3D-shaped N-type organic semiconductors based on naphthothiophene diimide: synthesis and applications

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Naphthothiophene diimide (NTI), originally developed as an n-type organic semiconductor,[1)] can be utilized as terminal building units for developing n-type organic semiconductors with low-lying LUMO energy levels. Such NTI-based materials were useful as the n-type organic semiconductors in field-effect transistor (OFET) and photovoltaic (OPV) devices.[2)] We also recently found that the direct arylation reaction can proceed at the thiophene α-position of the NTI unit, which allows us to readily introduce the NTI unit on various π-conjugated frameworks.[3)] By taking advantage of these features of the NTI unit, we designed novel multi-NTI n-type organic semiconductors with three-dimensional (3D) molecular shapes; in this study, a molecule with six NTI units on a benzene ring (NTI6, **Figure 1**) is featured, and its physicochemical properties and applications in OFET and OPV devices are reported.

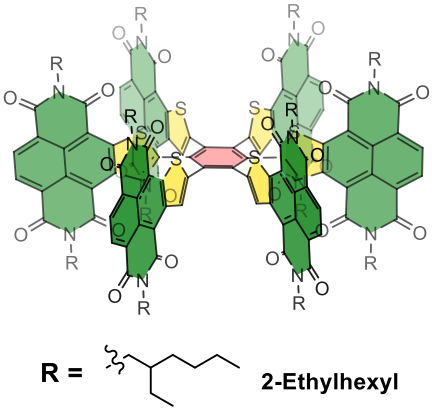

Figure 1. The structure of NTI6.

The OFET devices fabricated by the solution process showed decent n-channel FET behaviors, and the mobility extracted from the saturation regime was up to 1.9×10^{-2} cm^2/V s (**Figure 2a**). NTI6 also acted as the accepter molecule in the OPV devices combined with PCE10 as the donor material, affording a power conversion efficiency of up to 7.4% (**Figure 2b**). These results indicate that the present molecular design strategy, 3D-shaped NTI molecules, is promising for developing solution-processable novel n-type organic semiconductors.

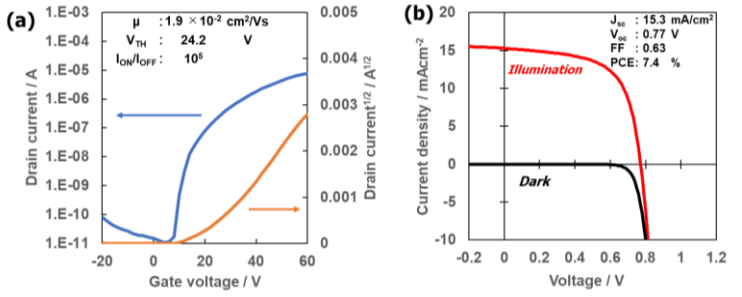

Figure 2. Results of OFET(a) and OPV(b) using NTI6.

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