Electronic Supplementary Information (ESI)

Efficient near-infrared organic light-emitting diodes based on a bipolar host

Yun Hu,[a] Yi Yuan,[a] Ying-Li Shi,[a] Jiu-Dong Lin,[a] Zuo-Quan Jiang*[a] and Liang-Sheng Liao*[a,b]

[a] Jiangsu Key Laboratory for Carbon-Based Functional Materials & Devices, Institute of Functional Nano & Soft Materials (FUNSOM), Soochow University, Suzhou, Jiangsu 215123, China

[b] Institute of Organic Optoelectronics, Jiangsu Industrial Technology Research Institute (JITRI), Wujiang, Suzhou, Jiangsu 215211, China

* E-mail: lsliao@suda.edu.cn; zqjiang@suda.edu.cn

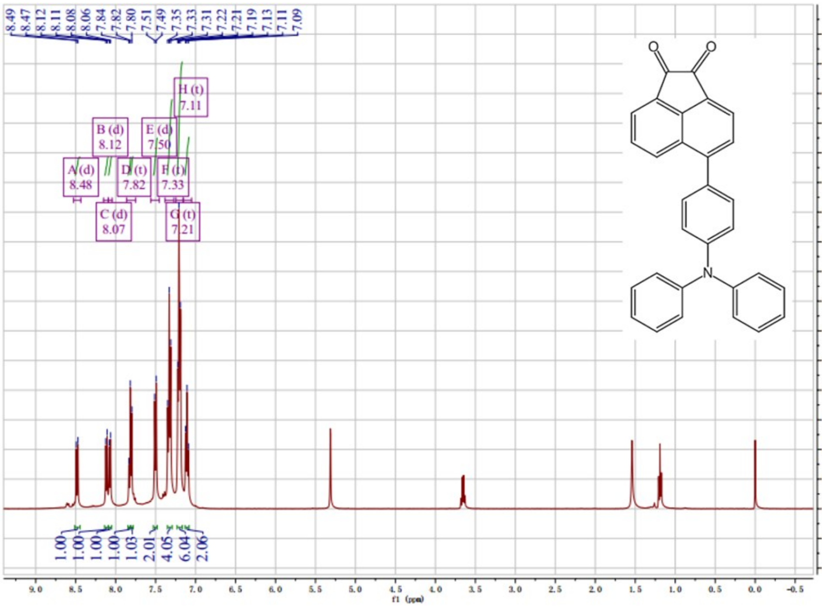

Fig. S1 ^{1}H NMR spectrum of the ADO-TPA.

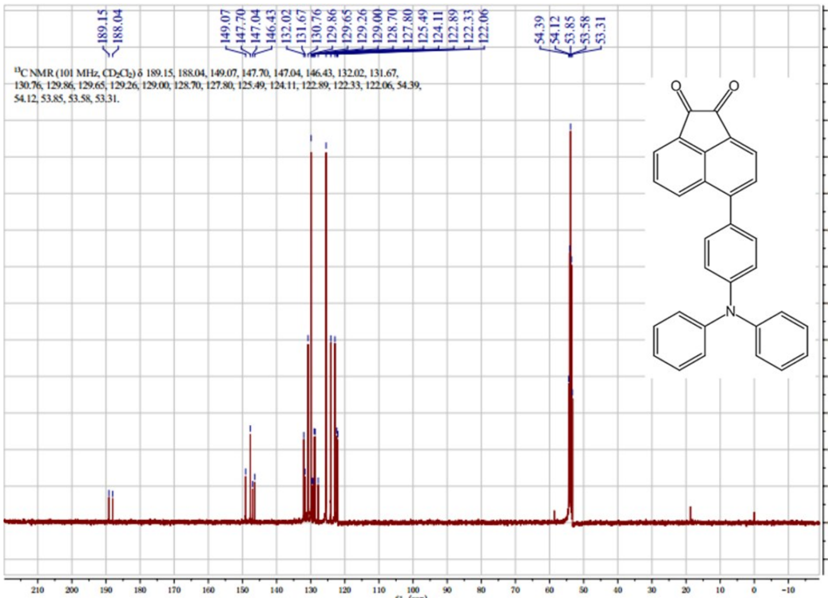

Fig. S2 ^{13}C NMR spectrum of the ADO-TPA.

