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2,3-thienoimide-ended oligothiophenes as ambipolar semiconductors for multifunctional single-layer light-emitting transistors

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Organic light-emitting field-effect transistors (OLETs) are emerging as an innovative class of multifunctional devices that integrates the electronic properties of a transistor, the light-generation capability and the full potential of organic photonics.
OLETs require the active materials to possess both high carrier mobility and high photoluminescence quantum yield to realize the potential applications in active-matrix full color display, integrated photonic circuitry, sensing, and possibly the long-searched electrically driven organic laser.
In most cases, organic semiconductors, and especially small-molecule conjugated compounds, suffer from luminescence quenching when they show high field-effect carrier mobility due to the strong intermolecular π–π stacking which finally promotes singlet fission or other exciton quenching mechanisms. Moreover, the outperforming external quantum efficiency that is inherently expected in the case of OLETs eventually relies on well-balanced charge ambipolarity that is very challenging to obtain in a single organic semiconductor [1].
In the latest years, a new synthesis strategy has been proposed to design a thiophene-derived molecule family - named 2,3-thienoimide-ended (TI) oligothiophene family- which has showed a great potential as emissive ambipolar compounds endowed with easily tunable structural and optoelectronic properties. The introduction of the thienoimide group as end-substituent in the thiophenic core turned out to be a powerful tool to i) obtain electron transport, ii) modulate ambipolarity (major p- or n-type behavior) on the basis of the number of thienoimide groups, iii) tune the highest and lowest occupied molecular orbital and energy values, iv) influence the solid-state packing and v) promote electroluminescence in oligothiophenes [2].
In this oral contribution, I report the major results reported in the latest years on the assessment of the correlation between the molecular structure, packing modalities, charge mobility and light emission in thin-films when the TI-ended oligothiophenes are used as active materials in transistor-based devices [3].
By referring to a particular class of multifunctional devices such as OLETs, we benchmark the quantification of the optoelectronic figures of merit (i.e. charge mobility, gate threshold voltage, emitted optical power) by systematically varying the molecular structures of these compounds, and the correlated post-synthesis processing approaches.
Finally, we focus our attention on a prototypal molecule of the family (named NT4N) given the remarkable characteristics in the balance of hole and electron mobility and in the emitted optical power, which enable the implementation of NT4N-based OLETs as both scientific and technological viable solutions for optimizing optoelectronic and photonic performance and envisaging real-setting applications in OLETs.

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