ACHIEVEMENTS

High-Performance Near-Infrared OLEDs Maximized at 925 nm and 1022 nm through Interfacial Energy Transfer

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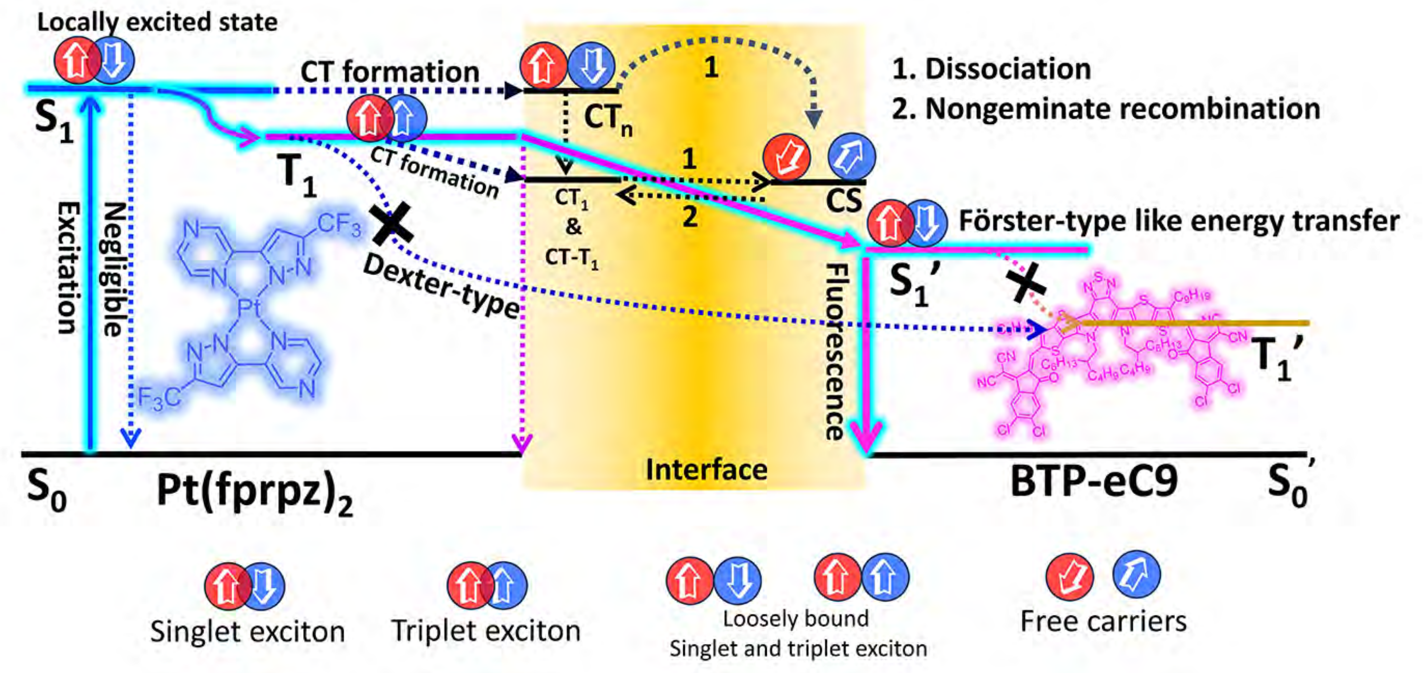


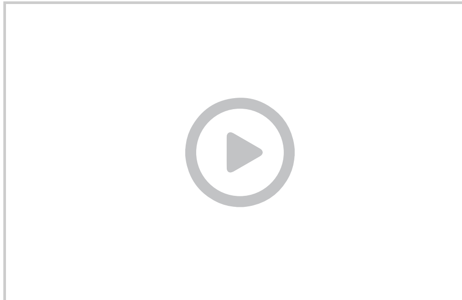
The diagram shows the role of interfacial energy transfer in NIR OLED functionality. The solid sky-blue pathway represents the process of interfacial energy transfer capable of facilitating FRET (Förster Resonance Energy Transfer). The S0 and S1 states denote the ground and excited states in the singlet manifold, while the T1 state represents the triplet state. T1→S1' FRET is viable because the T1→S0 transition is allowed for the Pt(II) complex due to its strong spin-orbit coupling. The diagram also outlines alternative pathways with dashed lines, where charge transfer (CT) and charge transfer-triplet (CT-T) states are included alongside the charge separation (CS) state, representing subsidiary processes occurring with a smaller probability.

Prof. Pi-Tai Chou and his team have been devoted to the study of near-infrared (NIR) organic light-emitting diodes (OLEDs) in recent years. By putting theory into practice, they have repeatedly broken the world record for NIR organic luminophores, overcoming the energy gap law. In 2017, they developed Pt(II) complexes with an external quantum efficiency (EQE) of 24% at 740 nm, followed by a molecule with an EQE of 10% at 800 nm in 2018. In 2020 and 2022, through the derivation of a new theory and deuterium C-D substitution, they successfully developed unprecedented OLEDs with an EQE of 4% at 1000 nm. Nevertheless, designing and synthesizing new cutting-edge Pt complexes is highly challenging. As to device engineering, the team has continuously tried new techniques to further enhance efficiency using existing organic materials. Their recent article, published in *Nature Communications*, reports the first time in the world that transfer technology was successfully utilized to break the energy gap law through energy transfer, achieving record-breaking efficiency in the NIR region using NIR organic dyes.

Prof. Pi-Tai Chou with his student, Chieh-Ming Hung, the first author of this paper.

Prof. Chou's team proposes that by adhering to three principles, interfacial energy transfer can be realized:

1. The photoluminescence of the energy donor must overlap with the absorption spectrum of the energy acceptor. The donor requires a high photoluminescence quantum yield (PLQY), while the acceptor needs a high absorption coefficient.
2. To ensure the effective operation of the donor and acceptor, there must be sufficient energy level differences between them. Overlapping energy levels would lead to uniform charge distribution rather than local concentration at the interface, resulting in adverse effects.
3. In OLEDs, the device must be optimized so that electron-hole recombination occurs near the interface region to effectively execute energy transfer, facilitating energy transmission.



Demonstration of the Differences Between Spin-Coating and Transfer Printing Techniques.

Click or Scan the QR code to read the journal article in *Nature Communications*.

Finally, they demonstrated two successful approaches:

1. Using the strongly emissive Pt(fprpz)2 at 740 nm, they simultaneously transferred BTP-eC9, which has strong absorption at 740 nm and emission at 925 nm, increasing the EQE from 0.18% to 2.24% and the radiance from 18.81 to 39.97 W sr–1 m–2.
2. Utilizing the strongly emissive Pt(II) complex at 800 nm paired with BTPV-eC9, which has strong absorption at 800 nm and emission at 1022 nm, the EQE increased from 0.08% to 0.66% and the radiance from 9.69 to 18.67 W sr–1 m–2.

Both approaches broke the record for the efficiency of organic dyes as emitters in OLEDs. The team predicts that interface technology will bring unprecedented new perspectives to NIR-OLEDs.

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