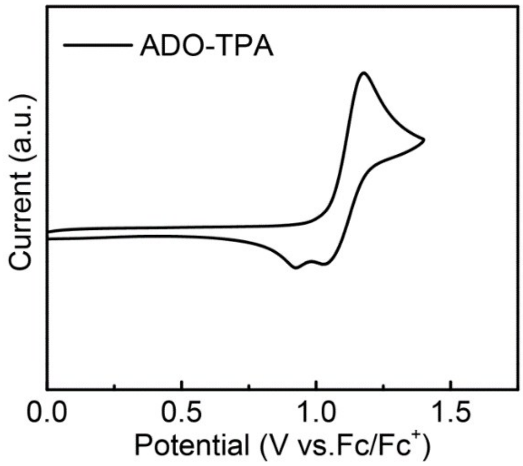

Fig. S3 CV curve of ADO-TPA in DCM for oxidation.

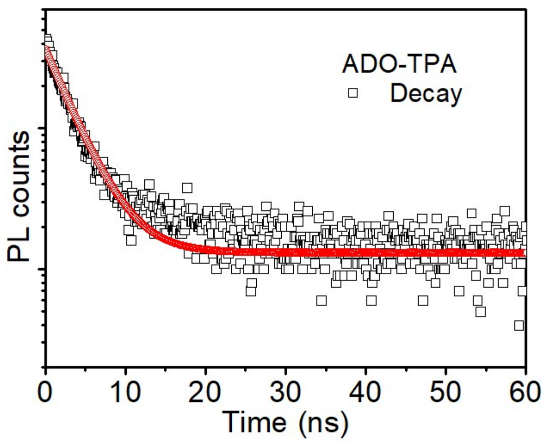

Fig. S4 The transient PL spectrum of ADO-TPA. Transient PL characteristics were detected with a single photon counting spectrometer from HORIBA JOBIN YVON via a Nano LED pulse lamp (455 nm) as the excitation source.

Table S1 The Photoluminescence quantum yield (PLQY) of emitting layers. The PLQY was tested by HORIBA, Fluorolog-3.

Emitting layer	PLQY
ADO-TPA	5%
mCP: 10 wt% APDC-DTPA	30%
mCP: 20 wt%APDC-DTPA	37%
Bpy-TP2: 10 wt%APDC-DTPA	47%
Bpy-TP2: 20 wt%APDC-DTPA	52%

ADO-TPA: 10 wt% APDC-DTPA	8%
ADO-TPA: 20 wt% APDC-DTPA	18%

Table S2 The carrier mobility of the host.

Host	Hole mobility (cm^2/Vs)	Electron mobility (cm^2/Vs)
ADO-TPA	1.6×10^{-3}	1.5×10^{-5}
mCP	3.2×10^{-4}	2.0×10^{-4}
Bpy-TP2	-	4.2×10^{-6}

We calculated the carrier mobility of the host in SCLC region with the structures of ITO/ MoO_3 (10 nm)/ host (50 nm)/ MoO_3 (10 nm)/ Al (100 nm) and ITO/ TPBi (10 nm)/ host (50 nm)/ Liq(2 nm)/ Al (100 nm). The carrier mobility was calculated using the following equation:

$$J = \frac{9}{8}\varepsilon_0\varepsilon_r\mu\frac{V^2}{L^3}$$

where $\varepsilon_0\varepsilon_r$, μ, and L are the permittivity of the organic molecule, the mobility, and the thickness of the organic layer. mCP is a bipolar host (3.2×10^{-4} and 2.0×10^{-4} cm^2/Vs.), which has been reported in literature (*J. Mater. Chem.*, 2010, 20, 8411–8416).

