

Fabrication and Optical Anisotropy of Non-Peripheral Octahexylphthalocyanine Films with Large Mono-Domain

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Abstract

Thin films of soluble non-peripheral octahexylphthalocyanine have been fabricated by spin-coating. The large-size domain could be obtained in the films fabricated by controlling processing temperature, and the anisotropic properties were observed by microscopic measurements. We discussed the optical anisotropy of the fabricated films by taking the molecular alignment into consideration.

1. Introduction

Organic semiconductors have been widely applied to electronic devices, such as thin-film transistors, photovoltaic cells, and light-emitting diodes. Semiconducting materials with long alkyl substituents are attracting much attention owing to their high solubility in solvents. Although device fabrication from solution, such as spin-coating, is effective for reducing the processing cost, fabricated organic semiconductor films are usually polycrystal with a considerable amount of grain boundaries, which interrupts mobile carriers^[1]. Therefore, the domain size in the organic semiconductor films fabricated by solution processes is desired to be enlarged for achieving high device performance.

In this study, we fabricate thin films of a phthalocyanine derivative with long alkyl substituents, which exhibits high carrier mobility of higher than $1 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$ in time-of-flight method^[2] and has been utilized for a photovoltaic cells with the efficiency of exceeding 4 %^[3]. For enlarging the domain size, the sample temperature is controlled during spin-coating process. We discuss about the optical anisotropy in the films by taking the molecular alignments into account.

2. Experiments

A phthalocyanine derivative, 1,4,8,11,15,18,22,25-octahexylphthalocyanine (C6PcH₂) were used in this study. The molecular structure of C6PcH₂ is shown in Fig. 1.

C6PcH₂ was dissolved into solvents with a concentration of 15 gL^{-1} . Chloroform and a mixture of *o*-dichlorobenzene and *p*-xylene with a volume mixing ratio of 1 to 3 were used as solvents for spin-coating at the temperatures lower and higher than 100 °C, respectively. The temperature of the spin-coating stage and the solution were

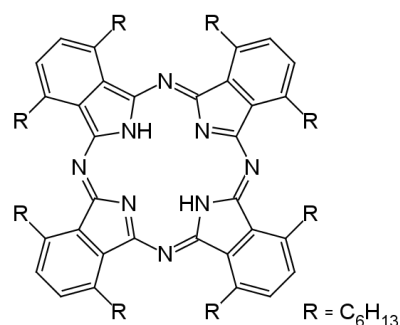


Fig. 1 Molecular structure of C6PcH₂.

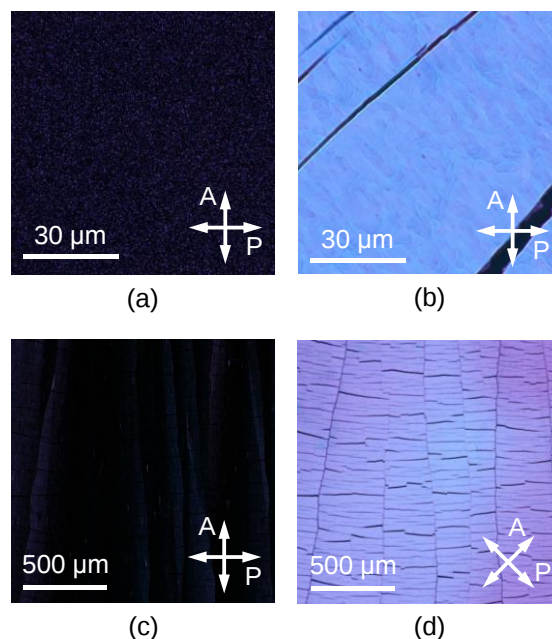


Fig. 2 Polarizing micrographs of the C6PcH₂ films fabricated (a) at room temperature and (b,c,d) at 160 °C.

controlled during spin-coating.

Optical properties of the fabricated films were observed by a polarized-light microscope. Polarized absorption spectra were measured by utilizing UV-Vis spectrophotometer attached to the microscope.

