Long Alkyl Chain Induced OFET Characteristic with Low Threshold Voltage in an n-Type Perylene Monoimide Semiconductor

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This work reports the fabrication of an n-channel OFET device using simple perylenemonoimide (PMI) derivatives by introducing a nonconjugated long alkyl chain (octadecyl) at the imide position. To demonstrate the primary role of the long pendant chain in the generation of OFET characteristics, a series of electronically similar PMI congeners were synthesized with different alkyl chains ~namely, hexyl, 2-ethylhexyl, octyl, and octadecyl. It was observed that the insertion of the octadecyl chain can significantly manipulate the supramolecular self-assembly in PMI-C18 with very good film-forming property, suggesting the prominent role of the pendant alkyl chain length in their condensed state intermolecular interaction. Along with the good film forming property, the long octadecyl chain at the imide position significantly improves the thermal, electrochemical, and photophysical properties, which help in generating OFET characteristics in PMI-C18, whereas other congeners do not show any device properties. With poly(methyl methacrylate) (PMMA) as the dielectric, top-contact bottom-gate n-channel OFET were fabricated on an economical glass substrate using these simple PMI derivatives. Among them, PMI-C18 demonstrates OFET properties with electron mobility (μ_e) of 1×10^{-4} cm^2 V^{-1} s^{-1} and current on/off ratio ($I_{on/off}$) of 8.8×10^2. Moreover, the threshold voltage (Vth) of 4.40 V obtained for PMI-C18 was the lowest among all the reported perylene monoimide core based OFET devices. Besides, these PMI cores also demonstrated the influence of the alkyl chain on the photophysical, electronic, and electrochemical properties along with the molecular packing and charge transport behavior. Thus, such simple yet strategic synthetic manipulations in PMIs could contribute to the development of imide based materials for OFET applications.

KEYWORDS: perylenemonoimide (PMI), n-type semiconductor, OFET, long alkyl chain, electron transport, threshold voltage