

# THE INFLUENCE OF $\gamma$ -IRRADIATED SODIUM HALIDE MICROCRYSTALS' MASS ON THE LYOLUMINESCENCE

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## ABSTRACT

When sodium chloride and sodium bromide microcrystals exposed to  $\gamma$  radiation were dissolved in luminol solution, the lyoluminescence intensity increased linearly over time, reached its maximum, then decreased and eventually vanished. Photo Multiplier Tube, whose output was coupled to an X-Y recorder, detected the LL intensity. The bulk of the solute affects the LL intensity. When more solute is introduced to the solvent, the LL intensity tends to reach a saturation value after first increasing with solute mass. A tenable explanation is provided for the experimental findings.

**Keywords :** Lyoluminescence, luminol (3 amino-phthalahydrazide).

## INTRODUCTION

The process by which light is released after the dissolution of an irradiation substance in a liquid solvent is known as lyoluminescence. Wiedemann and Schmidt were the ones who initially reported it [1]. Who observed that materials that had been exposed to radiation before dissolving released light, but those that had not been exposed to radiation would not have released light upon dissolving. After a few months, Ahnstrom and Ehrenstein's [2] research was reported. In research that looked into both organic and inorganic phosphors for LL, Westermark [3] provided details. Ahnstrom later suggested several explanations for the emission [4]. Colour centres occur in the materials when ionising radiation is applied to alkali halides. It is well known that electrolysis results in extremely stable colouring [5]. The coloration of microcrystalline powder made by crushing electrolytically coloured single crystals has been demonstrated not to be stable [6–10]. Deshmukh and his colleague found a correlation between microhardness, dislocation mobility, and the stability of colours in microcrystal powder [6–10]. The stability of colour centres in alkali

dissolved in a specific solvent volume is important since it affects the solid's solubility in the solution and changes its colour centre density. Arnikar [12] investigated how the quantity of irradiation halides given to 50 millilitres of distilled water affected the variance in LL intensity. At a certain mass of the additional crystallite, the observed LL intensity tends to saturate. Arnikar [12] states that the total number of colour centres generated and the solubility of each salt may be factors. Impact of LL decay in KCl doped with impurities Sahu et al. reported on microcrystalline powder in LL dosimetry of ionisation radiation[13]. The mass and temperature relationship of the LL intensity of KCl microcrystalline powder was investigated by Nayer et al. [14]. Sahu et al. reported on an experimental and theoretical evaluation of LL and ML for Li<sub>3</sub>PO<sub>4</sub>:RE [15]. In the current work, we have used sodium halide microcrystals to examine the impact of mass on lyoluminescence.

## **MATERIALS AND METHOD**

For the study of effect of mass on Lyo-luminescence we use  $\gamma$ -irradiated pure microcrystal. The pure crystal of sodium chloride, sodium bromide 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 using sieves of particular dimensions. Then the microcrystals were coloured by exposing them to <sup>60</sup>CO source. To study the effect of mass of solute on the LL, 2ml luminol solution 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 mass of solute.

## **RESULTS**

Fig. 1.1 and 1.2 shows the time dependence of  $\gamma$ - irradiated microcrystal's of pure sodium chloride and sodium bromide. It is seen from figure that, when  $\gamma$  – irradiated microcrystal are dissolved in a fixed volume of luminol solution, then the LL intensity initially increases, attains a maximum value at a particular time later on it decreases and finally disappears.

Fig. 2 shows the variation in peak of LL intensity  $I_m$  with mass of pure sodium chloride and sodium bromide. It is seen from the figure that the value of  $I_m$  initially increases with increasing mass of the sample, then tends to attain a maximum peak value for a particular mass of the solute and then after the intensity of the light saturated with increase in the mass of the solute added to the solvent.

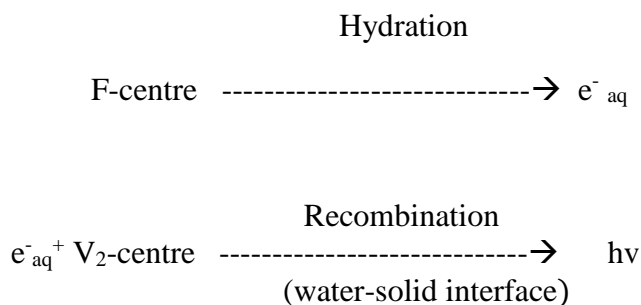
Fig. 3 shows the dependence of  $t_m$  on the quantity of solute dissolved in the solution for microcrystal of pure sodium chloride and sodium bromide. It is seen from the figure that the value of time  $t_m$  increases with increase in the quantity of the solute dissolved into the solvent for sodium chloride and sodium bromide.

