IX-D Development of Organic Semiconductors for Molecular Thin-Film Devices

Organic light-emitting diodes (OLEDs) and organic field-effect transistors (OFETs) based on π-conjugated oligomers have been extensively studied as molecular thin-film devices. Organic semiconductors with low injection barriers and high mobilities are required for highly efficient OLEDs and OFETs. Radical cations or anions of an organic semiconductor have to be generated easily at the interface with an electrode (or a dielectric), and holes or electrons must move fast in the semiconducting layer. Compared with organic *p*-type semiconductors, organic *n*-type semiconductors for practical use are few and rather difficult to develop. Recently, we found that perfluorinated oligomers are efficient electron-transport materials for OLEDs.

IX-D-1 Organic Thin-Film Transistors Based on Anthracene Oligomers

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[*J. Appl. Phys.* **95**, 5795–5799 (2004)]

OFETs with an active layer based on the organic semiconducting anthracene oligomers, 2,2'-bianthracene (**2A**), 2,6-trianthracene (**3A**), and their dihexyl derivatives (**DH-2A** and **DH-3A**), were fabricated. It was found that thin films of anthracene oligomers deposited by thermal evaporation had lamellar structures with a high degree of molecular ordering. Consequently, the OFETs based on anthracene oligomers showed high field-effect mobilities. The mobility of the OFETs was increased by the oligomerization and the substitution of alkyl groups. **DH-2A** on a SiO_2/Si substrate showed the highest mobility of 0.13 cm^2/V s. It was also found that the electrical characteristics of the OFETs were improved by using a Ta_2O_5 gate insulator.

IX-D-2 Perfluoropentacene: High-Performance *p-n* Junctions and Complementary Circuits with Pentacene

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[*J. Am. Chem. Soc.* **126**, 8138–8140 (2004)]

We report the synthesis and characterization of perfluoropentacene as an *n*-type semiconductor for OFETs. Perfluoropentacene is a planar and crystalline material that adopts a herringbone structure as observed for pentacene. OFETs with perfluoropentacene were constructed using top-contact geometry, and the electron mobility of 0.11 cm^2/V s was observed. Bipolar OFETs with perfluoropentacene and pentacene function at both negative and positive gate voltages. The improved *p-n* junctions are probably because of the similar d-spacings of both acenes. Complementary inverter circuits were fabricated, and the transfer characteristics exhibit a sharp inversion of the output signal with a high voltage gain.

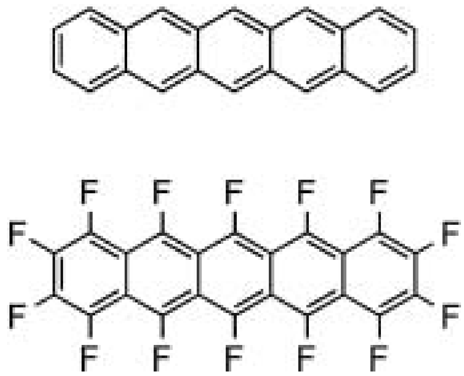

Figure 1. Structures of pentacene and perfluoropentacene.

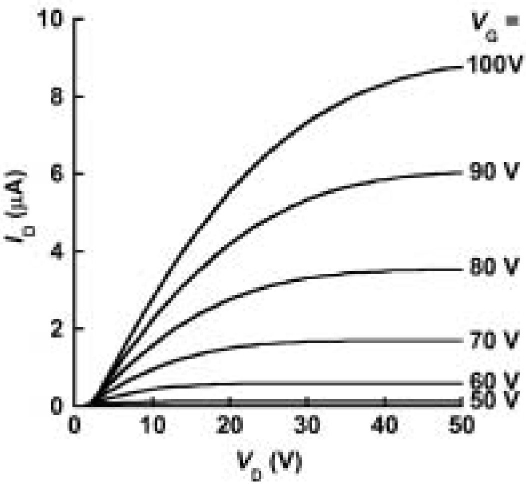

Figure 2. Drain current (I_D) versus drain voltage (V_D) characteristics as a function of gate voltage (V_G) for a perfluoropentacene OFET.