2019「中技社科技獎學金」

2019 CTCI Foundation Science and Technology Scholarship

境外生生活助學金

Living Grant for International Graduate Students

The study of optoelectronic properties of high-efficiency organic light emitting materials and devices

Pan Li ,4th PhD student. Advisor: Dr. Chung-Chih Wu
Graduate Institute of Photonics and Optoelectronics, National Taiwan University
Group of Organic Optronic and Display

Good

Abstract

Organic emitters have been widely developed since the demonstration of high efficiency in pure organic emitters represented by thermally activated delayed fluorescent (TADF) emitters. The development of new and easily available acceptor moieties for further expansion of the TADF family becomes imperative. In this study, new donor–acceptor TADF materials Dopant 1 and Dopant 2 are characterized. These materials exhibit green emission and high photoluminescence quantum yield of 100% in both CBP and CBPCN host and higher horizontal dipole ratio in CBPCN films than in CBP film.. Organic light-emitting diodes(OLEDs) formulated with this two emitters accomplished highest external quantum efficiency (EQE) of 32.5% and maximum current efficiency (CE) 110.1 cd A^{-1}.

Emitter Photo-physical Properties

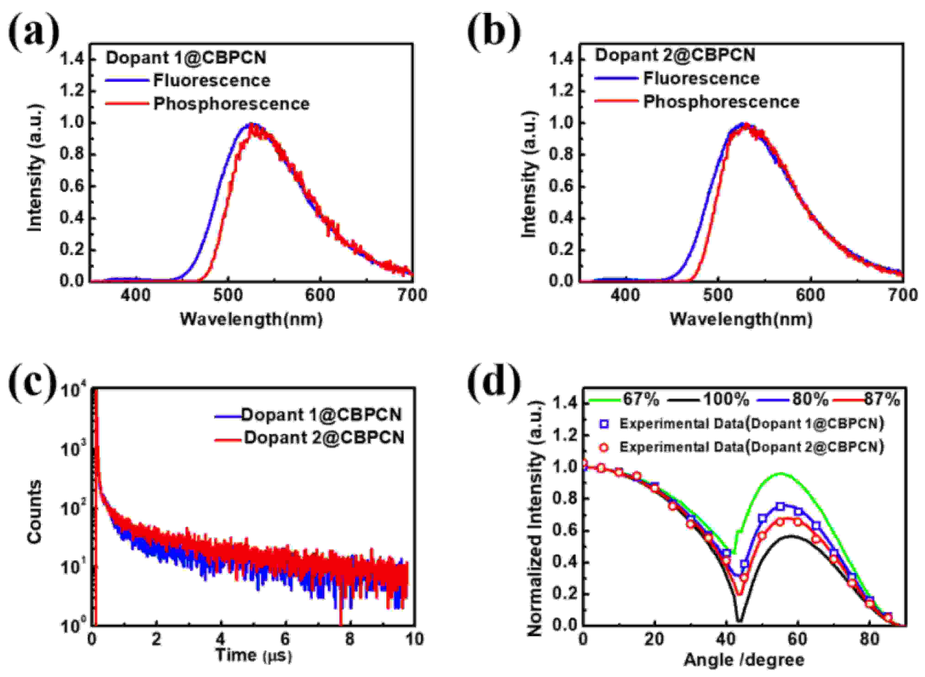

Figure 1. (a)-(b) Steady-state fluorescence (measured at 300 K) and phosphorescence spectra (measured at 77 K) of Dopant 1 and Dopant 2 doped (with a doping concentration of 6 wt.%) in host CBPCN. (c) PL decay curves of corresponding samples doped in CBPCN at 300K. (d)Measured (symbols) p-polarized PL intensity (at PL peak wavelength) of different emitting layers as a function of the emission angle for CBPCN: 6 wt% Dopant 1 and CBPCN: 6 wt% Dopant 2.

Table 1. The summary of photo-physical properties of Dopant 1 and Dopant 2

Emitter	Host	$\lambda_{PL,max}$ [a] [nm]	$\lambda_{PHOS,max}$ [b] [nm]	Φ [c] [%]	ΔE_{ST} [d] [meV]	τ_p [e] [ns]	τ_d [e] [μs]	$\Theta_{//}$ [f] [%]
Dopant 1	CBP	521.5	527	100	66.6	24.1	1.1	79
Dopant 2	CBP	518.5	526	100	34.1	23.1	4.3	81
Dopant 1	CBPCN	523.5	525	100	6.8	18.6	0.8	80
Dopant 2	CBPCN	525.5	530	100	20	24.2	2.04	87

[a] Fluorescence maximum wavelength; [b] Phosphorescence maximum wavelength; [c] Photoluminescence quantum yield; [d]Energy gap between lowest singlet and triplet states; [e] Lifetime of the prompt component in transient PL, lifetime of the delayed component in transient PL; [f] Horizontal dipole ratio measured in doped films (with 6 wt% concentration).

