

Supporting Information

Novel spiro[fluorene-9,9'-xanthene]-based hole transport layers for red and green PHOLED devices with high efficiency and low efficiency roll-off

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KEYWORDS Spiro[fluorene-9,9'-xanthene], Hole-transporting materials, Pure red PHOLEDs, High efficiency

Figures

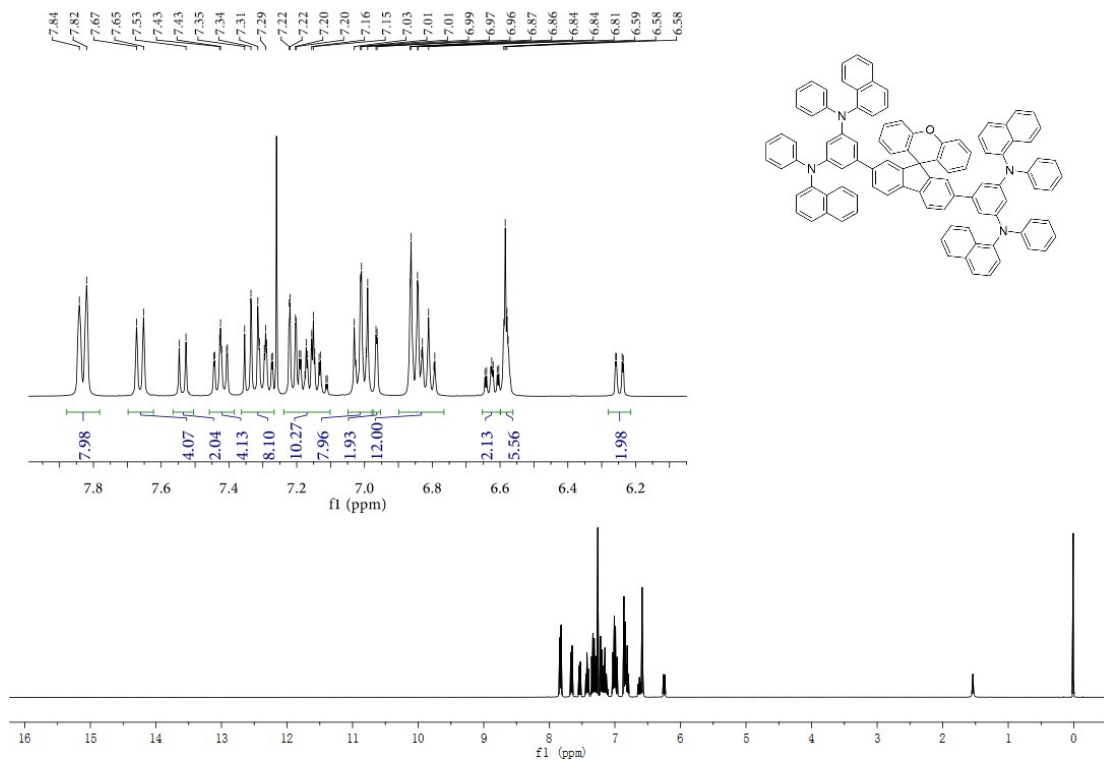


Fig S1. ¹H-NMR spectra of DPNA-SFX.

