Supporting Information

Exciton dynamics of an aggregation-induced delayed fluorescence emitter in non-doped OLEDs and its application as host for high efficiency red phosphorescent OLEDs

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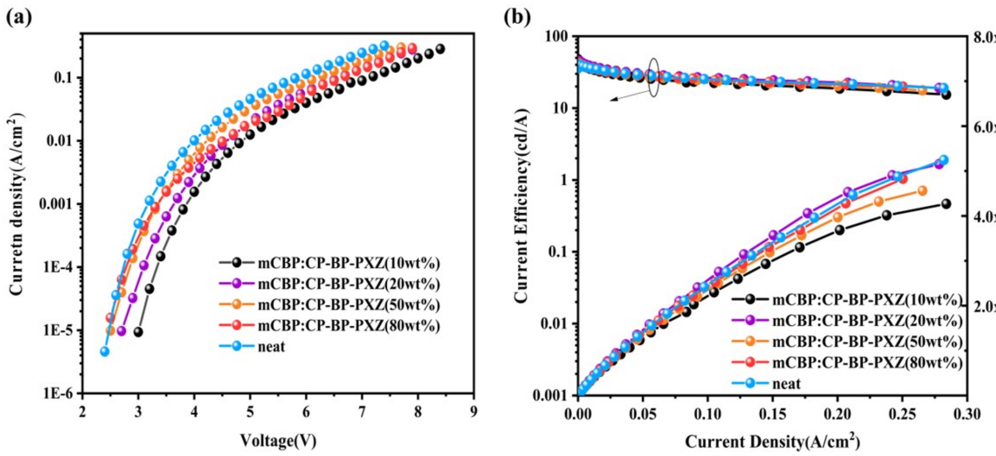

Figure S1. (a) Current density-voltage characteristics of the fabricated OLEDs with different CP-BP-PXZ doping concentrations in mCBP. (b) Current efficiency – luminance-current density characteristics of the fabricated OLEDs with different CP-BP-PXZ doping concentrations in mCBP.

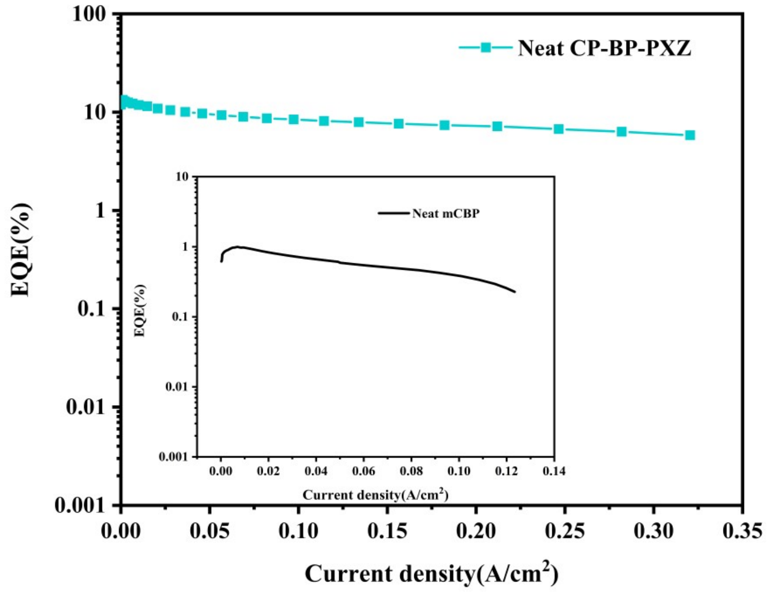

Figure S2. EQE characteristics of the two non-doped OLEDs with different emitters ofneat mCBP and CP-BP-PXZ.