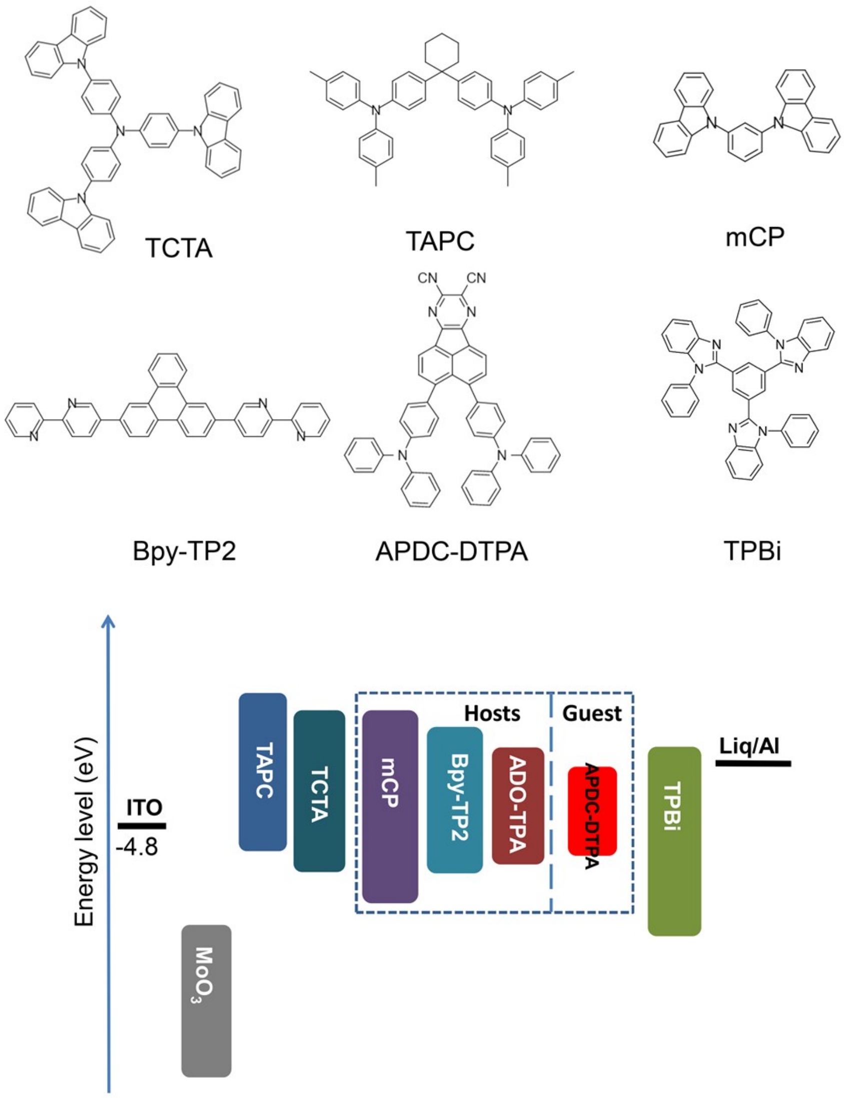

Fig. S4 Organic molecular structures and device structures with different host materials of OLED.

Table S3 EQE summary of the representative deep red and NIR fluorescent OLEDs.

Emitting layer	λ_{max}/nm	EQE_{max} (%)
TPBi:APDC-DTPA (x%)	693/ 696/777 nm	10.19% / 9.70% /2.1%[1]
TPBi: TPA-QCN (x%)	656/700/728 nm	12.8%/9.4%/3.9%[2]
TPBi:TPA-DCPP (x%)	668/710 nm	9.8%/2.1%[3]
TPATCN	675 nm	2.58%[4]
TPA-DCPP:TPA-ThQ (20%)	760 nm	5.2%[5]
$Ga_2(saph)_2q_2$:NSeD (50%)	700 nm	2.1%[6]

PTZ-BZP	690 nm	1.54%[7]
DMAC-PN: TPANSeD (4%)	730 nm	2.65%[8]
ADO-TPA:APDC-DTPA (20%)	735 nm	2.7% (this work)

References

1 Y. Yuan, Y. Hu, Y.-X. Zhang, J.-D. Lin, Y. K. Wang, Z. Q. Jiang, L. S. Liao and S. T. Lee, *Adv. Funct. Mater.*, 2017, **27**, 1700986.