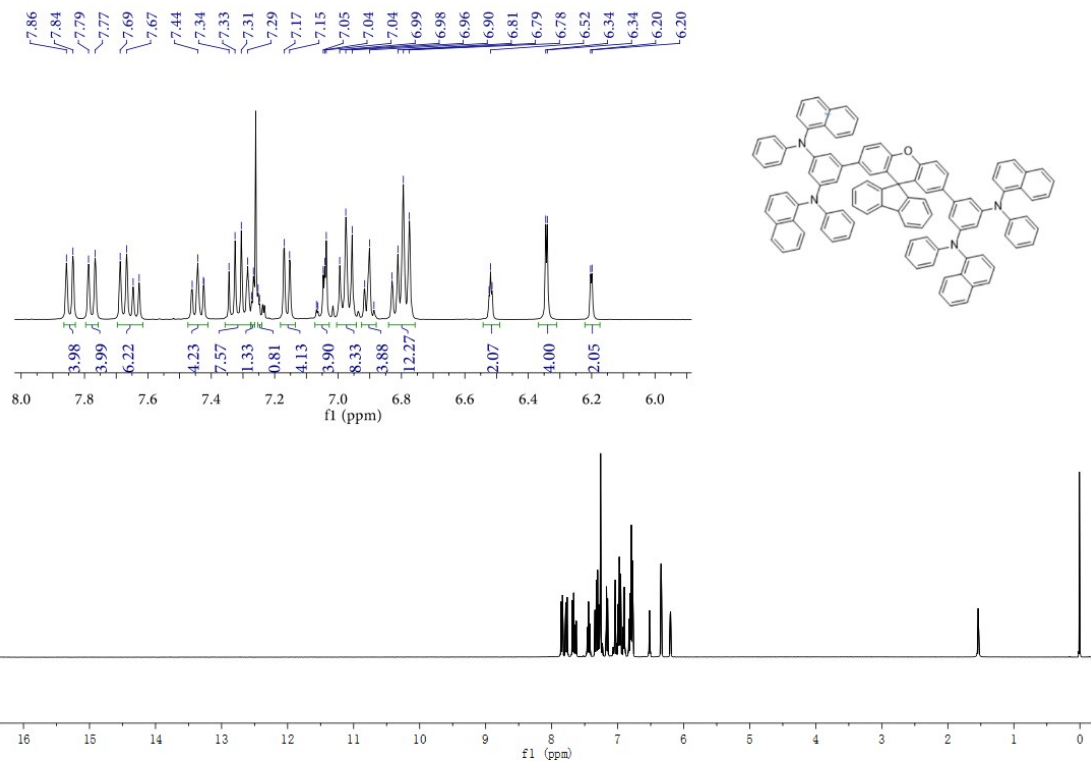


Fig S2. $^1\text{H-NMR}$ spectra of DOPNA-SFX.

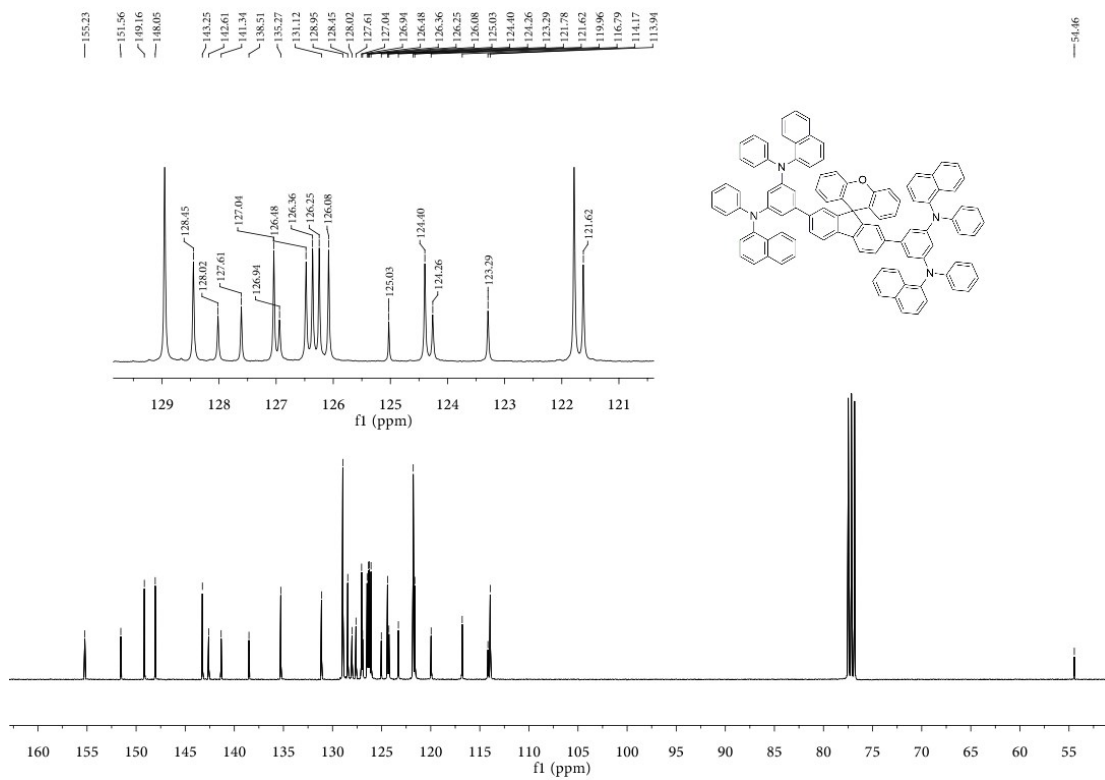


Fig S3. ^{13}C -NMR spectra of DPNA-SFX.

