. The newly developed phosphor material was compared with the commercially available Al_2O_3:C (Luxel™ , Landauer, USA) and BeO (Thermalox® 995, Materion, USA) phosphors. Though the phosphor is little less sensitive (~ 3 times less), the very easy method of synthesis makes it very cost effective. The fading in the material was found to be around 6.2% in 40 days is comparable with the commercially available phosphors and thus is acceptable for dosimetry. The dose response was found to be linear in the dose range of 0.05 – 10.0 Gy but shows supralinearity at higher doses (from 10.0 – 100 Gy) before it gets saturated. The supralinearity and the contribution of different kinds of traps has also been studied in details and explained.

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Notes and references

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