S3-I2

Advanced strategies for efficient solid-state photon upconversion

Karolis Kazlauskas

[1]*Institute of Photonics and Nanotechnology, Faculty of Physics, Vilnius University, Saulėtekio av. 3, LT-10257 Vilnius, Lithuania*
Email: karolis.kazlauskas@ff.vu.lt.

Triplet–triplet annihilation upconversion (TTA-UC) provides a unique molecular route for converting low-energy, incoherent light into higher-energy emission, thereby enabling applications in solar energy harvesting, photocatalysis, bioimaging, optogenetics, and 3D printing [1]. However, translating high solution efficiencies into solid-state architectures, which are preferred for practical applications, requires a shift from empirical optimization to mechanism-guided materials design.

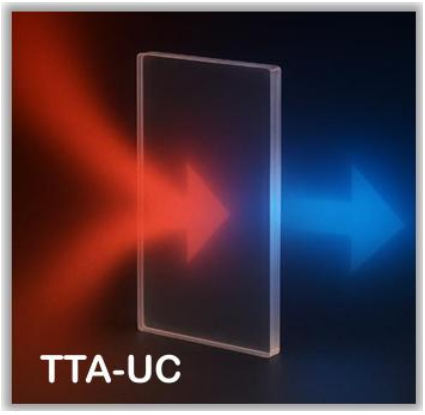

Fig. 1 Schematic illustration of TTA-UC process.

In this talk, we discuss how solid-state TTA-UC performance has advanced through the identification and control of coupled exciton-diffusion and loss processes. We first show that high annihilator loading, while needed for Dexter-type triplet hopping, can induce aggregation, emission quenching, and diffusion-assisted triplet loss at non-radiative sites [2]. We then describe strategies that turn these constraints into design rules: i) suppressing back-FRET from upconverted singlets with emissive singlet sinks [3]; ii) combining purification with melt-processing to obtain homogeneous, high-loading amorphous films with reduced singlet and triplet quenching [4]; and iii) using multi-resonant TADF emitters as advanced sink sites. Finally, we discuss recent routes to engineer the spin-statistical factor *f*, either by reducing losses to upper triplet states through annihilator design [5] or by exploiting aggregation-induced changes in the triplet manifold and spin–orbit coupling [6]. Together, these strategies define a route from managing exciton diffusion to actively engineering the fate of triplet-pair states in solid-state TTA-UC.

REFERENCES

[1] L. Zeng, L. Huang, J. Han, G. Han, *Acc. Chem. Res.* **55** (2022) 2604–2615.
[2] S. Raišys, K. Kazlauskas, S. Juršėnas, Y.C. Simon, *ACS Appl. Mater. Interfaces* **8** (2016) 15732–15740.
[3] S. Raišys, S. Juršėnas, Y.C. Simon, C. Weder, K. Kazlauskas, *Chem. Sci.* **9** (2018) 6796–6802.
[4] S. Raišys, S. Juršėnas, K. Kazlauskas, *Sol. RRL* **6** (2022) 2100873.
[5] L. Naimovičius, E. Radiunas, M. Dapkevičius, P. Bharmoria, K. Moth-Poulsen, K. Kazlauskas, *J. Mater. Chem. C* **11** (2023) 14826–14832.
[6] J. Lekavičius, E. Radiunas, G. Kreiza, A. Jozeliūnaitė, E. Orentas, K. Kazlauskas, *Chem. Sci.* **17** (2026) 6230–6237.