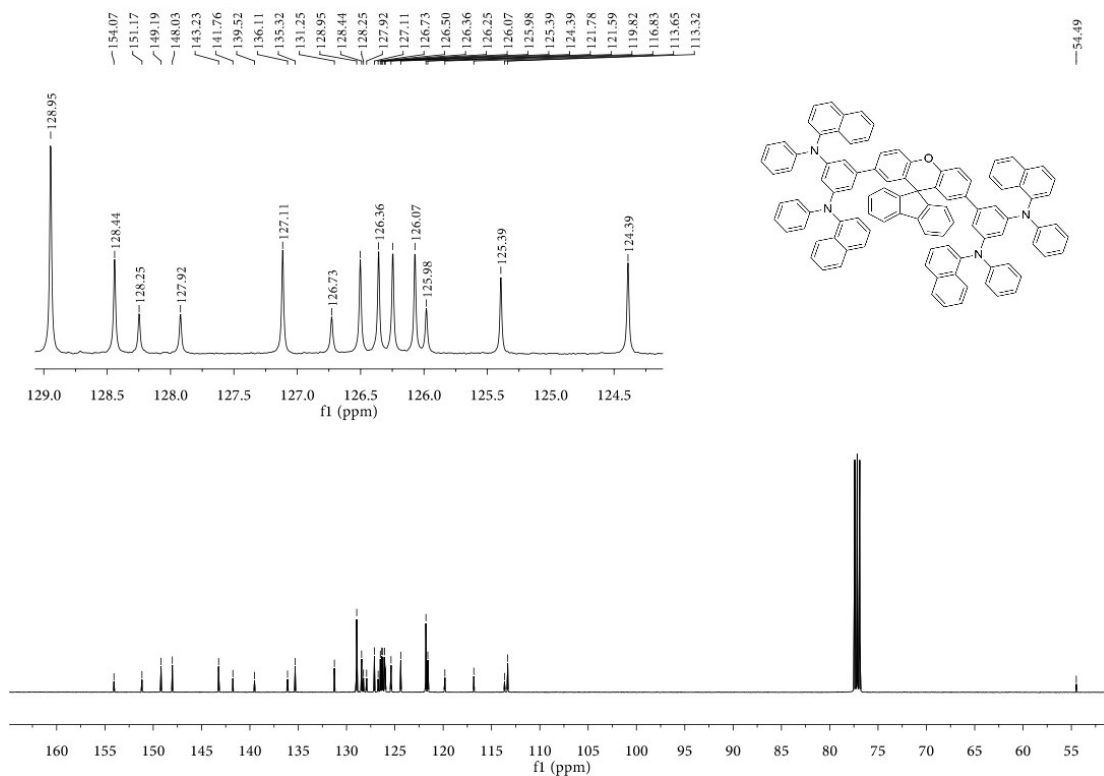


Fig S4. ^{13}C -NMR spectra of DPNA-SFX.

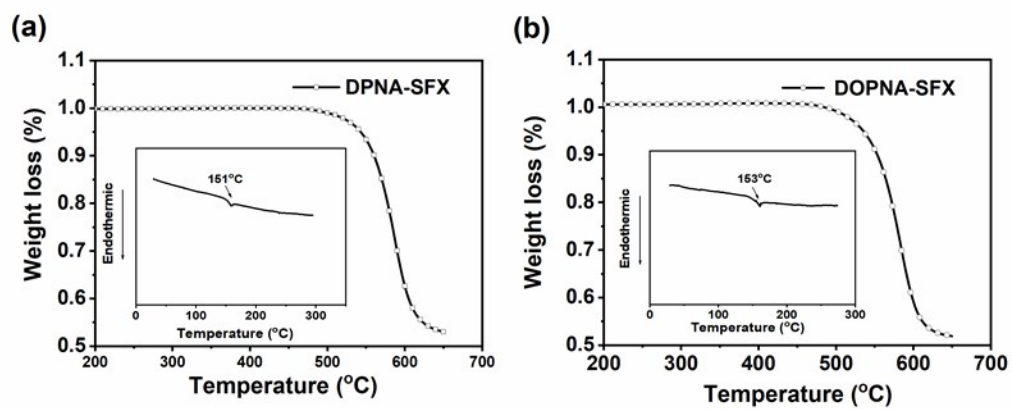


Fig S5. TGA and DSC (Inserted pictures) characteristics of (a) DPNA-SFX; (b) DOPNA-SFX.

