Pressure Effects in Phosphorescence*

L. REIFFEL
Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago, Illinois

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The influence of hydrostatic stress on the phosphorescence decay of thallium activated sodium iodide is shown to be very marked. Pressures as low as 100 kilograms per square centimeter produce readily observable effects. Interpretation in terms of pressure-increased effective trap depth is given.

THERE have been reported in the literature only a very few experiments in which hydrostatic stress has been applied to crystalline phosphor systems. The most recent work is apparently that of Reinsch and Drickamer,[1] who report the probable existence of a slight shift in the emission spectrum of cadmium tungstate at 10 000 kg/cm^2.

We have undertaken a study of the effects of hydrostatic pressure on the fluorescent and phosphorescent emission occasioned by gamma-ray bombardment of the activated alkali halides. Because of the very marked dependence of the phosphorescence decay rate on trap depth, it may be reasoned that measurements in the time domain would be considerably more sensitive than measurements in the frequency domain. That this appears to be the case can be seen from the data on thallium-activated sodium iodide[2] presented in Fig. 1 and in Table I. The phosphorescence decay curves are normalized at 0.1 minute after removal of the excitation so that their shapes may be readily compared. The intensities at the time of normalization relative to those during excitation are listed in Table I.

These data were obtained using Co^{60} gamma rays at a constant excitation density of 4.3 roentgens per minute and an excitation time of 10 minutes. Preliminary tests established that pressure induced effects in the mineral oil used as the pressure transmitting medium did not occur. Similarly, no shift in the optical transmission characteristics of the pressure bomb windows was detectable. Precautions were taken to assure isothermal conditions throughout the experiments.

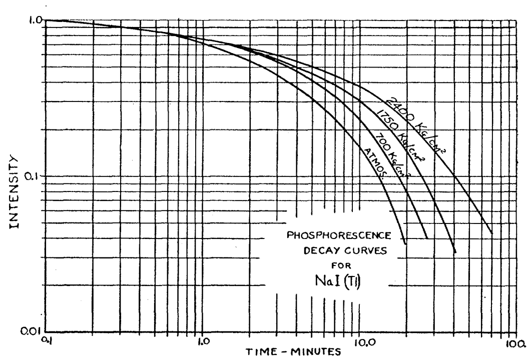

FIG. 1. Phosphorescence decay curves for NaI(Tl).

It is interesting to note that pressures as low as 100 kg/cm^2 will produce readily observable changes in NaI(Tl) decay curves.

These results are tentatively interpreted in terms of a stress-proportional increase in trap depth with the assumption of negligible changes in the associated rate constant. Such an approach is supported by an argument based on a typical configurational coordinate diagram to which is added a linearly increasing potential ascribable to the applied stress. Under pressure, therefore, the effective trap depth should be increased by a term proportional to the product of the stress and the displacement from equilibrium required for thermal escape from the trap.

TABLE I. Relative phosphorescent intensity.

Pressure (kg/cm^2)	Intensity Ratio $\times 10^3$
Atmospheric	8.25
700	6.70
1750	5.55
2400	4.25

In the case of NaI(Tl), the data, when fitted either by a power law or by an exponential in the 5-minute to 10-minute interval, indicate a change in trap depth of 4.6 percent for an applied stress of 2400 kg/cm^2. This type of computation requires the assumption of a unique trap depth, a condition which is not well fulfilled for NaI(Tl). This fact makes precise interpretation in terms of any simple picture rather difficult. Additional data are now being obtained for phosphors of apparently simpler behavior which should permit detailed computations on the pressure dependence of effective trap depth and allied parameters.

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[1] A. J. Reinsch and H. G. Drickamer, J. Appl. Phys. 23, 152 (1952).

[2] Crystals were obtained from Harshaw Chemical Company as scintillation grade material.