Singlet, doublet and triplet spin control in organic semiconductors

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The spin of ground and excited state levels in organic semiconductors gives the playground for photophysics in optoelectronics: with applications from solar cells to light-emitting diodes (LEDs) using energy and charge transfer processes.

Spin controls the functional behaviour: where the longstanding issue in organic LEDs is 1:3 ratio of singlet and triplet excitons formed following charge recombination. Non-emissive triplet excitons generated in these device limit the electroluminescence efficiency and the leading methods to recover efficiency is conversion to emissive singlet excitons in thermally activated delayed fluorescence. I discuss optical spectroscopy and magnetic resonance studies that probe key singlet-triplet spin conversion mechanisms in a series of delayed fluorescence emitters with varying energy gaps between the functional exciton states for advancing this technology.[1]

Finally I will present studies on light emission from luminescent organic radicals and the doublet-spin energy manifold.[2] I will discuss why most π-radical systems have poor optical properties, and how we can increase the absorption and luminescence yields with design rules for the chemistry and colour of radical emitters.[3] I will also share new device strategies for OLEDs arising from the singly occupied molecular orbital (SOMO) and doublet-spin properties, resulting in the most efficient performance in the red to infrared wavelength range. This presents a platform for next-generation technologies using spin control from singlet, doublet and triplet excitons.[4]

References

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[2] X. Ai *et al.*, *Nature*, **563**, pp. 536–540 (2018).
[3] Abdurahman *et al.*, *Nature Materials*, **19**, pp. 1224-1229 (2020)
[4] Li *et al.*, *Nature Communications*, in press (2022)