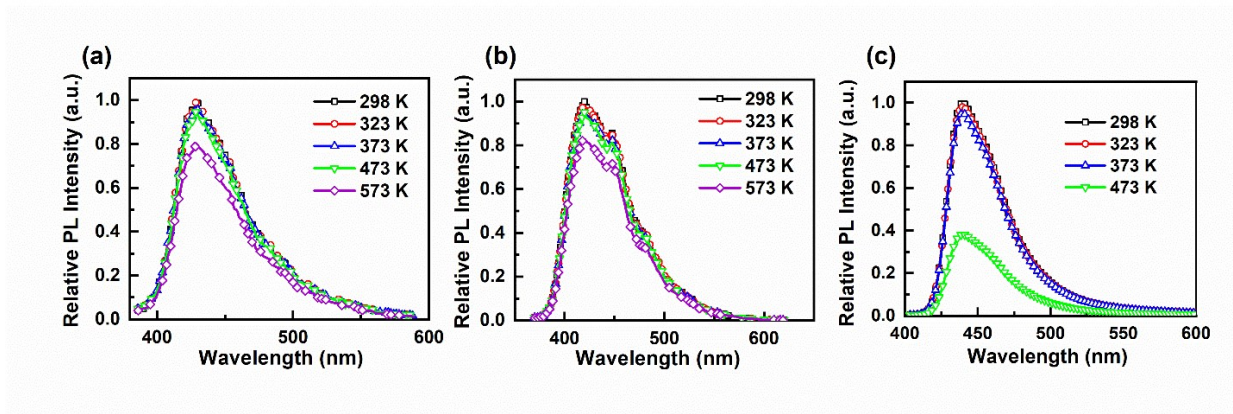


Fig S6. PL spectra of (a) DPNA-SFX; (b) DOPNA-SFX; (c) NPB in different temperatures.

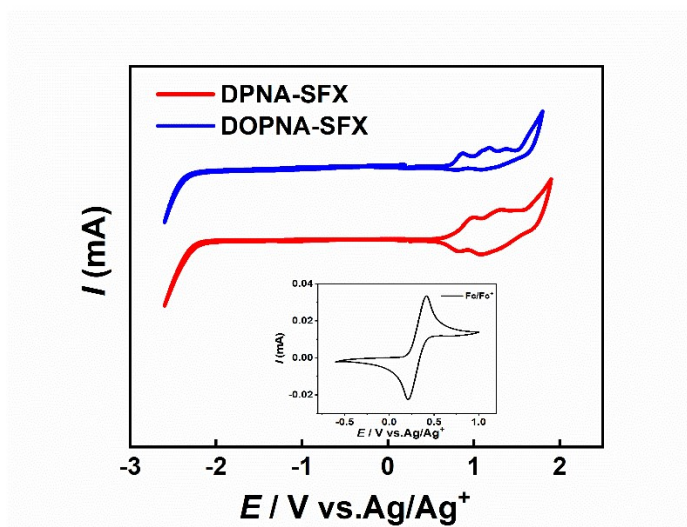


Fig S7. Cyclic voltammety curves of DPNA-SFX and DOPNA-SFX.

