Persistent luminescence from stable charge-separated states

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Abstract
A charge-transfer (CT) excited state is formed by photoexcitation at the electron donor-acceptor interface. This intermolecular CT excited state often exhibits thermally activated delayed fluorescence (TADF) because the highest occupied molecular orbital (HOMO) tends to localize on a donor and the lowest unoccupied molecular orbital (LUMO) tends to localize on an acceptor. On the other hand, a charge-separated (CS) state is formed by photoexcitation at the donor-acceptor interface used in organic solar cells.

By tweaking the donor and acceptor molecules and exciton processes, long persistent luminescence (LPL) over hours from organic molecules was realized. Phosphorescence is also known as long-lasting photoluminescence, but the emission processes of phosphorescence and LPL are different. Phosphorescence is long-lived because the slow radiative transition rate from the triplet excited state to the singlet ground state, whereas LPL is long-lived because the slow charge recombination.

The addition of carrier-trapping molecules stabilizes the CS state. Thermo-stimulated luminescence and photo-stimulated luminescence were also observed from this stable CS state.

Figure 1. (a) Chemical structures of the electron donor, m-MTDATA, and the acceptor, PPT. (b) HOMO and LUMO energy diagrams and the emission mechanism of an OLPL system. (c) Energy diagram of an m-MTDATA/PPT system. The OLPL system exhibits fluorescence, TADF, and LPL from the 1CT state.