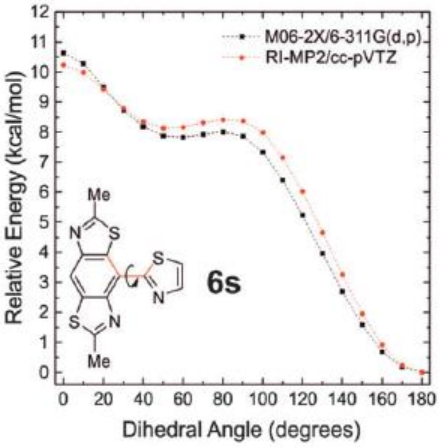
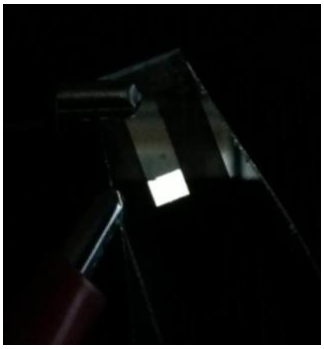
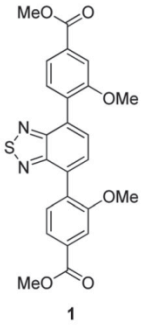
AmbiPOD project achievements illustrated

(FP7-PEOPLE-2013-IRSES-612670)

The control of molecular architecture in planar conjugated structures of organic semiconductors is a highly important aspect of organic electronics. The main question here is whether heteroatomic non-covalent interactions are coincidental or real, or if the sole driver for planar architectures in conjugated molecules is hydrogen bonding. Solid arguments have been presented, based on a combination of experimental data and modelling, for the importance of heteroatomic non-classical bonds in conjugated organic molecules and macromolecules, providing an insight to design rules for the manipulation of chemical structure towards targeted properties [1].







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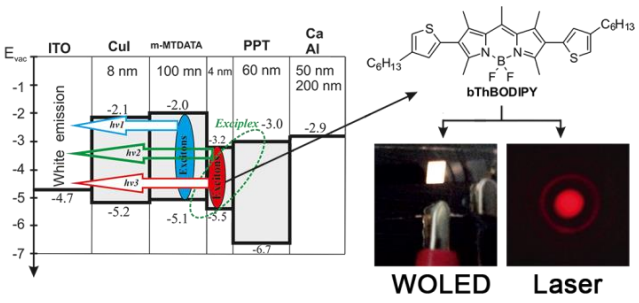
A new triaryl molecule based on functionalised bis(benzoic acid ester) and benzothiadiazole core has been applied as a single active layer in an OLED device. This very simple molecule emits intensively (> 5000 cd·m^{-2}) from a combination of emissive states (exciton / electromer / exciplex / electroplex) to give white light with CIE coordinates of (0.38, 0.45) and a colour temperature of 4500K [2].

A new interface engineering method was demonstrated for the preparation of an efficient white organic light emitting diode (WOLED) by embedding an ultra-thin layer of the novel ambipolar red emissive bis(alkylthienyl) - BODIPY in the exciplex formation region. The compound shows balanced hole and electron mobility. The resulting WOLED exhibited a maximum luminance of 6500 cd·m^{-2} with CIE 1931 colour coordinates (0.39; 0.35). The BODIPY derivative dye is also demonstrated to be an effective laser dye for a cholesteric liquid crystal (ChLC) laser. New construction of the ChLC laser, by which a flat capillary with an optically isotropic dye solution is sandwiched between two dye-free ChLC cells, provides photonic lasing at a wavelength well-matched with that of a dye-doped planar ChLC cell [3].



[1] P. J. Skabara et al. *Materials Horizons* **2016**, *3*, 333-339; DOI: 10.1039/c6mh00051g

[2] P. J. Skabara et al. *Journal of Materials Chemistry C* **2016**, *4*, 3851-3856; DOI: 10.1039/c6tc00750c

[3] P.J. Skabara.et al. *ACS Applied Materials Interfaces* **2017**, *9*, 4750-4757; DOI: 10.1021/acsami.6b13689