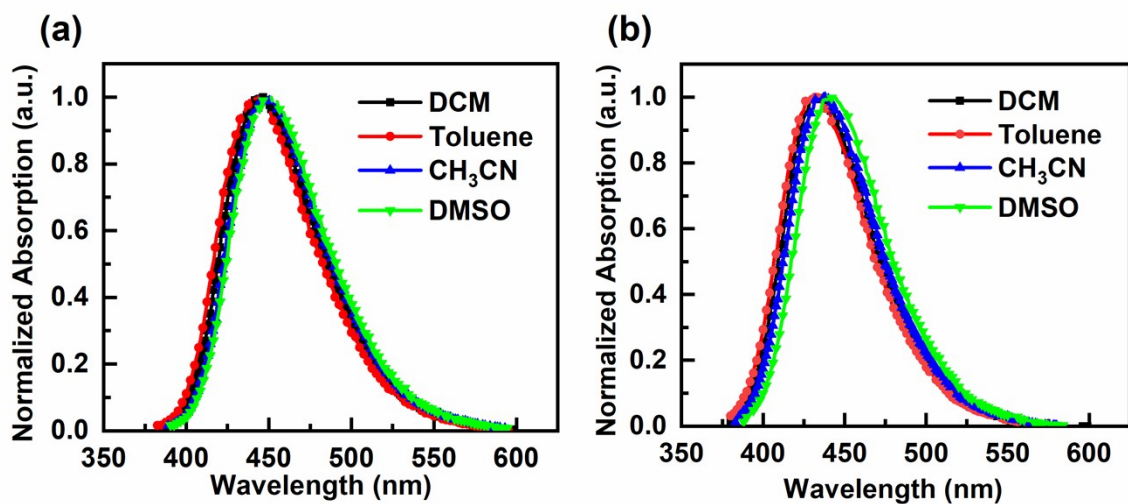


Figure S8. Emission spectra of (a) DPNA-SFX and (b) DOPNA-SFX in different solvents.

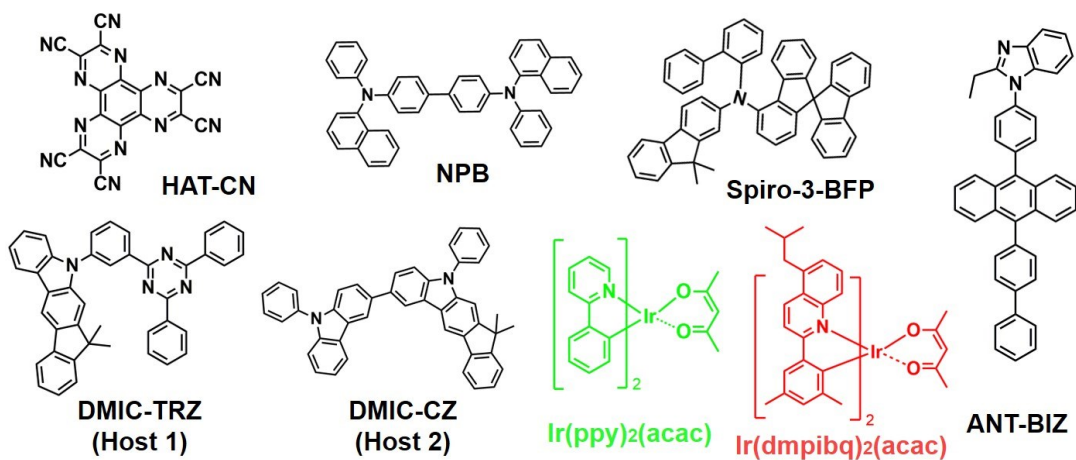


Fig S9. Molecules structures of materials used in green and red PHOLEDs.

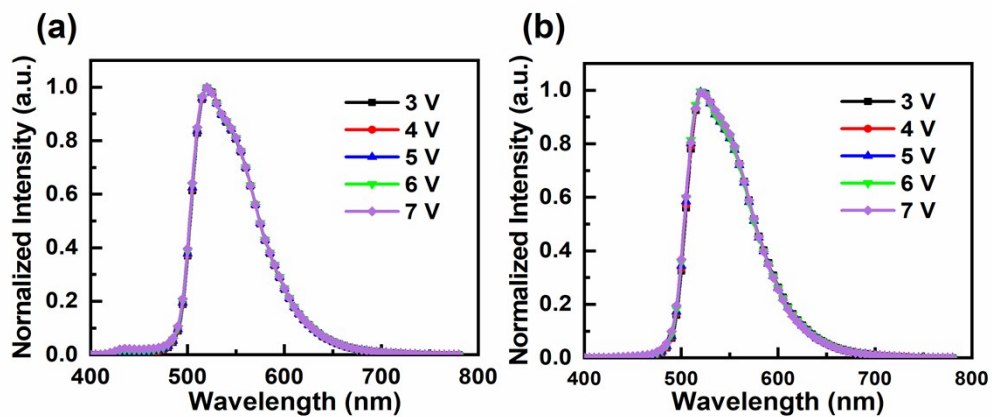


Fig S10. EL spectra of (a) DPNA-SFX; (b) DOPNA-SFX based green PHOLEDs under different operational voltage

