Impact of Luminol Concentration on Lyo-luminescence in Potassium Halide Microcrystals Irradiated with Gamma Rays

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ABSTRACT : When γ – irradiated micro-crystals of Sodium chloride and Sodium bromide were dissolved in luminol solution, initially the lyo-luminescence intensity increases linearly with time, attains an optimum value and then decreases and finally disappears. The lyo-luminescence intensity was detected by Photo Multiplayer Tube whose output was connected to X-Y recorder. The lyo-luminescence intensity depends upon the concentration of luminol. As the concentration of luminol is increased , the value of maximum intensity(I_m) also increases. I_m maximum at a particular concentration of luminol then decreases with further increase in concentration of luminol .A plausible explanation for the experimental results is given.

Keywords : Lyo-luminescence , luminol (3 amino-phthalahydrazide).

INTRODUCTION

Lyo-luminescense is the process by the term applied to the emission of light while dissolving a irradiated solid into a liquid solvent. It was first reported by Wiedemann and Schmidt [1]. Who noted that light was emitted by materials that had been irradiated prior to dissolution where as these same materials did not emit light on dissolution if they had not been irradiated. After some year Ahnstrom and Ehrenstein [2] was reported subsequent research. Westermark [3] described experiments in which not only organic but also inorganic phosphors were investigated for LL. Later on alternative mechanisms were proposed for the emission by Ahnstrom [4]. When alkali halides are irradiated with ionizing radiation, colour centres are formed in the materials. It is known that the coloration produced by electrolysis is very stable [5]. It has been shown that the coloration in microcrystalline powder obtained by crushing the electrolytically coloured single crystal is not stable [6-10]. Co-relation between micro-hardness, dislocation mobility and the stability of coloration in microcrystal powder established by Deshmukh and his co-worker [6-10]. Dhoble et al.[11]have observed that water containing luminol as solvent increased the LL. Theoretical approach has been made to the stability of colour centres in microcrystal powder of alkali halides [12].Mass of the LL phosphor dissolved in a particular volume of the solvent plays prominent role as the colour centre density available and solubility of the solid is then modified in the solution. Arnikar [13] studied the variation in LL intensity with the amount of irradiated halides added to 50ml of distilled water. The observed LL intensity tends to saturate at a given mass of the crystalline added. According to Arnikar [13], it may depend upon the total number of colour centres produced and the solubility of each salt. Chandok et al.[14] studied effect of particle size on the LL of γ- irradiated alkali halide microcrystals. Nayer et al.[15] studied the temperature dependence of LL intensity of microcrystalline powder. Experimental and theoretical study of LL and ML for Li_3PO_4:RE was reported by Sahu et al. [16].In order to investigate effect of concentration of luminol on the lyo-luminescence we have chosen sodium halide microcrystals in the present paper.

RESEARCH METHODOLOGY

For the study of effect of luminol concentration on Lyo-luminescence we use γ-irradiated pure KCl ,KBr and KI microcrystal. The pure crystal of KCl , KBr and KI were grown from their melt using slow cooling method. For the measurement of LL, the crystals were crushed into microcrystal having different grains sizes were separated by suing sieves of particular dimensions. Then the microcrystals were coloured by exposing them to [60]CO source. To study the effect of concentration of luminol on the LL, 2ml luminol solution of different concentration was injected with the help of a syringe into the sample taken in transparent glass tube placed close to the PMT in a LL cell. The intensity of LL produced was detected by RCA-931 PMT, whose output was connected to an X-Y recorder. The process was repeated for different concentration of luminol.

RESULTS

Fig. 1.1 ,1.2 and 1.3 shows the time dependence of the LL intensity of γ- irradiated micro-crystals of pure KCl, KBr and KI. It is seen from figure that, when γ – irradiated microcrystals are dissolved in a fixed volume of luminol   solution, then the LL intensity initially increases with time, attains a maximum value at a particular time later on it decreases and finally disappears.

