DOCTORAL THESIS

TADF process in blended organic luminescent material

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Abstract

Organic light-emitting diode (OLED) devices have been applied in the fields of display and solid-state lighting. In addition to phosphorescent OLEDs using heavy transition metals, a new approach of harvesting both singlet and triplet excitons generated in the OLED device by using pure organic materials has drawn a lot of attentions in recent years. It is thermally activated delayed fluorescence (TADF) process, which makes it possible to obtain potential 100% internal quantum efficiency (IQE).

TADF is a process existing in certain organic materials with small singlet-triplet exchange energy (ΔE_{ST}), which is generally observed in the molecules with weak-coupled electron-donating (D) group and electron-accepting (A) group. Individual molecule containing D/A, which is named intramolecular exciplex, or intermolecular exciplex with D/A on separated molecules, can fulfill this requirement. Although at present the intramolecular exciplex attracts considerable research interests, it takes a lot of efforts to design an individual molecule with high fluorescent quantum yield as well as small ΔE_{ST}. Intermolecular exciplex, which is achieved by physically blending individual D and A molecules with appropriate selection from present materials, has excellent performance comparable to the phosphorescent emitter.

In this work, we studied the TADF process in an intermolecular exciplex and its application in highly efficient OLED devices. By doping electron-donating material tris(4-carbazoyl-9-ylphenyl)amine (TCTA) with electron-accepting material 2,4,6-tris(3'-(pyridin-3-yl)biphenyl-3-yl)-1,3,5-triazine (Tm3PyBPZ), an exciplex with a

green emission around 514 nm was demonstrated. The time-resolved photoluminescence of the exciplex under different temperatures from 12 K to 300 K demonstrated the existence of temperature-dependent delayed fluorescence. By applying this exciplex as the emissive layer, a highly efficient all-fluorescent organic lighting emitting diode with maximum efficiencies of 13.1% and 53.4 lm/W was realized with an extremely low turn-on voltage of only 2.4 V. The efficiencies of the device have outperformed conventional fluorescent OLED devices due to the contribution of triplet excitons. By doping this exciplex with other conventional green or yellow fluorescent dopants, we observed that the performances of these dopants also surpass the limitation of conventional fluorescent OLED (~5 % external quantum efficiency).

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