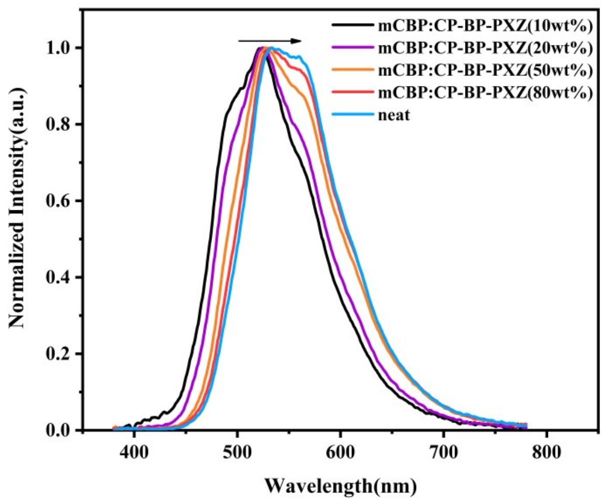

Figure S3. Normalized electroluminescence spectra of the resulting OLEDs with different CP-BP-PXZ doping concentrations in mCBP.

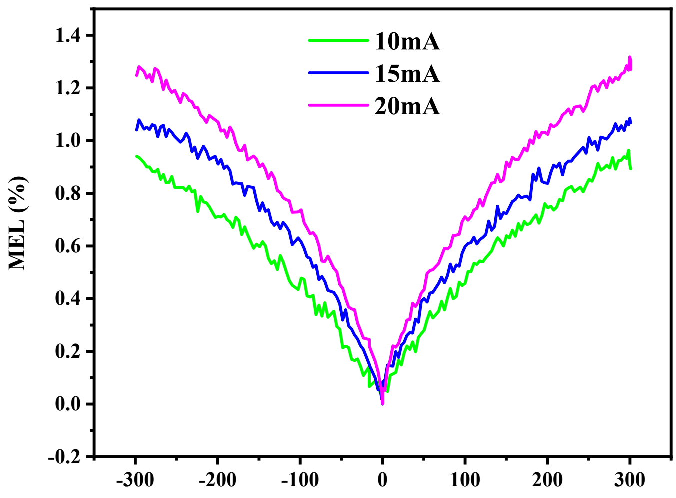

Figure S4. MEL responses of the non-doped OLED based on CP-BP-PXZ under different applied currents.

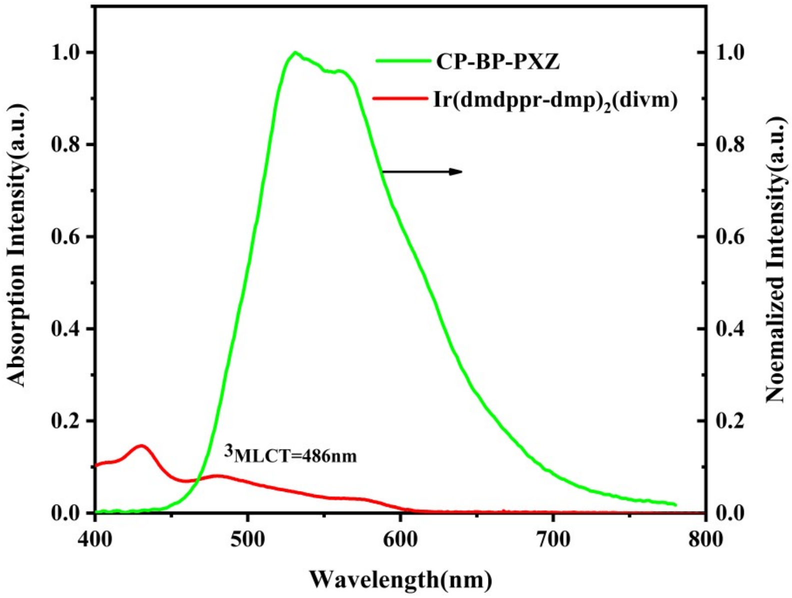

Figure S5. Absorption spectrum of Ir(dmdppr-dmp)$_2$(divm) and emission spectrum of CP-BP-PXZ.

