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Electroluminescence in the phosphor anthracene doped by 9-vinylanthracene

B R PANDEY, D R DUBEY and PADMAKAR
Department of Physics, University of Gorakhpur, Gorakhpur 273 001

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Abstract. Electroluminescence has been excited in the phosphor anthracene doped by 9-vinylanthracene (10^{-4} mole %) at room temperature (300°K). Variation of light output with voltage is governed by the relation $B=B_0 \exp[-(C/V^{1/2})]$ as in the case of inorganic phosphors. Here B_0 and C are constants and V is the rms value of the voltage applied to the phosphor. Frequency dependence of the electroluminescence has also been studied at different voltages of the applied electric field.

Keywords. Electroluminescence; Mott-Schotky barrier, luminance; phosphors; dopant concentration.

1. Introduction

Electroluminescence has been excited in a large number of inorganic semiconducting materials during the last few decades. Fluorescence and phosphorescence of organic materials have been studied extensively, but the excitation of electroluminescence in organic materials remained almost unexplored for a long time and only a little work has been done after the work of Barnanose and Vouaux (1955). Electroluminescence in anthracene has been studied by several workers (Helfrich and Schneider 1965; Mehl and Buchner 1965; Pott and Williams 1969; Vityuk and Micho 1973 and Brodzeli *et al* 1970). These investigations involved electroluminescence of intrinsic as well as extrinsic type. Recently some work has been done on doped anthracene (Kawabe *et al* 1971; Schwob and Granachev 1971; Wittmer *et al* 1973 and Tripathi *et al* 1977).

Anthracene has been reported to be a highly fluorescent organic compound. A close resemblance has been found in electroluminescence-fluorescene spectra of organic phosphors (Barnanose and Vouaux 1955) and only highly fluorescent organic compounds have been observed to show intrinsic electroluminescence. Electroluminescence in anthracene doped by tetracene has been reported by Kawabe *et al* (1971). The present studies involve the dependence of the luminance B on the voltage V_{rms} and frequency of the applied electric field, in anthracene doped by 9-vinylanthracene.

2. Experimental

The luminescent grade pure anthracene was doped with 10^{-4} mol % 9-vinylanthracene and then heated in water bath for about 90 min. The phosphor thus prepared was dispersed in castor oil after grinding and was then pressed between two electrodes, one made of aluminium and the other of thin conducting glass coated with SnO_2 (resistance ≈ 150 ohms cm^{-2}) with a thin mica sheet separating the aluminium plate from the phosphor. The thickness of the air bubble-free phosphor was 0·04 mm. The cell was excited with an a.c. voltage in the frequency range 20 Hz–2 kHz, by a generator coupled with a wideband amplifier, with a voltage ranging from 1 to 1000 V. The electroluminescence emission from the cell was measured with a highly sensitive galvanometer, coupled with RCA 1P21 photomultiplier tube. An attempt was made to study the emission spectrum using a constant deviation spectrograph capable of detecting light of different wavelengths, but the intensity of the emitted light was too low to be measured.

3. Results and discussion

Figure 1 shows the variation of light output with the voltage. A graph plotted between log $10B$ and $1/V^{1/2}$ gives a straight line. This confirms the relation

$$B = B_0 \exp(-C/V^{1/2}),$$

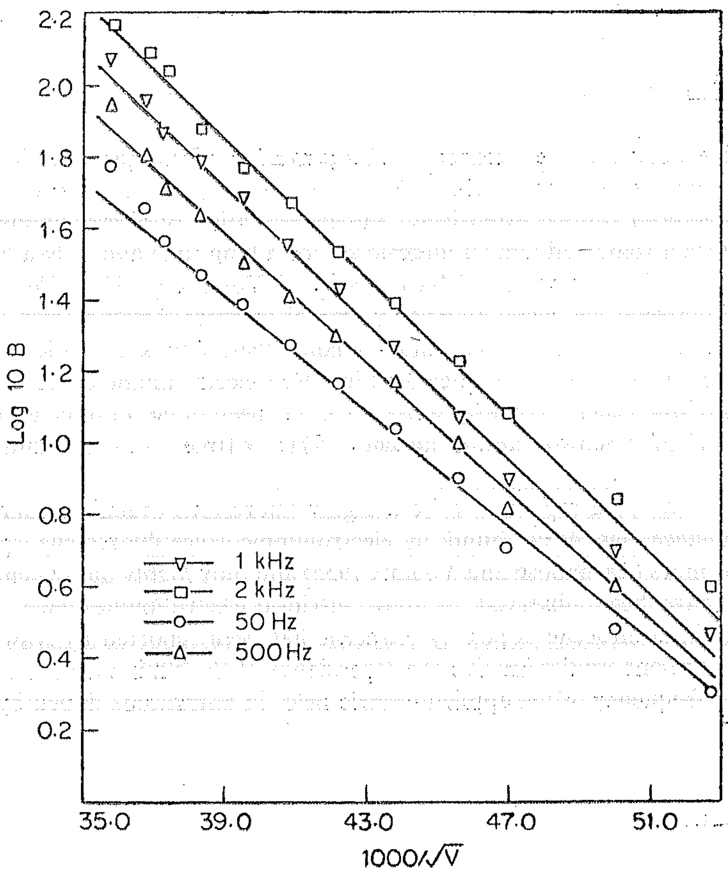

Figure 1. Variation of brightness vs voltage for the phosphor anthracene doped by 9-vinylanthracene.

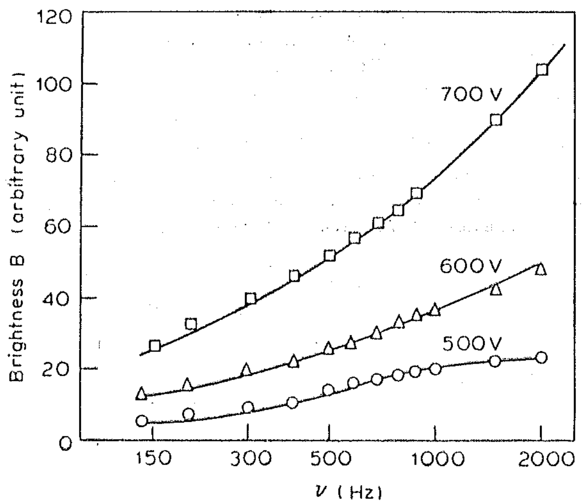

Figure 2. Variation of mean brightness vs frequency in the phosphor anthracene doped by 9-vinylanthracene (10^{-4} mole %).

observed in inorganic phosphors. Here B_0 and C are constants and V is the rms value of the voltage applied. Increase in dopant concentration is accompanied with a decrease in light output. Thus when anthracene was mixed with more than 10^{-3} mole % of 9-vinylanthracene, the light output was strongly quenched and the emission could not be detected.

The variation of light output with the frequency is shown in figure 2. At low voltage the effect of frequency on the brightness was quite small and was linear. At higher voltage the variation of light output with frequency was nonlinear. Saturation of light output within the range of applied frequencies could not be obtained.

The mechanism of intrinsic electroluminescence in anthracene considers the tunnelling of electrons from the valence band to the conduction band under the influence of the first few cycles of the electric field, through the Mott-Schotky barrier existing at the grain boundaries. These electrons recombine radiatively at a latter stage, with the holes created in the valence band, thus resulting in light emission. The excited energy level of the dopant 9-vinylanthracene appears to behave as electron trap, where non-radiative recombination takes place. Obviously, with increase in the dopant concentration, the density of such traps will increase reducing the electroluminescent brightness.

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