

Bipolar phenanthroimidazole-diazacarbazole hybrids with appropriate bandgap for highly efficient and low roll-off red, green and blue electroluminescent devices

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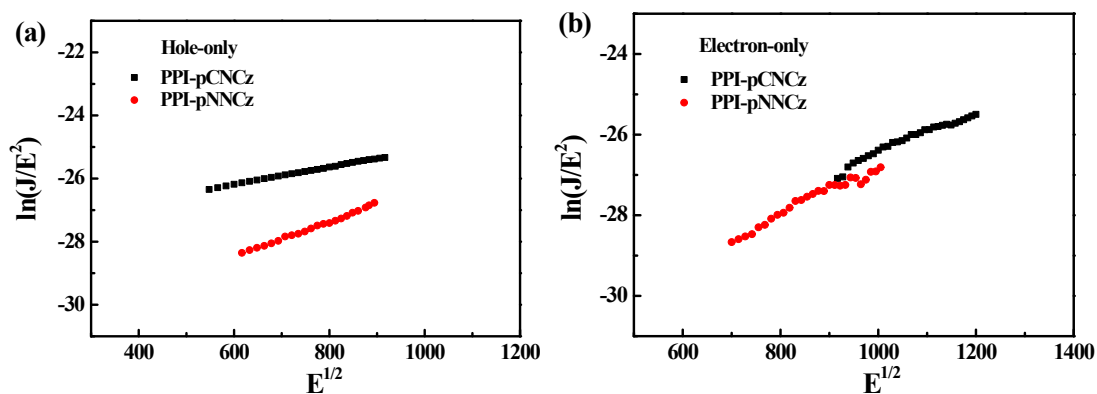


Figure S1. (a) The $\ln(J/E^2)$ - $E^{1/2}$ characteristics of the hole-only devices: ITO/MoO₃ (10 nm)/compounds (80 nm)/MoO₃ (10 nm)/Al. (b) The $\ln(J/E^2)$ - $E^{1/2}$ characteristics of the electron-only devices: ITO/BCP (10 nm)/compounds (80 nm)/BCP (10 nm)/LiF (1 nm)/Al.

Table S2. Key characteristics summary of the PPI-pCNCz and the PPI-pNNCz-based devices and recent reported high performance undoped deep-blue fluorescent devices.

Host	Dopant	V_{on} (V)	CE (cd/A) ^a	PE (lm/W) ^b	EQE (%) ^c	CIE (x, y) ^d	Reference
PPI-pCNCz	--	3.0	1.63, 1.33, 1.54	1.17, 0.99, 0.81	2.15, 1.75, 2.01	(0.15, 0.08)	This work
PPI-pNNCz	--	3.3	1.69, 1.46, 1.63	1.14, 0.85, 0.71	2.97, 2.49, 2.76	(0.15, 0.06)	This work
Be(PPI) ₂	--	3.2	2.41, 2.18, 2.04	2.52, 1.60, 0.95	2.82, 2.55, 2.40	(0.15,0.09)	Ref 9
Zn(PPI) ₂	--	3.2	2.06, 1.31, 0.74	2.02, 0.75, 0.26	2.08, 1.32, 0.75	(0.15,0.09)	Ref 9
PPI-F-TPA	--	4.2	1.35, --, 1.26	1.0, --, 0.5	3.11, --, 2.5	(0.16, 0.05)	Ref 22
DPO-PPI	--	3.4	1.51, 1.36, 1.01	1.29, 0.76, 0.38	1.88, 1.32, 0.79	(0.16, 0.09)	Ref 21
DPO-2PPI	--	3.4	1.75, 1.21, 0.71	1.53, 0.67, 0.26	2.24, 1.92, 1.42	(0.16, 0.08)	Ref 21

^a Current efficiency. ^b Power efficiency. ^c External quantum efficiency corresponding to the value at the maximum, 100 and 1000 cd m⁻². ^d The CIE1931 coordinates of these OLEDs.

Table S3. Key characteristics summary of the PPI-pCNCz and the PPI-pNNCz-based devices and recent reported high performance green phosphorescent devices.