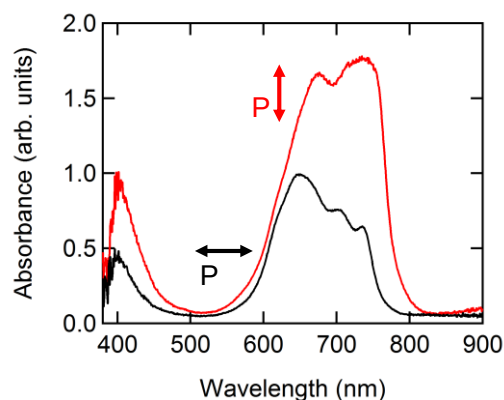


Fig. 3 Polarized absorption spectra of the C6PcH₂ films

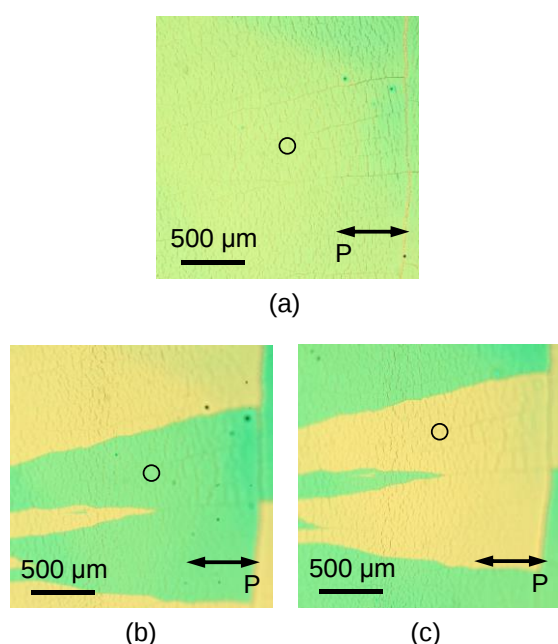


Fig. 4 Polarizing micrographs of the C6PcH₂ films at the tilted angles of (a)0°, (b)20°, and (c)-20°. Circles indicate observing area for absorption spectra.

3. Results and Discussion

Figure 2 shows micrographs of the fabricated C6PcH₂ films under cross-polarized light. Small domains with diameters of lower than 1 μm were observed in the films fabricated at room temperature as shown in Fig. 2(a). On the other hand, in the films fabricated at 160 $^{\circ}\text{C}$, large domains with diameters of larger than 60 μm were observed as shown in Fig. 2(b). The directions of optic axis of domains were almost uniform in the area with diameters of exceeding 1 mm as shown in Figs. 2(c) and 2(d).

Figure 3 shows polarized absorption spectra of the C6PcH₂ film. The observed spots were with a diameter of 100 μm and were indicated by circles in Fig. 4. The polarizing directions of incident light are indicated by colored arrows and the direction indicated by a black arrow corre-

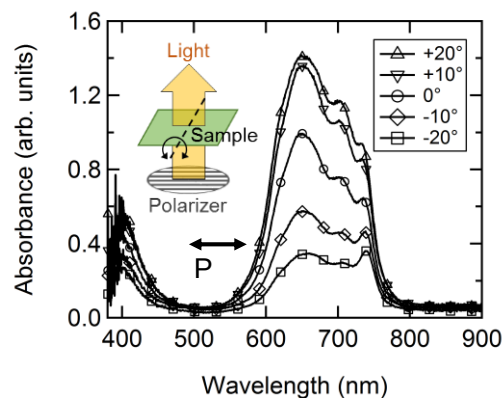


Fig. 5 Polarized absorption spectra of the C6PcH₂ films. Angles in the legend indicates tilted angles of samples with respect to incident light.

spond to the direction indicated in Fig. 4. The absorption intensity and shape of absorption spectrum of fabricated films changed depending on the polarizing angle. The optical anisotropy in the films implies the molecular alignment of C6PcH₂.

Figure 4 and 5 show micrographs and polarized absorption spectra of the C6PcH₂ film, respectively. The sample substrates were rotated around an axis parallel to the substrates and perpendicular to polarizing direction of inserted polarizer as shown in the inset of Fig. 5. The tilted angle with respect to incident light and absorption spectra were compensated under the assumption that refractive index of the film is 1.5. The absorption spectrum and color in the micrograph in Fig. 4 drastically changed depending on the tilted angles. Two kinds of domains with green and yellow colors appeared when the film was tilted, and these colors were replaced each other by tilting with the inversed angle as shown in Figs. 4(b) and 4(c). C6PcH₂ molecules possess disk-like structure and must show minimal absorption intensity when the polarizing angle of incident light is perpendicular to the molecular plane. Therefore, it is considered that C6PcH₂ molecules in the fabricated film tend to be oriented with certain angle respect to the substrate.

4. Conclusions

We fabricated C6PcH₂ films with large domains by spin-coating under controlled processing temperature. We demonstrated optical anisotropy in the fabricated C6PcH₂ films, which is considered to be related with molecular alignment in the films.

Acknowledgements

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