Fig. 2 shows the dependence of concentration of luminol on lyo-luminescence of KCl, KBr and KI micro-crystals. It is seen from the figure that the value of I_m initially increases with increasing concentration of luminol and tends to attain a maximum peak value for a particular concentration of luminol and then after that intensity of the light decreases with further increase in the concentration of the luminol .
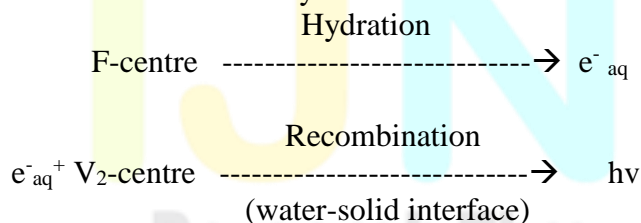
Fig. 3 shows the dependence of t_m on the concentration of luminol on lyo-luminescence of KCl , KBr and KI micro-crystals . It is seen from the figure that the value of time t_m increase with increase in luminol   concentration in the solution.

Fig.4.1, 4.2 and 4.3 shows that the plot of log I vs $(t-t_m)$ is a straight line with a negative slope for KCl ,KBr and KI. The slope of log I vs $(t-t_m)$ is found to be nearly a constant for different concentrations of luminol.

Fig.5 shows the dependence of the decay time **τ** of LL intensity on the concentration of luminol for KCl , KBr and KI micro-crystals .   It is seen from figure that decay time increases with increasing concentration of luminol .

DISCUSSION

When γ – irradiated microcrystals of KCl , KBr and KI were dissolved in luminol solution, the LL emission is found in which electrons are released from F- centres and the formation of hydrated electrons takes place. The hydrated electrons radiatively recombines with the holes on the surface of the crystallites and gives rise to LL emission. The mechanism of LL may be described as

$$\text{F-centre} \xrightarrow{\text{Hydration}} e^-_{aq}$$

$$e^-_{aq} + V_2\text{-centre} \xrightarrow[\text{(water-solid interface)}]{\text{Recombination}} h\nu$$

The expression for I peak intensity of LL, I_m and t_m are as given below.

$$I = \eta\gamma\alpha n_F N_0 \exp[-(t-t_m)/\tau] \quad \ldots\ldots\ldots\ldots\ldots(1)$$

$$I_m = \eta\gamma\alpha n_F N_0 \quad \ldots\ldots\ldots\ldots\ldots(2)$$

$$t_m = \frac{1}{(\beta-\alpha)} \ln(\beta/\alpha) \quad \ldots\ldots\ldots\ldots\ldots(3)$$

Where β is the rate constant for the recombination of hydrated electrons with holes, $\alpha=1/\tau$ is the rate of dissolution of solute in the solvent, η the probability of radiative recombination, γ is the factor correlating the number of hydrated electrons, n_F is the density of F-centers, and N_0 the initial number of the molecules of solute.

Equation (1) shows that when luminol solution will be dropped into the solute then initially the intensity should increase linearly with time, attains a maximum value and then it should decrease exponentially with time such results are shown in figure 1.1,1.2 and 1.3 .

Fig. 2 shows that I_m increases with increasing concentration of luminol solution. At a particular concentration of luminol solution , it attains a maximum value and with further increase in concentration it decreases. This may be due to initially the number of luminescence centres increases and therefore , the LL intensity increases . For higher concentration of luminol , Concentration quenching takes place and thereby the LL intensity decreases with increasing concentration. Thus ,the LL intensity is optimum for a particular concentration of luminol.

It is seen from Fig. 3 that time t_m increases with increasing concentration of the luminol solution. This may be due to longer time duration needed for dissolving the sample in higher concentration of luminol solution.

Fig. 4.1,4.2 and 4.3. Shows the plot of log I vs $(t-t_m)$ is a straight line with a negative slope. The slope of log I vs $(t-t_m)$ is found to be nearly a constant for different concentrations of luminol.