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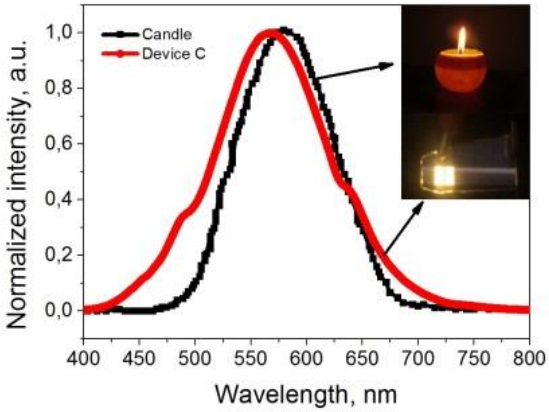
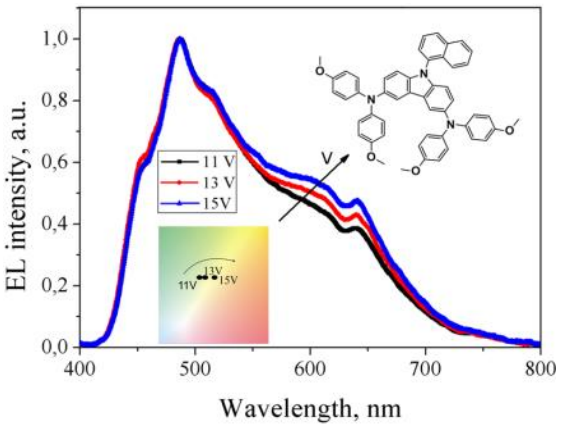
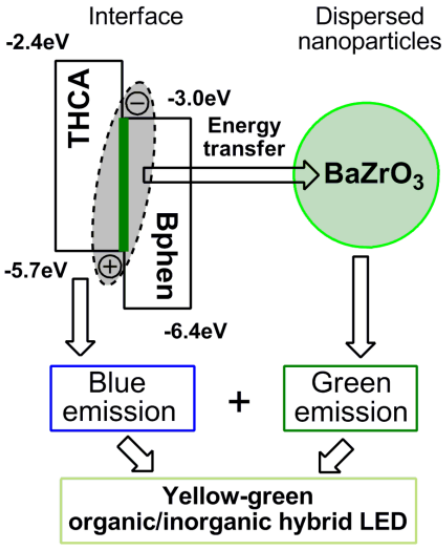
Bicarbazole - (trifluoromethyl)benzonitrile derivative demonstrating intensive thermally-activated delayed fluorescence (TADF), and exciplex excited states with (m-MTDATA) delivers combined warm white like electroluminescence, close to wax candle emission. OLED devices demonstrated very high brightness of 40900 Cd/m^2, current efficiency of 53.8 Cd/A, 19.3 lm/W power efficiency, with EQE reaching impressive 18.8 %. At standard test conditions (1000 Cd/m^2) emission parameters remain high, with current efficiency of 46.2 Cd/A, power efficiency of 10.6 lm/W, EQE of 17.0 %) [4] .





New naphthylcarbazole – diphenylamine fluorophore, demonstrated bipolar semiconducting properties. Working as an emissive material in single-layer OLED, voltage-dependent electroplex emission band (550–650 nm) marked the electroluminescence spectrum of the device. Supplemented with additional electron transporting bathophenanthroline layer, strong exciplex-type band emerged at ca. 540 nm. With electroluminescence spectra dependent on the applied bias, efficient and colour-tuneable OLEDs have been demonstrated [5].

Double-channel emission from organic exciplexes coupled to inorganic nanoparticles has been demonstrated affording broadened yellow-green electroluminescent emission in light-emitting diodes based on organic exciplexes hybridized with perovskite-type dispersed $BaZrO_3$ nanoparticles. Harvesting the energy transfer from the exciplexes at the interface between organic layers of THCA, Bphen, and randomly deposited spherical-shaped $BaZrO_3$ nanoparticles, OLED device exhibited maximum brightness of 3465 cd/m^2, current efficiency value of 3.88 C d/A and external quantum efficiency of about 1.26%. Förster dipole-dipole energy transfer model has been effectively applied to evaluate the efficiency of energy transfer from the exciplex to the $BaZrO_3$ nanoparticles [6].



