Side-chain engineering for efficient photon upconversion

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Photon upconversion is a methodology to transform low-energy photons into higher-energy ones. This process is particularly relevant in applications such as solar energy harvesting, where the efficient conversion of sunlight into usable energy forms is paramount. Triplet-triplet annihilation photon upconversion (TTA-UC) involves a triplet sensitizer (donor) and an emitter (acceptor). Excited triplet sensitizers transfer energy to acceptors via Dexter-type triplet energy transfer (TET). Subsequently, two excited acceptors then undergo triplet-triplet annihilation (TTA), forming one ground state and one emissive excited singlet state (Figure 1(a)).

Recent efforts to design triplet acceptors have demonstrated the role of bulky substituents in suppressing triplet excimer formation, which induces nonradiative decay.[1] However, steric hindrance reduces the wavefunction overlap between acceptors and slows down intermolecular processes such as TET and TTA, which increases the threshold excitation intensity (I_{th}).[2] In this study, we systematically modulated net π-interplanar distances through novel side-chain modifications and assessed their impact on UC efficiency and I_{th} in solution (Figure 1b).

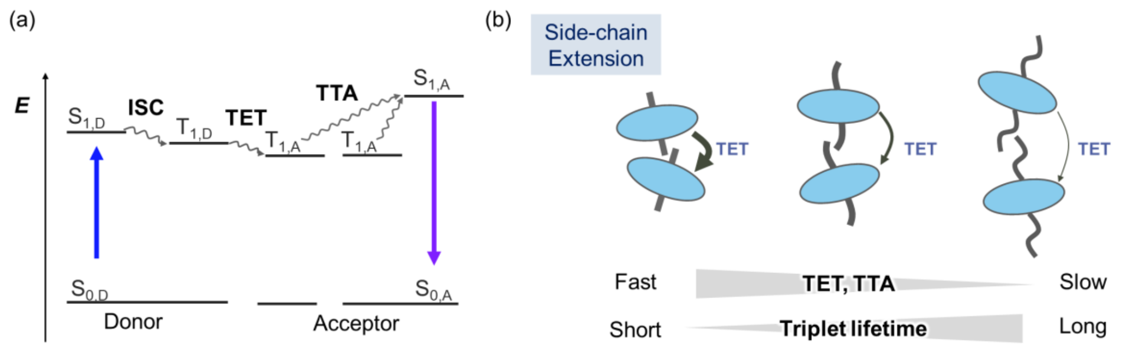

Figure 1. (a) Energy diagram of TTA-UC and (b) side-chain engineering of triplet acceptor molecules for controlling the dynamics of triplets and their lifetimes.

1) A. Olesund, S. Ghasemi, K. Moth-Poulsen, B. Albinsson. *J. Am. Chem. Soc.* **2023**, *145*, 22168–22175.
2) L. Naimovičius, S. K. Zhang, A. B. Pun. *J. Mater. Chem. C* **2024**, *12*, 18374–18380.