Fig5. Shows that the decay time of LL intensity increases with increasing concentration of solution. This is in accordance with equation (1) which shows that the time τ should inversely depend on the rate constant α of the dissolution .

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LEGENDS TO THE FIGURES

Fig.1.1   Time dependence of LL intensity of γ-irradiated KCl sample for different concentration of luminol solution.

Fig.1.2   Time dependence of LL intensity of γ-irradiated KBr sample for different concentration   of luminol solution.

Fig.1.3   Time dependence of LL intensity of γ-irradiated KI sample for different concentration of luminol solution.

Fig.2   Dependence of LL intensity Im of pure KCl ,KBr and KI microcrystals for different concentration of luminol.

Fig.3   Dependence of tm pure potassium halides on the concentration of luminol.

Fig.4.1   Plot of log I versus (t-tm) of different concentration of luminol for KCl microcrystal.

Fig.4.2   Plot of log I versus (t-tm) of different concentration of luminol for KBr microcrystal

.Fig.4.3   Plot of log I versus (t-tm) of different concentration of luminol for KI microcrystal.

Fig. 5   Dependence of time of LL intensity on the concentration of luminol solution for different potassium halides .
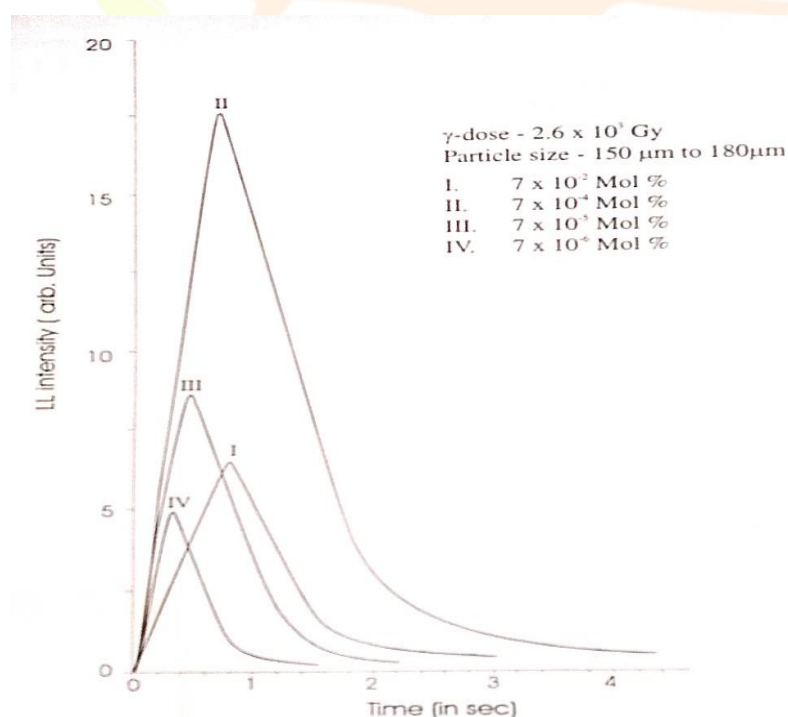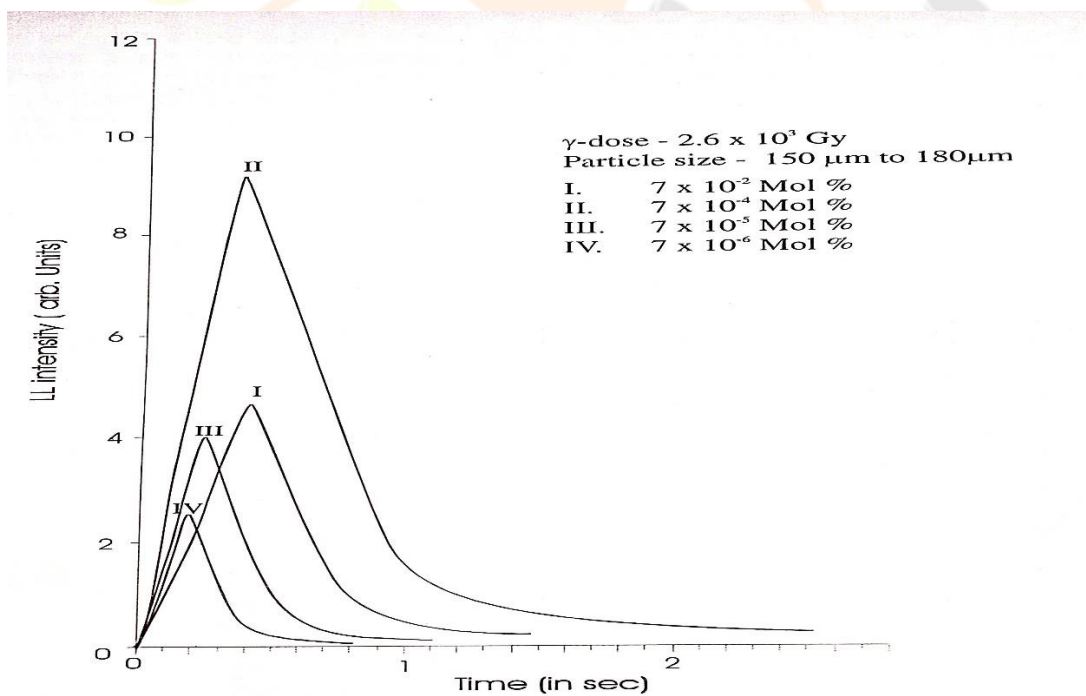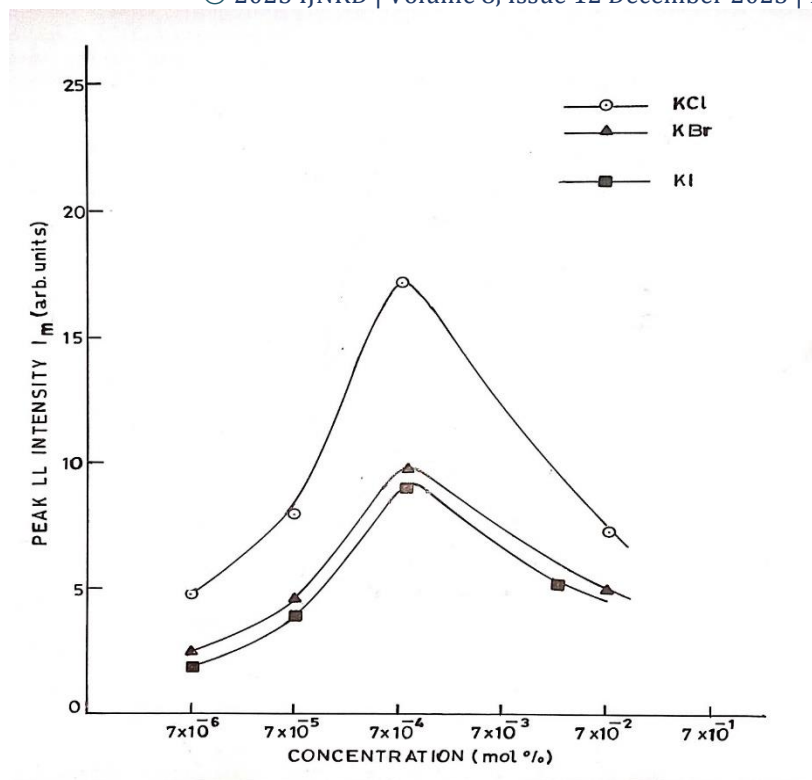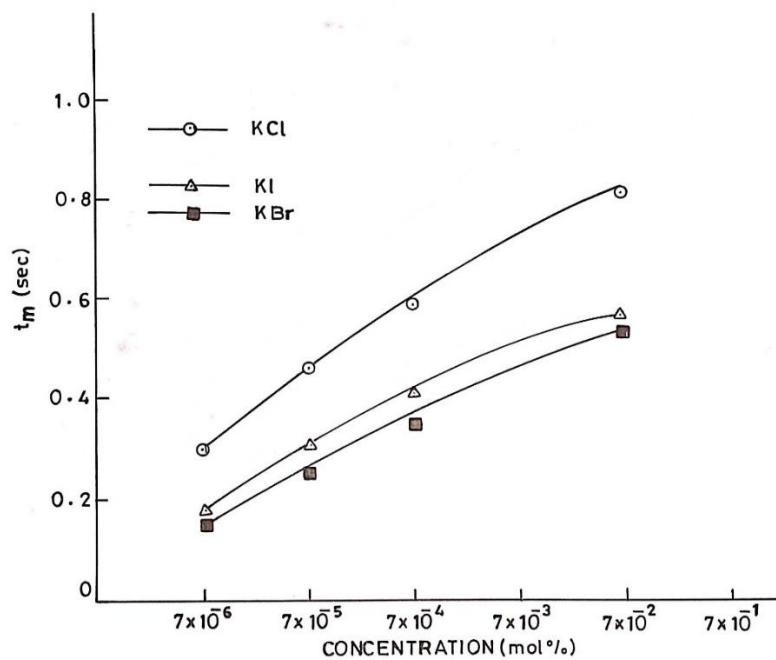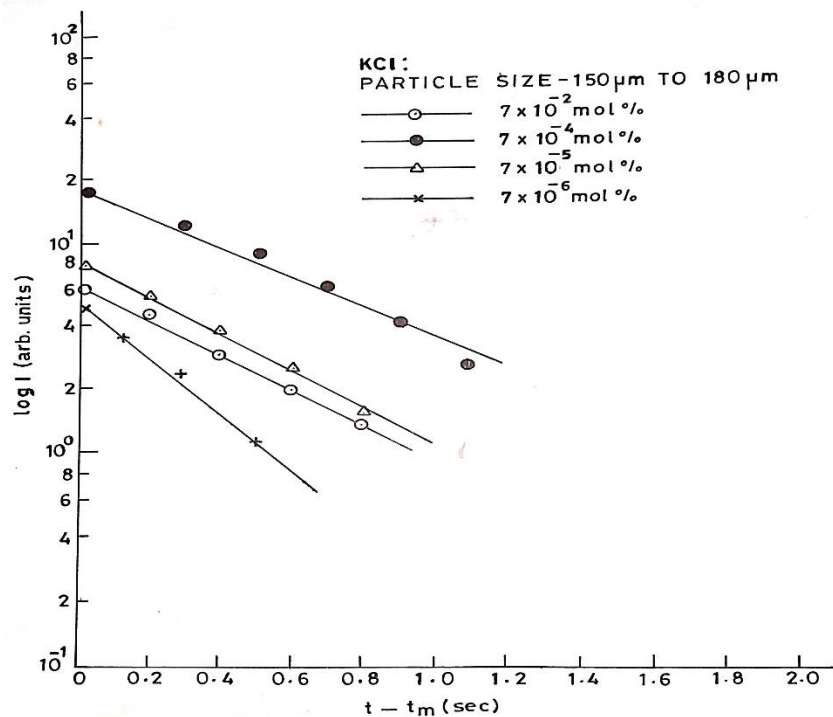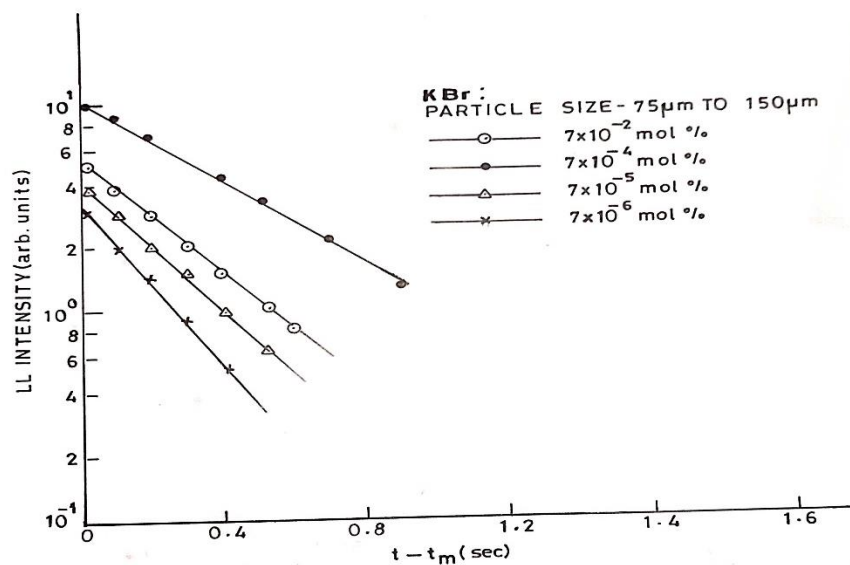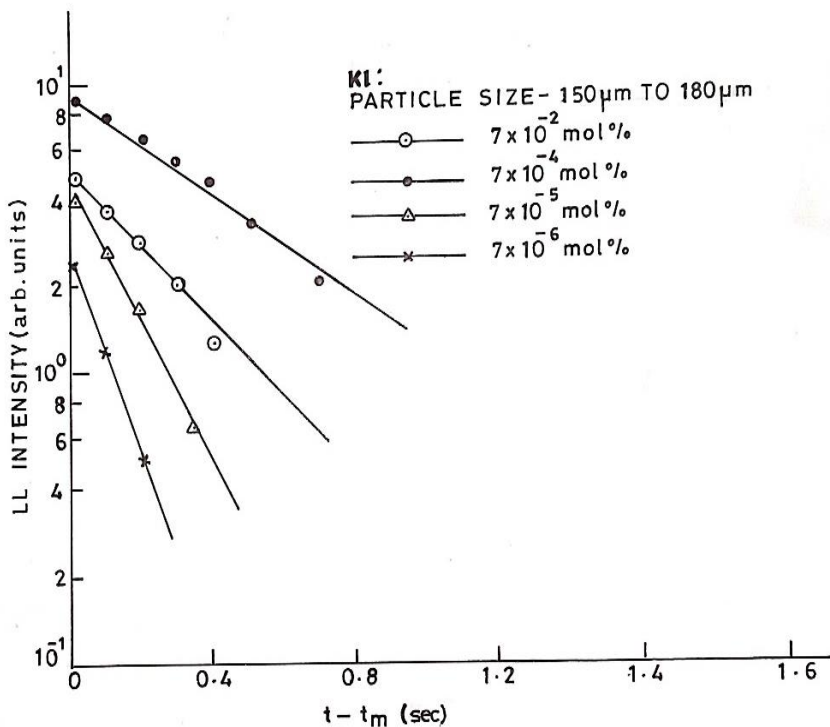