Device Structure and EL Characteristics

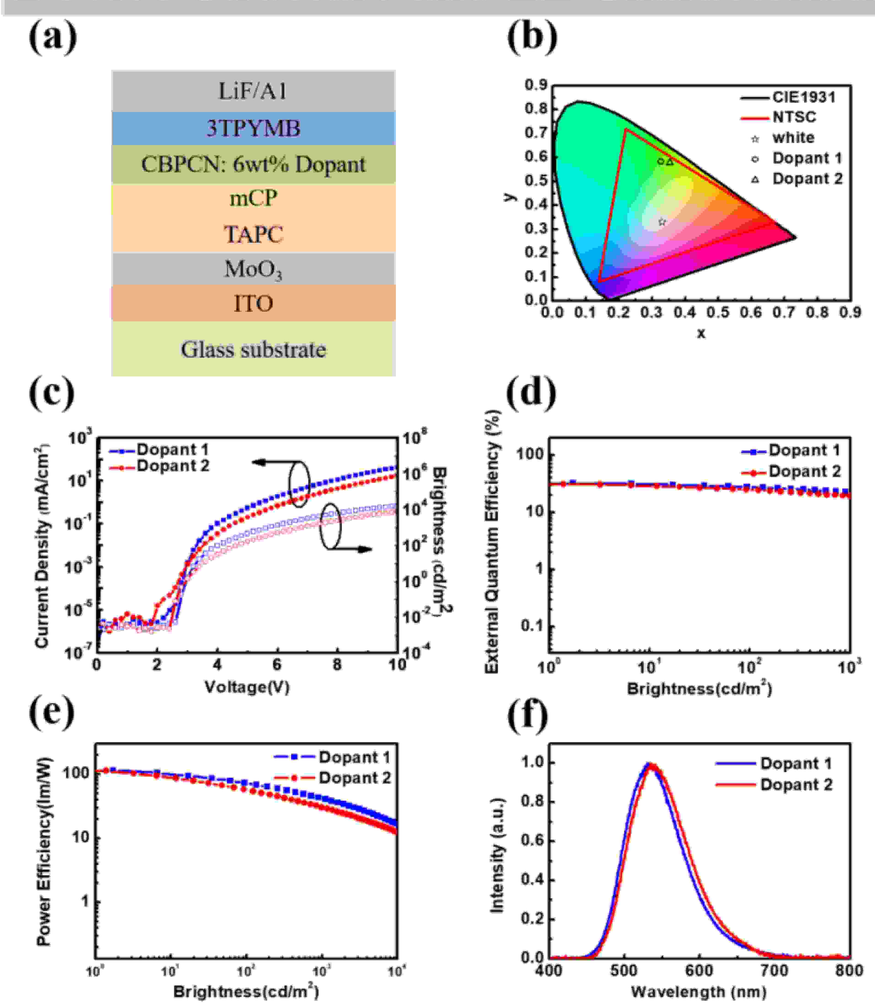

Figure 2. (a) The device configuration and chemical structures of materials used in this work,(b) CIE1931 coordinates of EL spectra of devices,(c) current–voltage-luminance (I–V–L) characteristics,(d) external quantum efficiency and (e)power efficiency of Dopant 1 and Dopant 2 devices, and (f) EL spectra.

Table 2. The summary of OLED characteristics of Dopant 1 and Dopant 2

Device	V_{on} [a] [V]	EL_{peak} [nm]	CE [b] [cd A^{-1}]	PE [c] [lm W^{-1}]	EQE [d] [%]	Φ_{out} [e] [%]	$\Phi_{PL} \times \Phi_{out}$ [%]
Dopant 1	2.9	530.5	110.1, 92.8, 75.9	115.3, 72.4, 41.9	32.5, 27.4, 22.4	37.4	37.4
Dopant 2	2.9	534.5	107.0, 84.2, 65.6	116.5, 54.7, 30.3	31, 24.4, 19.0	40.4	40.4

[a]The turn-on voltage recorded at a brightness of 1 cd m^{-2}; Maximum value, values at 100 and 1000 cd m^{-2} of b)current efficiency; c)power efficiency; and d)external quantum efficiency; e)Calculated out-coupling efficiency

Conclusion

In conclusion, we have characterized two new TADF emitters, Dopant 1 and Dopant 2, and these materials exhibit a prominent delayed decay emission, high PLQY of 100% at both CBP and CBPCN host material and higher horizontal dipole ratio at CBPCN. As expected, the OLEDs using Dopant 1 as emitter shows green emission and acquire a maximum EQE of 32.5%, a maximum CE of 101.1 cd A^{-1} , a maximum PE of 115.3 lm W^{-1}, and using Dopant 2 as emitter shows a maximum EQE of 31%, a maximum CE of 107cd A^{-1}, a maximum PE of 116.5 lm W^{-1}. These results prove that the new TADF emitters represent a new kind of ideal candidate for high efficiency TADF OLEDs.

財團法人中技社 CTCI FOUNDATION