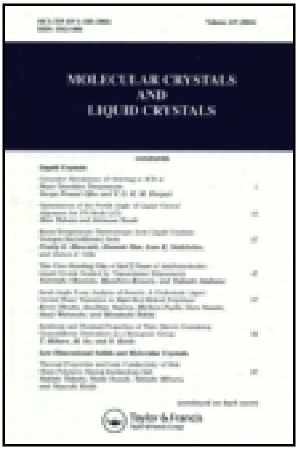

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Anisotropy of Trapping Factors in Perylene-Doped Anthracene Crystals

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ANISOTROPY OF TRAPPING FACTORS IN PERYLENE-DOPED ANTHRACENE CRYSTALS.

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Abstract The depth of the hole traps formed by perylene in anthracene crystals was found to vary markedly depending on the crystallographic direction of measurements. The trap depth in the a and b direction amounts to ca. 0.32 eV and to ca. 0.39 eV in the c' direction.

Since the experiments carried out by Hoesterey and Letson[1], the measurements of the temperature dependence of the effective drift mobility have been accepted as a technique to study parameters of traps in organic crystals. Recently, Probst and Karl[2] having employed this technique on single crystals of anthracene doped with tetracene reported an anisotropy of the depths of the hole and electron traps formed by tetracene molecules. The aim of this communication is to present results of a similar study carried out on perylene-doped anthracene crystals.

On the basis of arguments put forward in Ref.3, one can expect perylene molecules to create hole traps ca. 0.2-0.3 eV deep; this was qualitatively confirmed by the measurements of steady-state space-charge-limited currents[4].

The crystals used in this study were grown employing the Bridgman technique from carefully purified anthracene with an amount of perylene added into the growing tubes. Single-crystalline platelets were cut from the boules using a string saw. The concentration of perylene in each sample was determined after the measurements, from UV spectra of the sample dissolved in tetrahydrofurane. The effective drift mobility was measured employing a standard time-of-flight technique[5]. The details of the experimental arrangement were described in Ref.6. The time of flight (t_f), i.e. the time after which the front of carriers injected into the sample by a short pulse of light reaches the collecting electrode, can be related to the mobility by the equation

$$\mu = L^2/V\ t_f \qquad (1)$$

where L is the sample thickness and V stands for the voltage applied to the sample. Thus, if the mobility is independent of the voltage, its value can be determined from the slope of the $1/t_f$ vs. V straight lines. It is worth to note that we did not observe any deviation from straight-line behaviour over the entire temperature and voltage ranges (cf. Fig.1).

The mobilities of holes were determined in several doped samples within the temperature range 290-390 K. The mole fraction of dopant

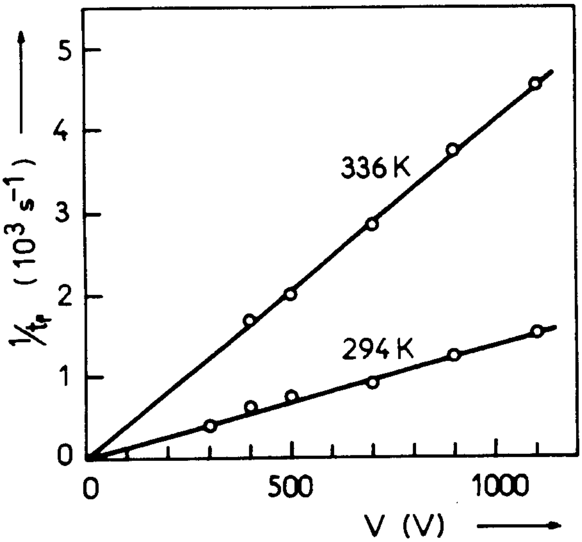

FIGURE 1 Voltage dependences of the reciprocal transit time. Crystal thickness amounts to 1.42 mm, concentration of perylene to 16 ppm, direction of measur. - c'.

varied from ca. 10^{-6} to ca. 10^{-4}. Typical temperature dependences are shown in Fig.2. The results obtained can be interpreted assuming perylene molecules acting as shallow traps for holes. In the case of shallow trapping the temperature dependence of the effective mobility may be expressed as[1]

$$\mu = \mu^{0}(T)\ [\ 1+N_t/N_c \exp(E_t/kT)\ ] \qquad (2)$$

where μ^{0} is the 'lattice' mobility (i.e. the mobility in a pure crystal), N_t and E_t are the concentration and depth of traps, respectively and N_c is the effective density of states. From Eq.2 the concentrations and depths of traps may be determined by plotting $\lg(\mu^{0}/\mu - 1)$ vs. 1/T.