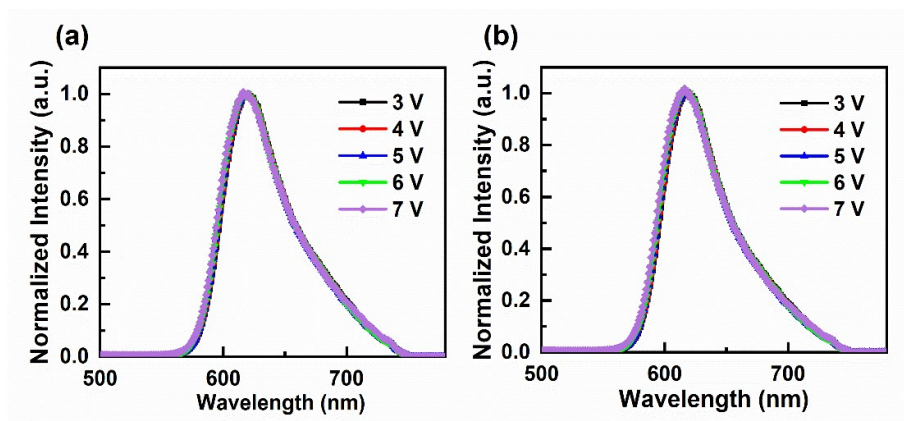


Fig S11. EL spectra of (a) DPNA-SFX; (b) DOPNA-SFX based red PHOLEDs under different operational voltage

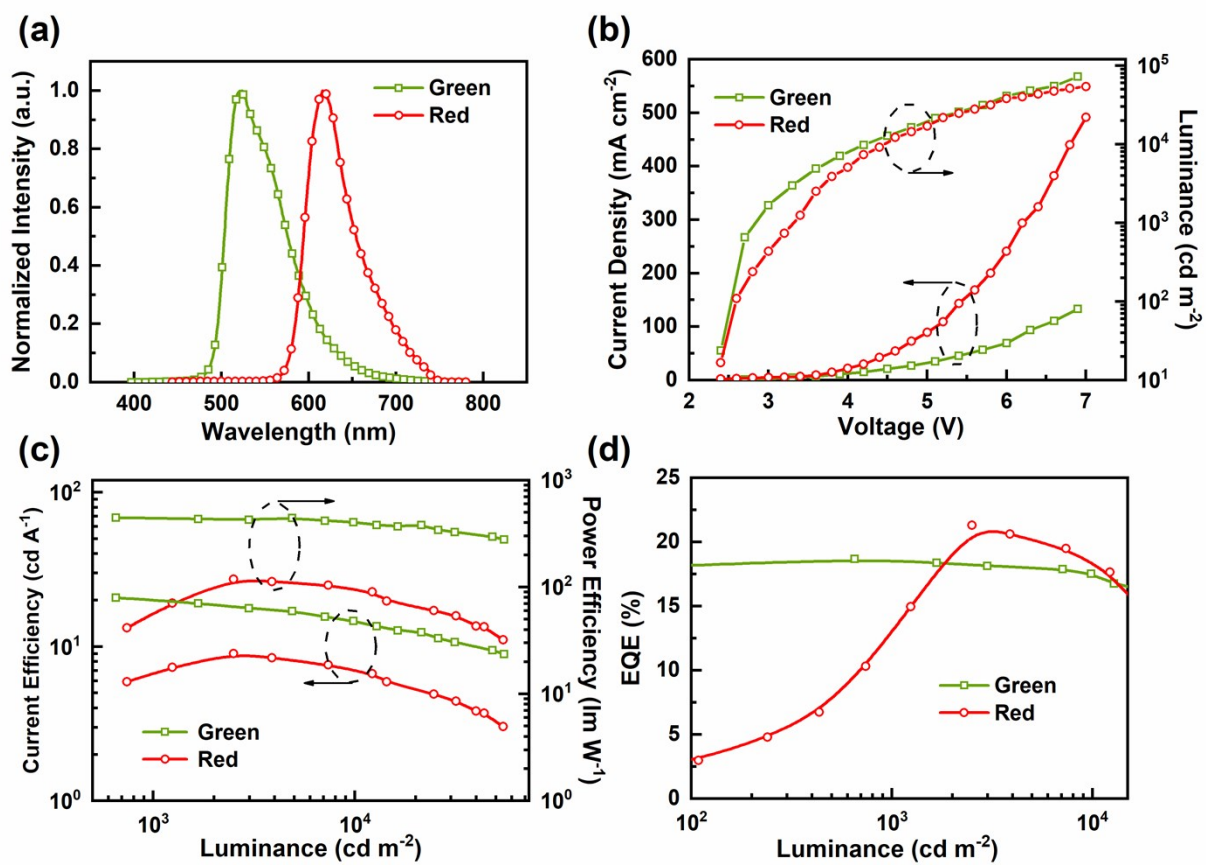


Fig S12. Device performances of NPB-based red and green PHOLEDs: (a) EL spectra (4.0 V),

