SOLAR CELLS AND THIN FILM TRANSISTORS BASED ON PERYLENE-FUNCTIONALIZED POLYMERS

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Two main classes of semiconducting molecules are commonly used for opto-electronic applications: polymers, featuring an easy solution-processability in thin and uniform yet poorly ordered films, and small poly-aromatic molecules, forming highly defined (liquid)-crystalline architectures with excellent charge mobility. Herein, we combine the two material types by employing structurally well-defined polyisocyanopeptide polymers (PIC) as scaffolds to precisely arrange thousands of electron accepting molecules, i.e. perylene-bis(dicarboximides) (PDIs), in hundreds of nanometer long, well-defined chromophoric wires (fig. 1).[1] The PIC polymer backbone enforces high control over the spatial location of PDI dyes favoring both enhanced exciton and charge transfer.

By adding to a monomeric PDI polycrystalline film just 17% of the PIC-PDI polymer, acting as percolation pathways for charge transfer between the different crystals, we obtained a two orders of magnitude increase in charge carrier mobility within the film, as measured in thin film transistor (TFT) devices (fig. 2).[2,3]

Furthermore, the photovoltaic activity of this polymeric PIC-PDI shows a significant improvement, respect to monomeric PDI, when blended with regio-regular poly(3-hexylthiophene) (P3HT) in solar cells.[4] For the first time we visualized by Kelvin Probe Force Microscopy (KPFM) the photovoltaic activity occurring in such a blend, thus allowing to gain quantitative insight into the correlation between architecture and function with a nanoscale resolution.[5]

These multi-chromophoric wires represent a new class of versatile building blocks for nanoelectronics.

References:

[1] Schwartz, E., et al., Chemistry a European Journal, 2009. 15(11): p. 2536.
[2] Dabirian, R., et al., Journal of the American Chemical Society, 2009, accepted.
[3] Finlayson, C.E., et al., Advanced Functional Materials, 2008. 18(24): p. 3947.
[4] Foster, S., et al., Macromolecules, 2009. 42(6): p. 2023.
[5] Palermo, V., et al., Journal of the American Chemical Society, 2008. 130(44): p. 14605.

Figures:

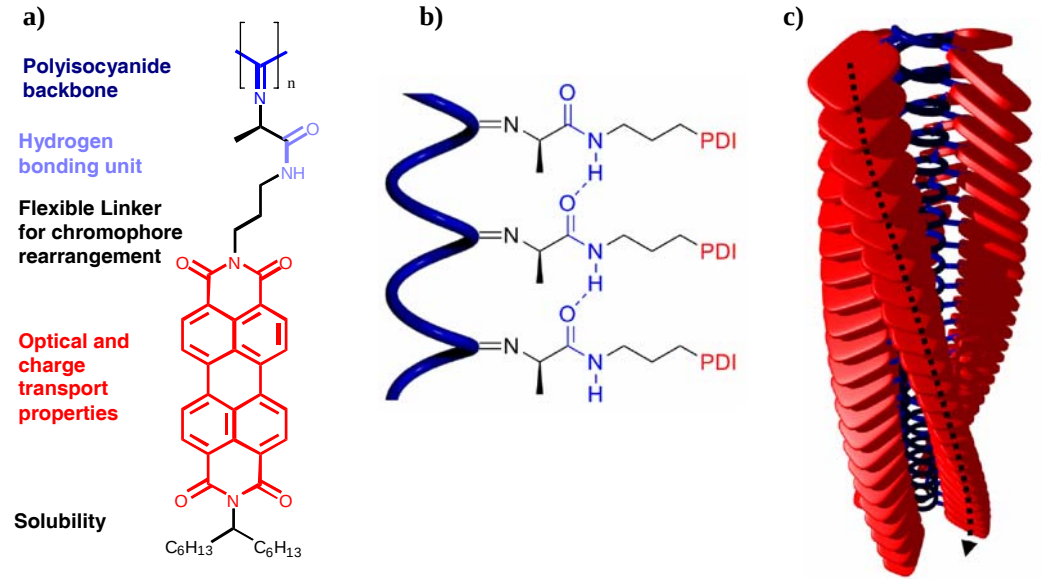

Figure 1: Chemical structures. a) Chemical structure of PIC-PDI; The relevant parts of the molecule and their role in the macromolecular properties are shown in different colours. b) Illustration of the hydrogen-bonding between the n^{th} and $(n+4)^{th}$ monomeric units within the polymer; the blue helix represents the carbon backbone. c) Cartoon showing the complete helical structure of PIC-PDI. The dashed arrow indicates a stack of PDI units running along the central polyisocyanide

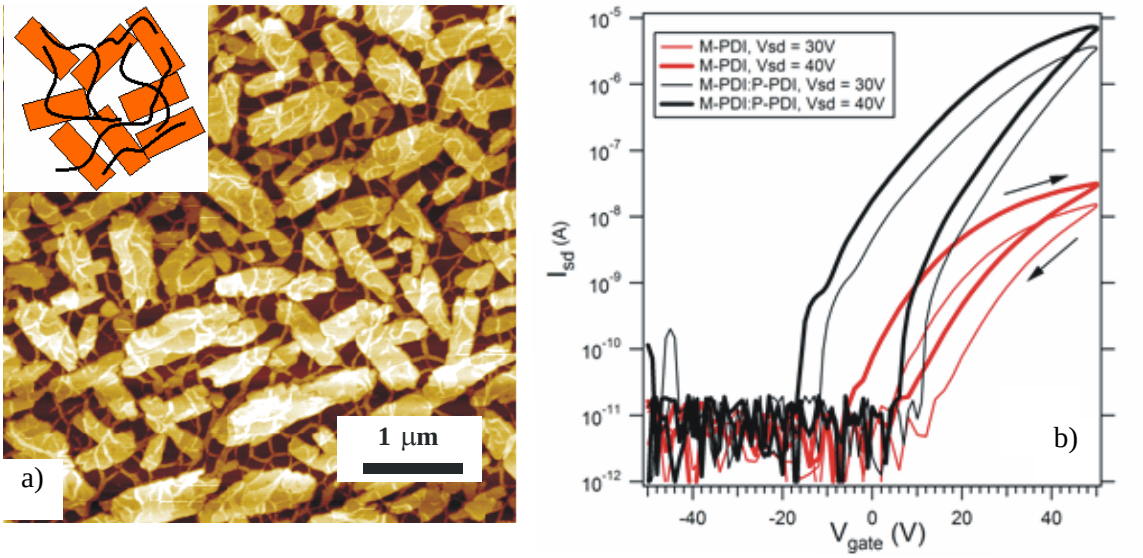

Fig.2 a) AFM image of nanocrystals of monomeric PDI bridged by PIC-PDI fibers. Inset: a cartoon of blend structure. b) Transfer curves of FETs based on a blend of polymeric and monomeric PDI vs. monomeric PDI .