Increase in d.c. Dark Conductivity of Anthracene in a Magnetic Field

Frankevich and Balabanov[1] have reported magnetic enhancement of the photoconductivity of single crystals of anthracene. Similar effects in the dark conductivity have been observed in this laboratory.

Measurements were made of the d.c. dark conductivity at 10^5 V/m in an argon atmosphere, with and without a guard ring, over a period of 12 days. Fig. 1 shows the results for a crystal 1 mm thick which had been degassed in the dark for 3 days before the measurements were undertaken. Evaporated gold electrodes were used because deleterious effects had been observed with metallic pastes. It was found that the methyl-iso-butyl ketone used in "dag" silver preparation slightly reduced the resistivity of the single crystals of anthracene: on 5μ films of anthracene the resistivity was reduced by three orders of magnitude and the activation energy changed from 0·9 eV to 0·3 eV. This could have arisen from the formation of a charge-transfer complex by the ketone with anthracene or with impurities such as anthraquinone and anthrone.

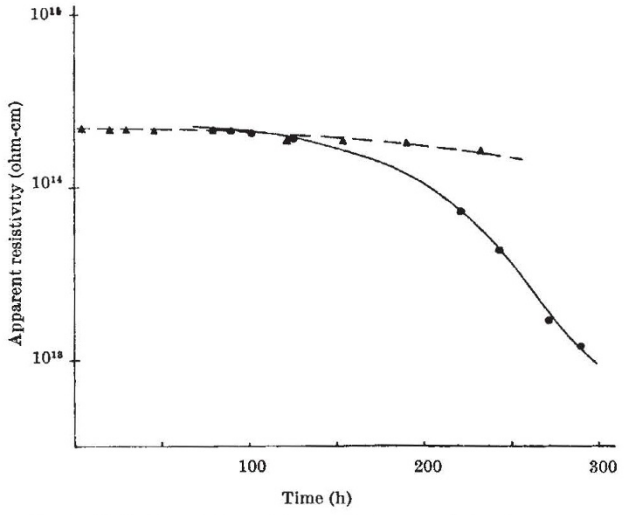

Fig. 1. Variation of the resistivity of single crystals of anthracene parallel to the "*ab*" plane with time at 290° K. ▲, With guard ring; ●, without guard ring.

We investigated the effect of applying a magnetic field perpendicular to the current through the crystal. Care was taken in all measurements to ensure that stability of temperature and space charge had been secured: this often took up to 4 h. Fig. 2 shows the increase in dark current with magnetic field when the guard ring was used. Fig. 3 illustrates the measurements obtained without the guard ring: they suggest that the results of Fig. 2 were due to a bulk rather than a surface effect. The results were independent of current and field polarity.

The energy gaps for zero and 0·67 Tesla magnetic fields were determined between 255° K and 320° K as 0·84 eV for both conditions within the experimental error of ± 0·02 eV.

The results shown in Fig. 2 for the magneto conductivity were much greater than and of opposite sign to that allowed by conventional semiconductor theory. Measurements made on single crystals of anthracene in the dark of the Hall current (to be published) suggested a Hall mobility of the order of 1×10^{-3} m²/V sec, which can be compared with a similar photoconductive Hall mobility observed by Delacote and Schott[2]. Following Smith[3], in a field of 0·7 Tesla

$$\Delta\sigma/\sigma_0 \simeq -5 \times 10^{-9}$$

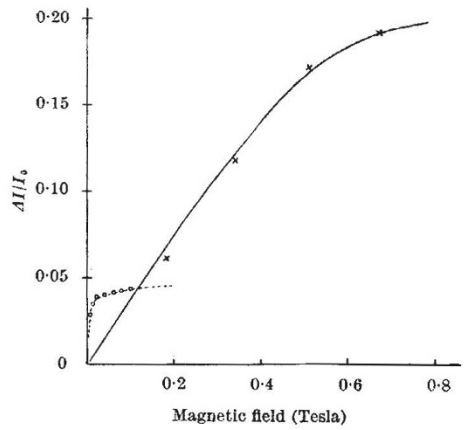

Fig. 2. Fractional increase of dark current against magnetic field, with a guard ring. Broken rule, photoconductivity result of Frankevich and Balabanov[1].

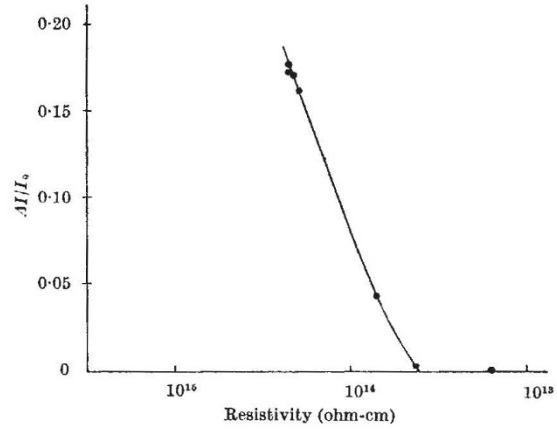

Fig. 3. Fractional increase of dark current against apparent crystal resistivity for a magnetic field of 0·51 Tesla and no guard ring.

Friedman[4] has shown that for narrow band semiconductors the effect would be smaller than this by a factor of 10^4 and the Hall effect would be anomalous. Frankevich and Balabanov explained their results for photoconductivity in terms of increased exciton lifetime.

A change in activation energy of less than 10^{-2} eV would account for the magnetoconductivity increase at 300° K. This could result from small shifts and splittings of impurity and molecular energy levels within the Davydov exciton model[5]. Furthermore, the internal space charge reduced the initial crystal current by at least three orders of magnitude and a small decrease in this space charge by diffusion of "trapped" carriers to surface recombination centres could explain the observed magnetoconductivity effect.

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