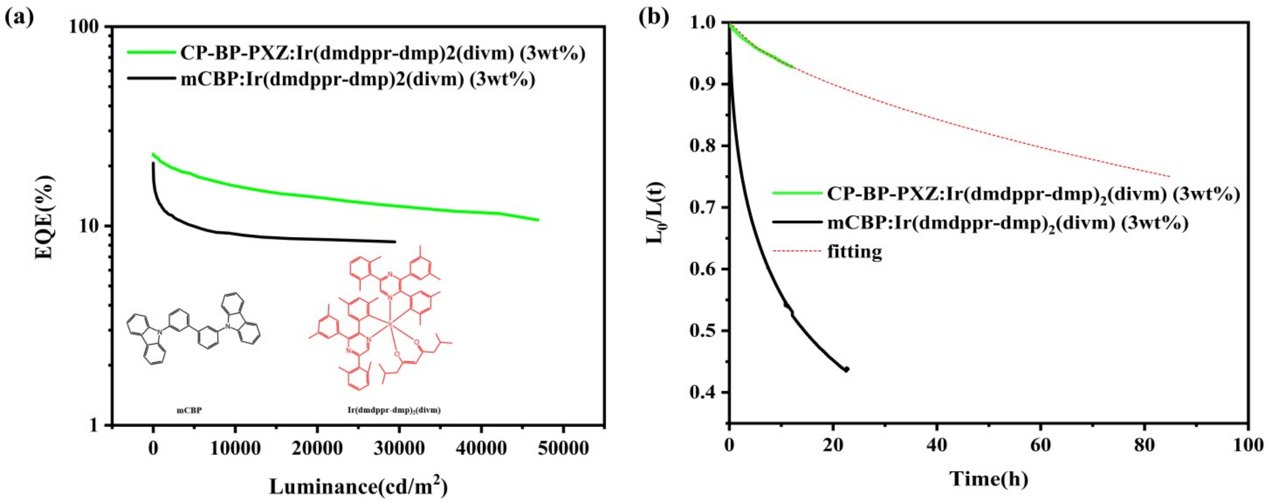

Figure S6. (a) EQE - luminance characteristics of the resulting red phosphorescent OLEDs based on CP-BP-PXZ and mCBP as host. The insert is the chemical structure of mCBP and Ir(dmdppr-dmp)$_2$(divm). (b) Lifetime comparison of the resulting red phosphorescent OLEDs based on CP-BP-PXZ and mCBP as host at the initial luminance of 500 cd/m^2.

Table S1. Summary of EL performances of the OLEDs with different CP-BP-PXZ doping concentrations in mCBP host.

Doping Concentration	V_{on} (V)	L_{Max} (cd/m^2)	CE (cd/A)	PE (lm/W)	EQE/EQE[a] (%)	k_{STA} (cm^3/s)	k_{TTA} (cm^3/s)	CIE[b]
10wt%	3	42674	47.76	48.50	16.24/13.98	1.52*10-13	6.49*10-14	(0.31,0.51)
20wt%	2.7	51536	45.55	44.31	15.30/14.10	1.00*10-15	3.24*10-14	(0.33,0.53)
50wt%	2.5	46699	41.98	42.56	13.83/12.95	3.59*10-15	3.67*10-14	(0.37,0.54)
80wt%	2.5	50069	40.06	42.58	13.23/12.59	2.06*10-14	2.69*10-14	(0.39,0.54)
neat	2.4	54830	40.31	47.28	13.31/12.80	2.42*10-14	3.45*10-14	(0.39,0.54)

a.EQE at 1000cd/m^2 ;b.the CIE coordinates at 6 V

Table S2. Calculations of the rate constants of CP-BP-PXZ doped mCBP host with different doping concentrations.