Host	Dopant	V_{on} (V)	CE (cd/A) ^a	PE (lm/W) ^b	EQE (%) ^c	CIE (x, y) ^d	Reference
PPI-pCNCz	Ir(ppy) ₃	2.6	69.8, 68.8, 65.0	81.2, 65.5, 45.3	20.2, 19.8, 18.7	(0.27, 0.63)	This work
PPI-pNNCz	Ir(ppy) ₃	2.7	79.8, 78.8, 74.6	88.3, 68.7, 45.9	22.6, 22.3, 21.1	(0.28, 0.63)	This work
Be(PPI) ₂	Ir(ppy) ₃	2.7	55.6, 54.9, 53.5	61.4, 48.8, 36.1	15.3, 15.2, 14.7	(0.32,0.61)	Ref 9
Zn(PPI) ₂	Ir(ppy) ₃	2.7	58.0, 53.2, 50.7	67.5, 49.1, 35.8	15.9, 14.6, 13.9	(0.30,0.63)	Ref 9
Si(PPI) ₂	Ir(ppy) ₃	3.4	--, --, --	51.1, 41.6, 26.5	19.2, 19.1, 17.8	(0.32, 0.61)	Ref 16
m-DPPI	Ir(ppy) ₃	2.7	58.5, 57.9, 54.6	67.1, 60.4, 41.5	15.5, 15.4, 14.6	(0.32, 0.61)	Ref 17
m-PPPI	Ir(ppy) ₃	2.7	50.7, 47.5, 43.2	58.9, 44.0, 29.4	13.5, 12.8, 11.5	(0.30, 0.63)	Ref 17
PPI-F-TPA	Ir(ppy) ₃	2.7	57, --, 49.5	60, --, 37.5	15.6, --, 13.9	(0.34, 0.62)	Ref 22
DPO-PPI	Ir(ppy) ₃	2.6	62.6, 61.6, 59.3	70.2, 61.4, 49.6	17.2, 17.1, 16.4	(0.32, 0.61)	Ref 21
DPO-2PPI	Ir(ppy) ₃	2.6	65.4, 63.9, 61.8	73.3, 64.7, 52.2	18.0, 17.5, 16.9	(0.30, 0.63)	Ref 21
m-BPPI	Ir(ppy) ₃	2.6	66.3, --, 66.1	63.1, --, 55.0	18.2, --, 18.1	(0.32, 0.61)	Ref 22

^a Current efficiency. ^b Power efficiency. ^c External quantum efficiency corresponding to the value at the maximum, 100 and 1000 cd m⁻². ^d The CIE1931 coordinates of these OLEDs.

Table S4. Key characteristics summary of the PPI-pCNCz and the PPI-pNNCz-based devices and recent reported high performance red phosphorescent devices.

Host	Dopant	V_{on} (V)	CE (cd/A) ^a	PE (lm/W) ^b	EQE (%) ^c	CIE (x, y) ^d	Reference
PPI-pCNCz	Ir(MDQ) ₂ (acac)	3.0	19.2, 19.1, 18.1	19.3, 11.7, 7.28	16.3, 16.1, 14.9	(0.64, 0.36)	This work
PPI-pNNCz	Ir(MDQ) ₂ (acac)	3.3	24.7, 24.6, 23.6	22.5, 15.1, 9.16	19.3, 19.1, 18.1	(0.63, 0.36)	This work
Be(PPI) ₂	Ir(MDQ) ₂ (acac)	2.3	15.9, 15.4, 13.9	19.9, 17.5, 12.6	15.1, 14.7, 13.3	(0.64, 0.36)	Ref 9
Zn(PPI) ₂	Ir(MDQ) ₂ (acac)	2.3	15.9, 11.3, 10.7	21.7, 8.48, 4.83	15.2, 10.8, 10.2	(0.64, 0.36)	Ref 9
Si(PPI) ₂	(bt) ₂ Ir(dipba)	3.3	--, --, --	15.6, 7.5, 3.3	12.0, 10.6, 7.3	(0.64, 0.36)	Ref 16
m-DPPI	Ir(MDQ) ₂ (acac)	2.3	19.7, 17.1, 16.6	26.9, 17.8, 12.0	11.6, 11.2, 10.5	0.64, 0.36	Ref 17
m-PPPI	Ir(MDQ) ₂ (acac)	2.3	14.6, 14.3, 13.2	16.8, 11.4, 7.02	12.8, 12.6, 10.8	0.64, 0.36	Ref 17
DPO-PPI	(bt) ₂ Ir(dipba)	2.6	17.9, 16.2, 12.9	19.9, 14.6, 8.64	12.7, 11.5, 9.18	(0.63, 0.36)	Ref 21
DPO-2PPI	(bt) ₂ Ir(dipba)	2.6	19.0, 17.3, 13.8	21.3, 15.8, 9.57	13.5, 12.0, 9.65	(0.63, 0.36)	Ref 21
p-BPPI	(bt) ₂ Ir(dipba)	2.4	20.1, --, 17.9	20.4, --, 14.1	13.5, --, 9.65	(0.64, 0.36)	Ref 22
m-BPPI	(bt) ₂ Ir(dipba)	2.5	19.8, --, 15.9	19.5, --, 10.7	12.6, --, 9.18	(0.63, 0.37)	Ref 22

^a Current efficiency. ^b Power efficiency. ^c External quantum efficiency corresponding to the value at the maximum, 100 and 1000 cd m⁻². ^d The CIE1931 coordinates of these OLEDs.