Bull. Inst. Chem. Res., Kyoto Univ., Vol. 46, No. 1, March 1968

Radiation Damage to Optical Absorption Properties of Anthracene Crystals

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Received January 18, 1968

The optical absorption spectra of single crystals of pure anthracence and those of anthracene doped with 10^{-3} gr/gr of tetracene have been observed for various absorbed doses at room temperature. It was found that the optical density increases linearly with the absorbed dose for pure anthracene crystal and new stable absorption centers were produced in the irradiated pure anthracene. In the case of doped crystal, we conclude that the same absorption centers were produced in doped crystal as in the pure anthracene at the higher dose region. However, at the lower dose region, such formation of absorption centers can not be seen because absorbed energy is spended to destroy tetracene molecules.

Several works have been reported on radiation damage of anthracene crystals concerning their fluorescence and scintillation efficiencies[1~3]. We have not, however, reliable data of optical absorption on radiation damage to organic solids. We study the dose dependence of the optical absorption spectra at room temperature of single crystals of pure anthracene and those of anthracene doped with a small quantity of tetracene, attempting to observe the protective nature of impurity molecules which is popular in dissociation of a variety of aromatic substances in liquid phase.

Pure and tetracene doped anthracene crystals were irradiated between 1.18×10^{6} R to 4×10^{7} R at room temperature by Co^{60} γ-rays of $\sim 6.8 \times 10^{4}$ R/hr. Absorption spectra of these irradiated samples were measured with a spectrophotometer (Shimazu M. P. S.). In order to avoid the experimental errors, the same sample was used throughout for a series of the measurements at different doses. The results are shown in Fig. 1 (a) and (b). As shown in Fig. 1 (a), absorption spectra of pure anthracene crystal show a shoulder at the range from 4300 to 5800 Å at the each dose. The shoulder must be new stable absorption centers (damaged centers) produced in the irradiated pure anthracene because the area of the shoulder (integrated optical density) increases linearly with the absorbed dose (Fig. 2, curve (a)). In the case of anthracene crystal doped with 10^{-3} gr/gr of tetracene, the distinct shoulder can not be seen owing to the superposition of absorption peak as shown in Fig. 1 (b). At the higher dose region, integrated optical density remarkably increases (Fig. 2, curve (b)) and the absorption spectrum has a small peak at 5200 Å which also appeared for updoped anthracene. Accordingly, we conclude that the same absorption centers were produced in the

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doped crystal as in pure anthracene. At the lower dose region, characteristic peaks at 4600 Å and 4900 Å attributed to absorption by tetracene molecule become smaller with doses. The decreases in the peak intensities may be caused from the destruction of tetracene molecules by irradiation. Therefore, curve (b) in Fig. 2 is supposed to consist of two components; the one is the decrease of tetracene absorption and the other is the increase from the formation of new absorption centers. In the absorbed doses less than $\sim 1\times10^7$ R, the decrease of absorption in tetracene molecule is predominant, but it tends to saturate above $\sim 1.4\times10^7$ R. The linear increase in the dose dependence curve at the higher dose region shows that the formation of absorption centers is dominant compared with the destruction of tetracene molecules.

Efficient energy transfer from anthracene to tetracene molecules has been verified in the scintillation process of such crystals[1,4]. In the case of radiation damage of the crystals, the absorbed energy transfers to tetracene molecules destroy them, so that the host crystal is protected from suffering radiation damage. In the case that the absorbed dose is small, the host crystal is efficiently protected and the absorption centers are not so much produced. As the dose increases, the absorption centers accumulate and the energy transfer to tetracene is prevented. Thus, no more tetracene molecule can be destroyed by irradiation and the rate of the formation of absorption centers increases, resulting the optical density of the sample becomes to increase linearly with the absorbed dose.

In Fig. 1 (b), absorption spectra of irradiated samples are normalized to unirradiated sample at the 7000 Å. The absolute value of optical density does not only decrease at the characteristic absorption region of tetracene molecules but also at the longer wavelength where no tetracene absorption occurs. This result might be reffered to a optical scattering which is reduced by irradiation.

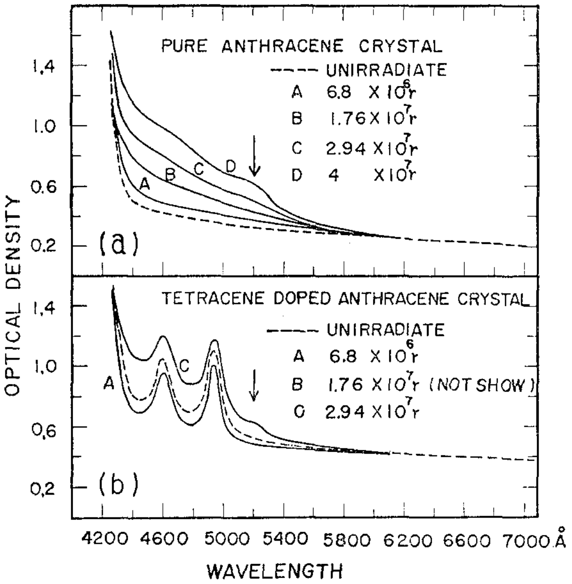

Fig. 1. (a) and (b) Absorption spectra at various doses for pure and tetracene doped anthracene crystals, respectively.

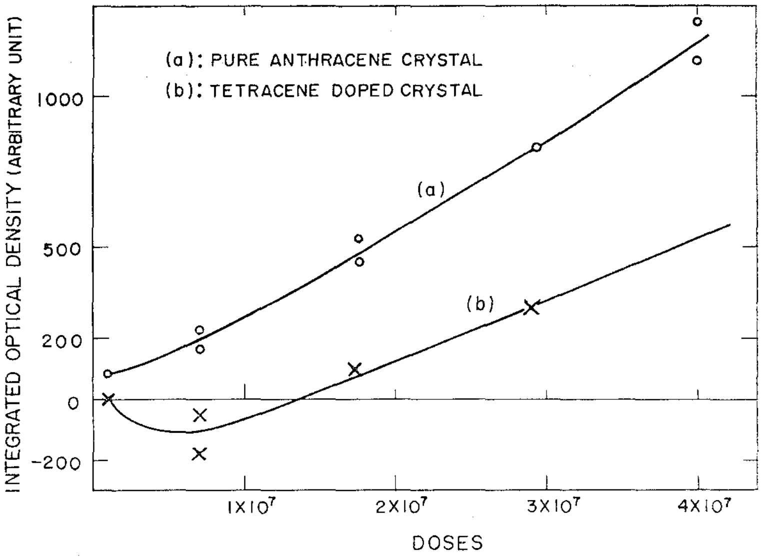

Fig. 2. Optical density which is integrated over wavelength region from 4300 to 5100 Å at various doses for pure and tetracene doped anthracene crystal.

ACKNOWLEDGMENT

The author wishes to thank Mr. R. Katano of the Institute for Chemical Research of Kyoto University for his cooperation in irradiation procedure.

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