Fig.4.1 and 4.2 shows that the plot of  $\log I$  vs  $(t-t_m)$  is a straight line with a negative slope for different amount of solute added to the solvent for sodium halides.

Fig.5 shows the dependence of the decay time  $\tau$  of LL intensity on the quantity of the solute dissolved into the solution. It is seen from figure that decay time increases with increasing quantity of the solute.

## DISCUSSION AND CONCLUSION

When  $\gamma$  – irradiated microcrystals of sodium chloride and sodium bromide 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



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

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

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

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

Where  $\beta$  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,  $\eta$  is the probability of radiative recombination,  $\gamma$  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 and 1.2 .

Fig. 2 shows that  $I_m$  increases with increasing quantity of the solute dropped into the solution. At a particular quantity of solute, it attains a saturation value with further increase in the quantity of solute dropped into the solution. This may be due to the formation of more hydrated electrons produced in a larger quantity of the solute dropped into the solution. Such result is predicted from equation (2) which shows  $N_0$  is related to the quantity of the sample added to the solution. When higher quantity of crystallites are added to the solution, a saturation will occur and only a fixed amount of the solute will be dissolved, hence the LL intensity will attain a saturation value at a particular quantity of the solute.

It is seen from Fig. 3 that time  $t_m$  increases with increasing quantity of the solute dropped into the solution. This may be due to longer time duration needed for dissolving the sample of larger quantity of the solute. As the rate of dissolution of solute decreases with increasing quantity of solute dropped into the solution. Equation (3) show that the time  $t_m$  should increase with increasing quantity of the solute dropped into the solution.

Fig5. Shows that the decay time of LL intensity increases with increasing quantity of the solute dissolved into the solution. This is in accordance with equation (1) which shows that the time  $\tau$  should inversely depend on the rate constant  $\alpha$  of the dissolution of solute into the solution.

## LEGENDS TO THE FIGURES

Fig.1.1 Time dependence of LL intensity of  $\gamma$ -irradiated NaCl sample for mass of solute.

Fig.1.2 Time dependence of LL intensity of  $\gamma$ -irradiated NaBr sample for mass of solute.

Fig.2 Variation in peak LL intensity  $I_m$  with mass of (I) NaCl , (II) NaBr .

Fig.3 Dependence of  $t_m$  pure sodium halides on the mass of solute.

Fig.4.1 Plot of  $\log I$  versus  $(t-t_m)$  of different mass of solute for NaCl microcrystal.

Fig.4.2 Plot of  $\log I$  versus  $(t-t_m)$  of different mass of solute for NaBr microcrystal.

Fig.5 Dependence of decay time of LL intensity on the different mass of solute of sodium halide microcrystals.