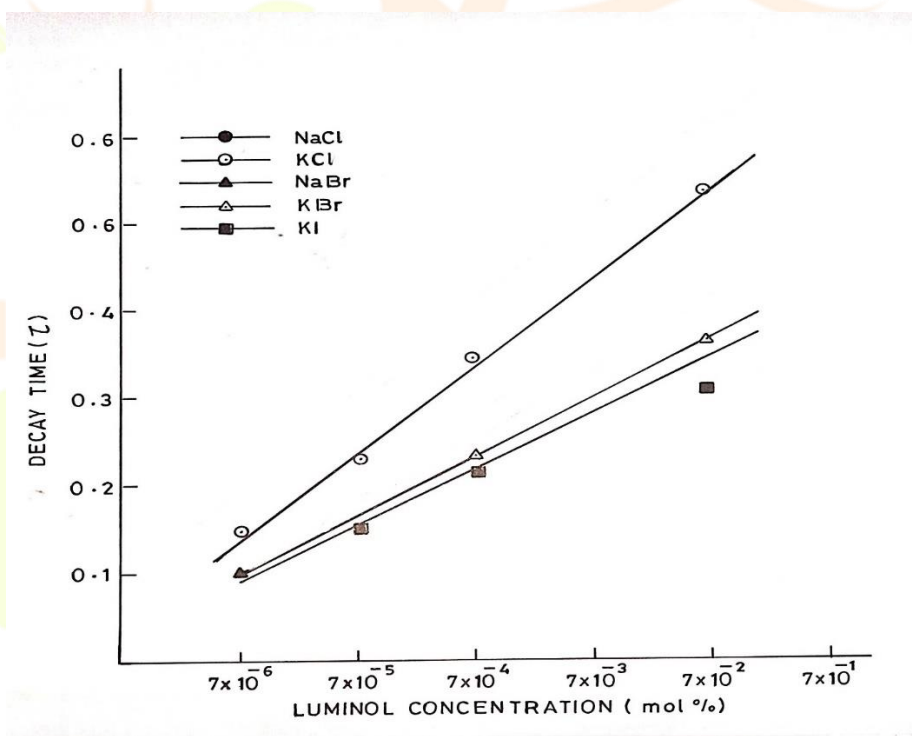Figure 1.1
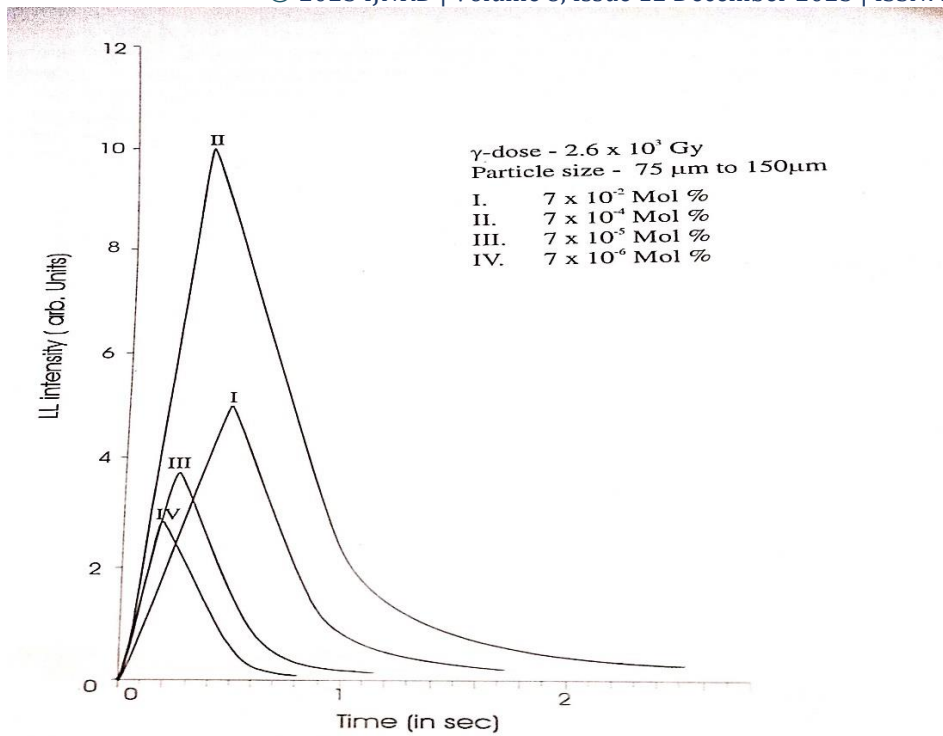
Figure 1.2

Figure 1.3

Figure 2

Figure 3

Figure 4.1

Figure 4.2

Figure 4.3

Figure 5