[4] J. V. Grazulevicius et al. *Journal of Materials Chemistry C* **2018**, *6*, 1543-1550; DOI: 10.1039/c7tc05392d

[5] J. V. Grazulevicius et al. *New Journal of Chemistry* **2017**, *41*, 559–568; DOI: 10.1039/c6nj02865a

[6] G. Baryshnikov et al. *Dyes and Pigments* **2017**, *145*, 399-403; DOI: 10.1016/j.dyepig.2017.06.020

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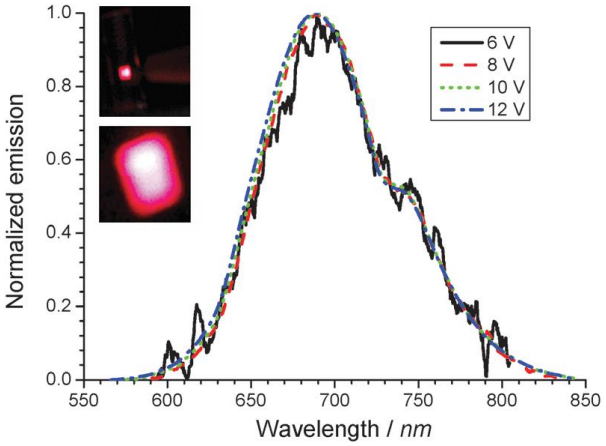
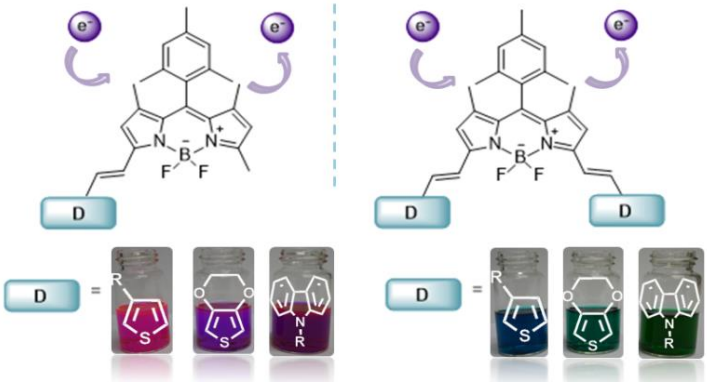
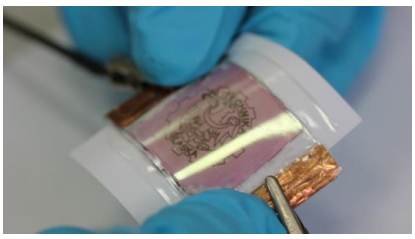
Vinyl conjugated benzothiadiazole and carbazole D-π-A-π-D structure demonstrated reversible p- and n- redox chemistry, strong CT absorption band and near infrared fluorescent emission in the solid state. OLEDs based on this compound demonstrated efficient emission at the deep red / infrared edge, with brightness reaching 34800 cd/m^2 external quantum efficiency of 3.13% and current efficiency of 6.8 cd/A. These figures of merit are indeed remarkable as far as solid state red-emitting organic diodes are concerned [7].

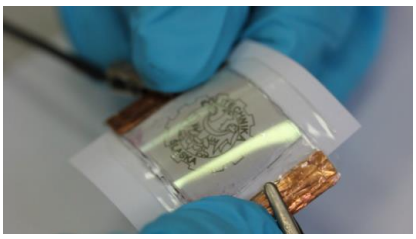




Extending the efficient light harvesting π-conjugated system of boron-dipyrrin (BODIPY), the dye was coupled with polymerisable carbazole, and thiophene derivative units. Redox properties of a series of these BODIPY derivatives have been studied, including their propensity to develop p- and n- dopable polymer films upon electrochemical oxidation of the thienyl or carbazoyl unit. Reversible redox states have been scrutinised, and (de)localisation patterns of the doping imparted unpaired electron elucidated. Structure – property relationships have been identified providing clues to conscious design of BODIPY based panchromatic dyes [8,9].

Flexible rapid-switching electrochromic windows were fabricated and their characteristics tested on reference polymeric electrochromes. Judicious choice of gel electrolyte, its working viscosity and layer thickness all proved determining factors in effective, reversible, low voltage threshold operation of these tuneable optic filters. Developed methodology will enable to screen other π-conjugated polymers for efficient colour-switching performance in device operating conditions.





[7] P. Ledwon et al. *Journal of Materials Chemistry C* **2016**, *4*, 2219-2227; DOI: 10.1039/c5tc04183j

[8] K. Wagner et al. *Electrochimica Acta* **2018** (in press); DOI: 10.1016/j.electacta.2018.03.044

[9] P. Wagner et al. *RSC Advances* **2016**, *6*, 36500-36509; DOI: 10.1039/c6ra04984b