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**FIGURE**

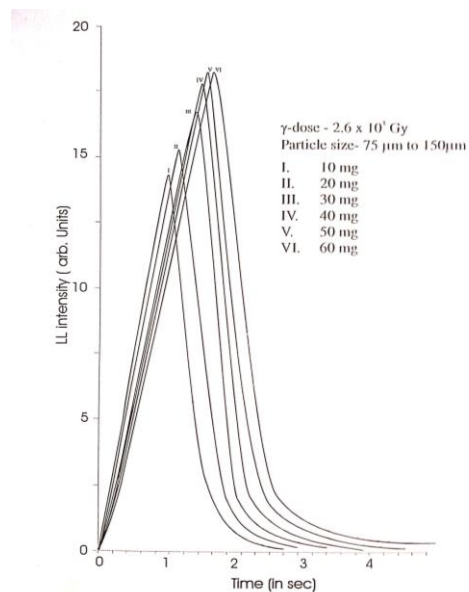


Fig.1.1

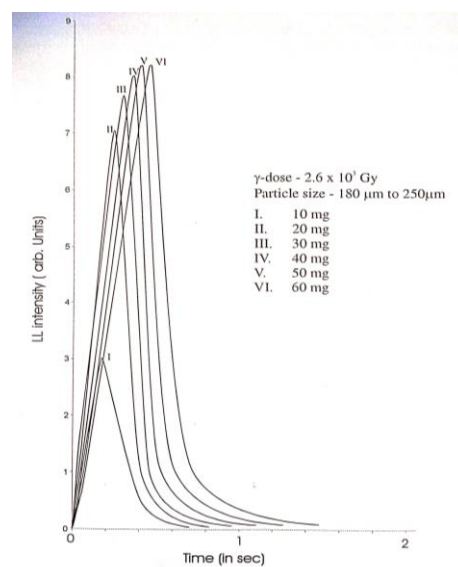


Fig.1.2

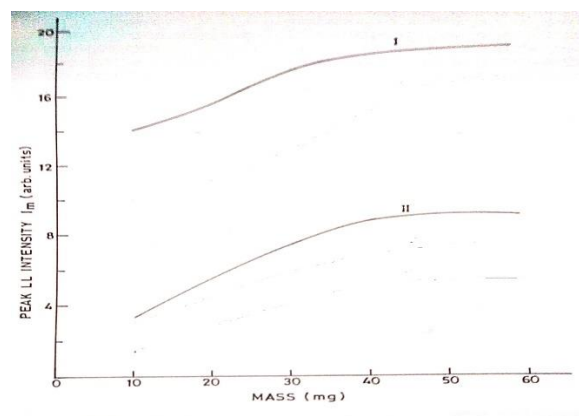


Fig.2

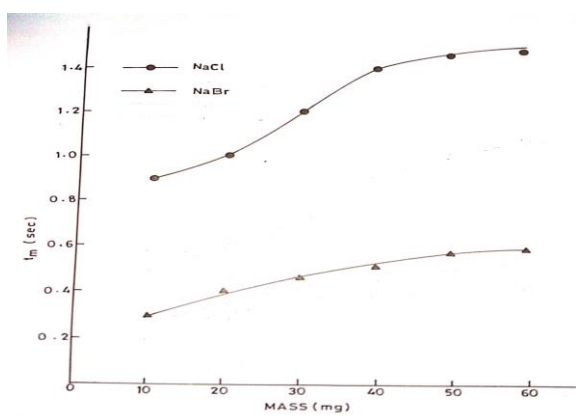


Fig.3

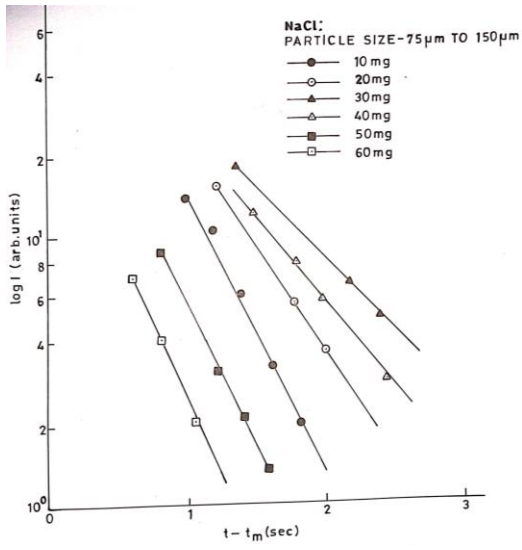


Fig.4.1

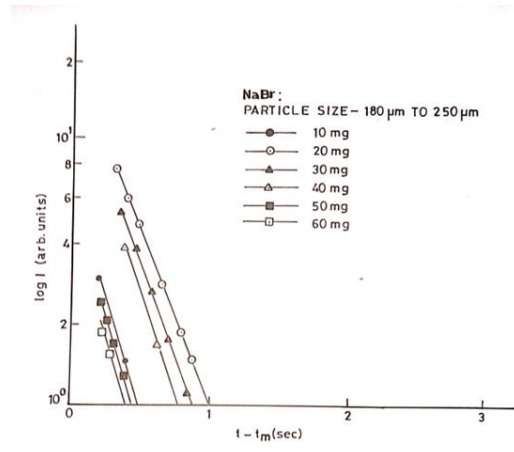


Fig.4.2

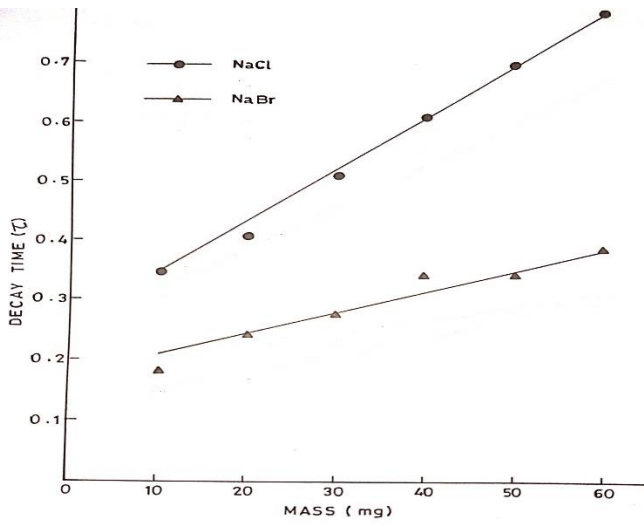


Fig.5