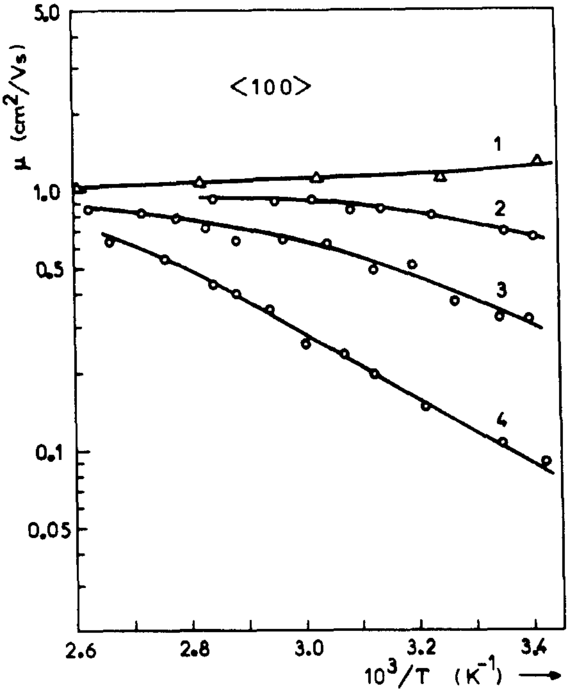

FIGURE 2 The temperature dependence of hole mobilities measured in a direction. Concentrations of perylene (ppm) determined spectrophotometrically and from Eq.2 (values in brackets) amount to: 1 - 0 (0) , 2 - 1 (1) , 3 - 6 (16) , 4 - 7 (23) .

Typical curves are presented in Fig.3. The trap depths determined from the temperature dependences of the mobilities appeared to be practically independent of the perylene concentration but a marked anisotropy of the trap depths was found in all samples. The results, averaged for several samples are given in Table 1.

The anisotropy well exceeds the spread of the experimental results and seems to be an evi-

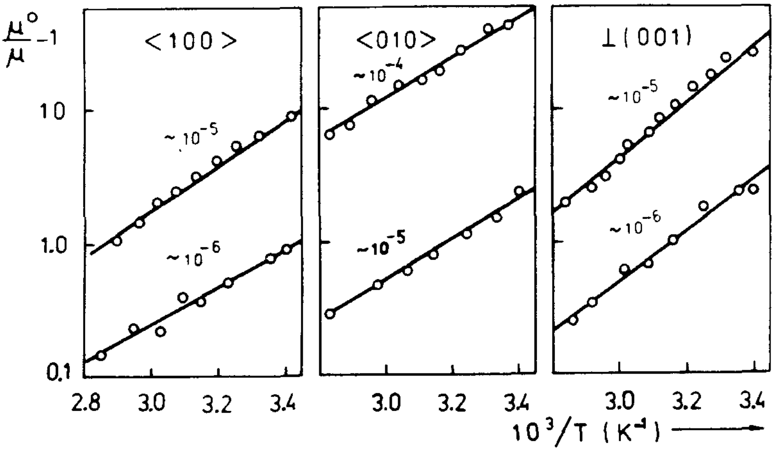

FIGURE 3 Examples of the dependence of $\mu^0/\mu-1$ vs. T for the measurements in various directions. Approximate concentrations of perylene are given in the figure.

TABLE 1 Average depths of hole traps in perylene-doped anthracene crystals

Direction	Trap depth (eV)
a	0.31 ± 0.02
b	0.32 ± 0.02
c'	0.39 ± 0.01

dence that the potential walls around trapping centres are anisotropic and the directions of the release of carriers from traps are field-dependent. It is also not impossible that, contrary to commonly accepted opinions[7], the effective thermal velocity in real crystals is compatible with drift velocities. The latter opinion, however, has only a weak support on the basis of the results presented in this note, and further studies are necessary to explain the effect described in Ref.2 and in this paper.

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