2 C. Li, R. Duan, B. Liang, G. Han, S. Wang, K. Ye, Y. Liu, Y. Yi and Y. Wang, *Angew. Chem. Int. Ed.*, 2017, **56**, 11525.

3 S. Wang, X. Yan, Z. Cheng, H. Zhang, Y. Liu and Y. Wang, *Angew. Chem.*, 2015, **54**, 13068.

4 X. Han, Q. Bai, L. Yao, H. Liu, Y. Gao, J. Li, L. Liu, Y. Liu, X. Li, P. Lu and B. Yang, *Adv. Funct. Mater.*, 2015, **25**, 7521.

5 T. Yamanaka, H. Nakanotani, S. Hara, T. Hirohata and C. Adachi, *Appl. Phys. Express*, 2017, **10**, 074101.

6 J. Xue, C. Li, L. Xin, L. Duan and J. Qiao, *Chem. Sci.*, 2016, **7**, 2888.

7 L. Yao, S. Zhang, R. Wang, W. Li, F. Shen, B. Yang and Y. Ma, *Angew. Chem.*, 2014, **126**, 2151.

8 J. Xue, Q. Liang, Y. Zhang, R. Zhang, L. Duan and J. Qiao, *Adv. Funct. Mater.*, 2017, 1703283. DOI: 10.1002/adfm.201703283

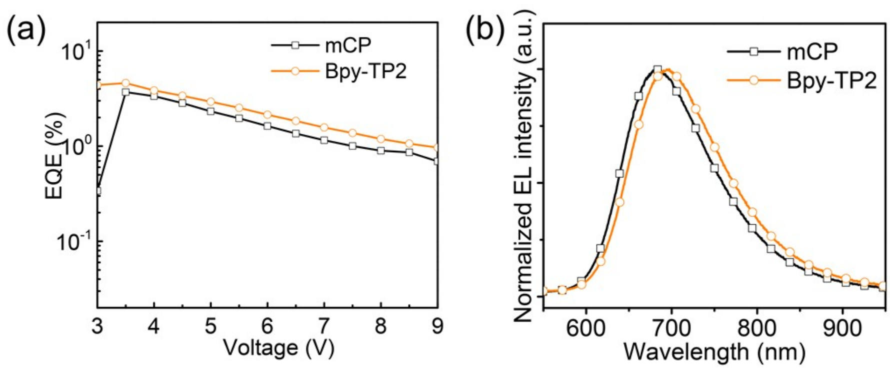

Fig. S5 (a)The EQE-voltage curves, and (b) EL spectra for the mCP and Bpy-TP2 based devices under operating voltage of 5 V.

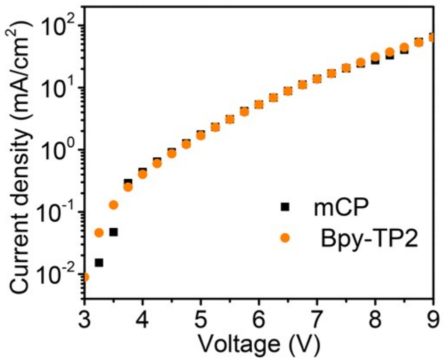

Fig. S6 The current density-voltage curves for the mCP and Bpy-TP2 based devices.

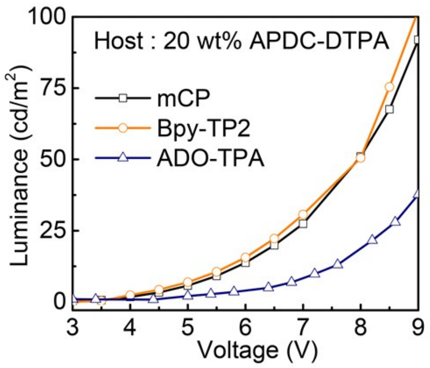

Fig. S7 The voltage-luminance curves of the different host devices.