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Anisotropic Photoconductive Properties of Aromatic Polyimide Films Containing Diphenyl-benzidine Structure with High Electron-donating Ability

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Abstract Polyimide (PI) is a widely used super-engineered plastics exhibiting high thermal, chemical stability, and mechanical strength. Recently, PIs containing triphenylamine structure were reported to show electric conductivity by photo-irradiation, called photoconductivity (PC). We have previously investigated the PC of various PIs and reported that charge transfer transition ability (CT interaction) between the diamine and dianhydride moieties, molecular chain orientation and denser aggregation structures are essential to enhance the PC [1]. The CT interaction strength can be strengthened with enhancing the electron-accepting ability of dianhydride and the electron-donating ability of diamine moieties. In this study, we synthesized novel PI films based on a diamine containing *N,N*-diphenyldimethylbenzidine structure (Fig. 1), which has strong electron-donating ability and rigid linear structure. We investigated the correlation between the out-of-plane/in-plane anisotropy of PC and the main chain orientation of the PIs. PC values induced by applying positive voltage under UV/visible irradiation was measured using the setups in Fig. 2. The PC value in the out-of-plane direction was significantly larger than those in the in-plane direction for all the PIs (Fig. 3). Since the PI chains prepared by spin coating are preferentially oriented in the film plane direction, the anisotropy in PC could be reasonable if the carriers are more efficiently transported in the direction of intermolecular interactions than that of intramolecular chains. We have also reported that denser aggregation of PI chains promote carrier recombination and deactivation along the out-of-plane direction, resulting in a decrease in PC because the carrier mobility is higher than the in-plane direction. When comparing PIs having the same recombination efficiency, the anisotropy in PC is enhanced with increasing the degree of in-plane orientation. Therefore, these results strongly suggest that charge carriers are more likely to transport in the intermolecular direction. In conclusion, the anisotropy in PC is enhanced with increasing the in-plane orientation with suppressing the carrier recombination owing to the preferential transportation of carriers along the intermolecular direction.

References [1] K. Takizawa, S. Asai, S. Ando, *Polymer J.*, **46**, 201 (2014).

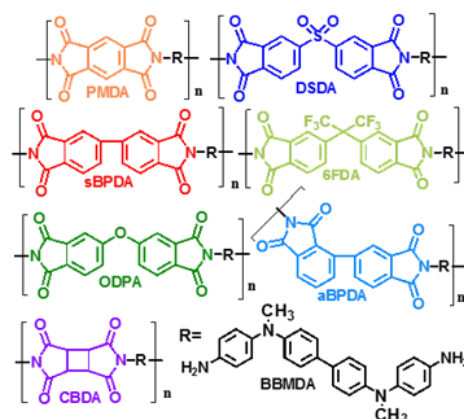


Fig. 1 Chemical structures of target PIs.

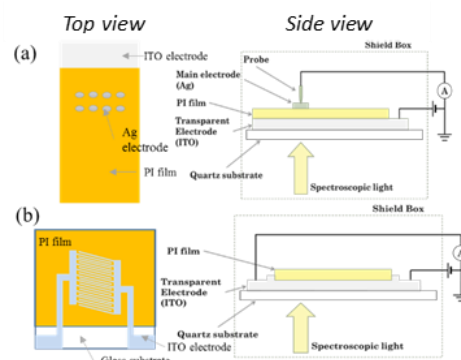


Fig. 2 Setups for (a) out-of-plane and (b) in-plane photocurrent measurement.

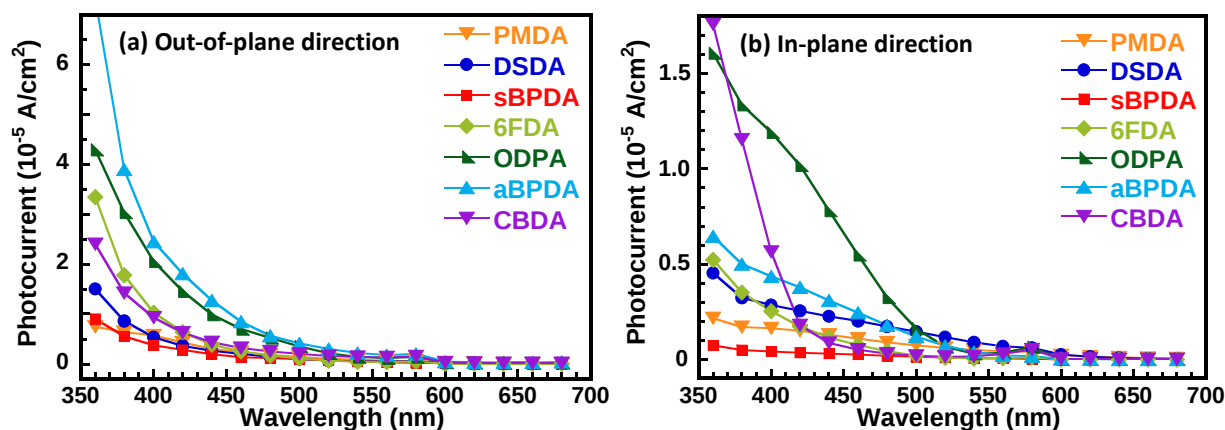


Fig. 3 Photo-current spectra of aromatic polyimide films derived from different dianhydrides. (a) out-of-plane and (b) in-plane directions. The photo current in the out-of-plane direction are much higher than the in-plane direction.