Doping Concentration(wt%)	$\tau_p(ns)$	$\tau_d(\mu s)$	k_s^r($10^7 s^{-1}$)	k_{ISC}($10^7 s^{-1}$)	k_{RISC}($10^6 S^{-1}$)
10wt%	20.8	1.49	2.71	2.09	1.18
20wt%	25	1.07	1.28	3.25	3.29
50wt%	25	1.04	1.24	2.75	3.06
80wt%	25	0.93	1.37	2.62	3.09
Neat	26	0.87	1.41	2.43	3.13

	Host	Dopant Concentration	V_{on}(V)	EQE(%)	EQE^{a}(%)	CIE^{b}
Device 1	CP-BP-PXZ	1wt%	2.4	17.6	16.3	(0.48.0.47)
Device 2	CP-BP-PXZ	2wt%	2.4	21.7	20.1	(0.60,0.38)
Device 3	CP-BP-PXZ	3wt%	2.4	23.0	21.2	(0.64,0.34)
Device 4	CP-BP-PXZ	5wt%	2.4	16.0	13.9	(0.66,0.33)
Device 5	mCBP	3wt%	3.2	20.6	12.3	(0.64,0.33)

a.at 1000cd/m^2; b. the CIE coordinates at 6 V

Table S3. EL performance summary of the fabricated red phosphorescent OLEDs based on CP-BP-PXZ as host

The photophysical parameters are calculated by the following functions[1, 2]:

$k_F = \Phi_{prompt}/\tau_{prompt}$

$k_p = 1/\tau_{prompt}$; $k_d = 1/\tau_{delayed}$

$k_P = k_F + k_{ISC}$

$k_P k_d = k_F k_{RISC}$

$k_{ISC} = k_P - k_F = k_P\,(1 - \Phi_{prompt})$

$k_{RISC} = (k_p k_d)/(k_P - k_{ISC})$

The carrier kinetics

As hole and electron transport and recombination on CP-BP-PXZ in non-doped OLED, the free carriers can be described as following equations[3]

$\frac{dn_h}{dt} \cong \frac{jh}{eL_h} - \gamma n^2$

$$\frac{dn_e}{dt} \cong \frac{je}{eL_e} - \gamma n^2$$

where the γ is the bimolecular recombination coefficient , jh and je are the hole and electron injection currents flowing through the transport layers(L_h and L_e), respectively. Under the stead-state condition, L_h=L_h≅40nm for device, jh=je=j, and n_0 can attained as following

$$n_0 = (2j/e\gamma L)^{1/2}$$

The electrons and holes in the recombination zone are free and equal to each other(n_h=n_e=n), after turn off pulse ,the charge decay can be express as

$$\frac{1}{n} = \frac{1}{n_0} + \gamma t$$

Taken into account EL yield, $\phi_{EL} = \phi_{PL} P_S \gamma n(t)^2$, ϕ_{PL} is PLQY ,P_S is the function that excitons generated. The EL decay can be described as

$$\frac{1}{\sqrt{\phi EL(t)}} = \frac{1}{\sqrt{\varphi PLP_S \gamma n_0^2}} + \sqrt{\frac{\gamma}{\varphi PLP_S}} t$$

and γ can be calculated as

$$\gamma = (\frac{(\gamma/\varphi PLP_{S)}^{0.5}}{(\varphi PLP_S \gamma n_0^2)^{-\frac{1}{2}}})^2 eL//J$$

Reference

1. L.-S. Cui, A. J. Gillett, S.-F. Zhang, H. Ye, Y. Liu, X.-K. Chen, Z.-S. Lin, E. W. Evans, W. K. Myers, T. K. Ronson, H. Nakanotani, S. Reineke, J.-L. Bredas, C. Adachi and R. H. Friend, *Nature Photonics*, 2020, **14**, 636-642.
2. Y. Fu, H. Liu, D. Yang, D. Ma, Z. Zhao and B. Z. Tang, *Science Advances*, **7**, eabj2504.
3. Y. Chen, Q. Sun, Y. Dai, D. Yang, X. Qiao and D. Ma, *Advanced Optical Materials*, 2019, **7**, 1900703.