(b) J-V-L curves, (c) CE-L-PE curves, (d) *EQE*-L curves

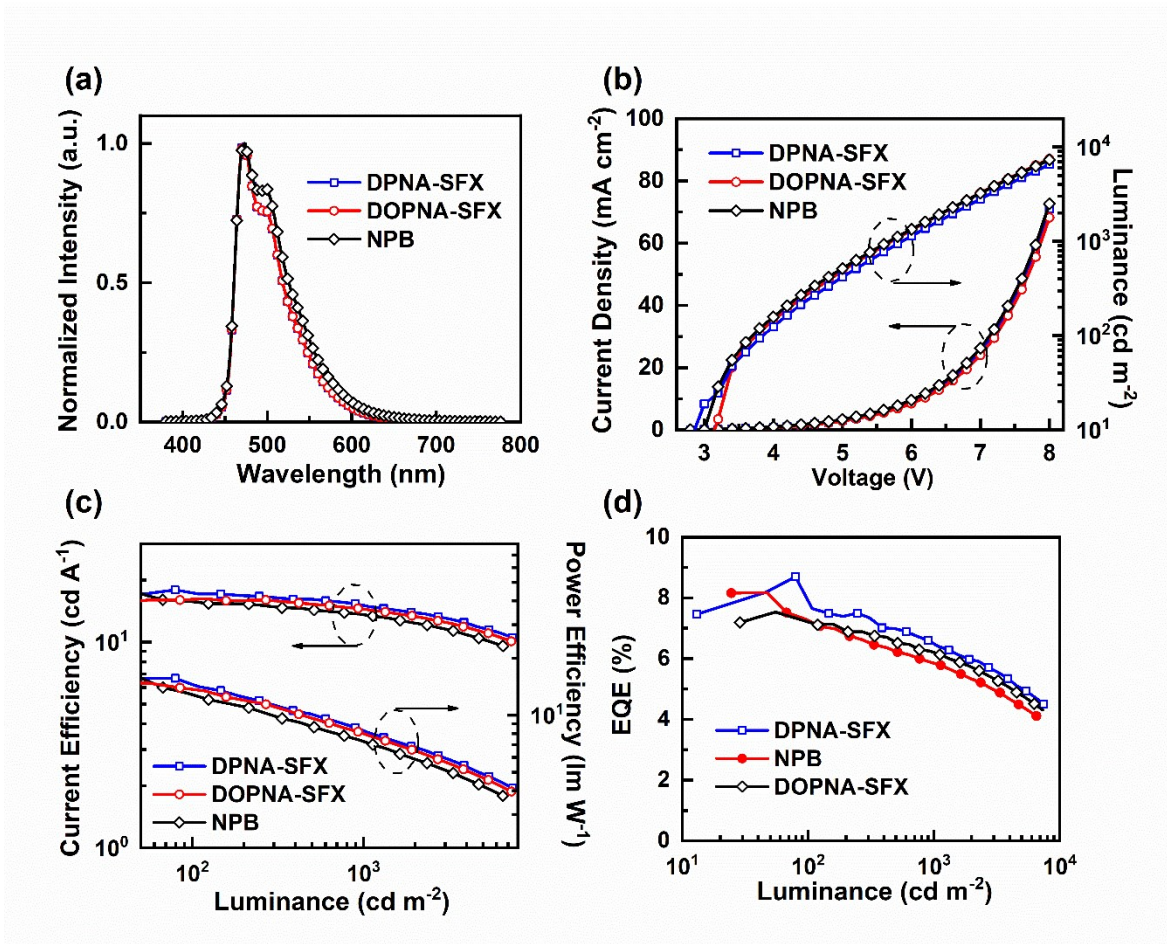


Fig S13. Device performances of blue PHOLEDs: (a) EL spectra (4.0 V), (b) J-V-L curves, (c) CE-L-PE curves, (d) EQE-L curves

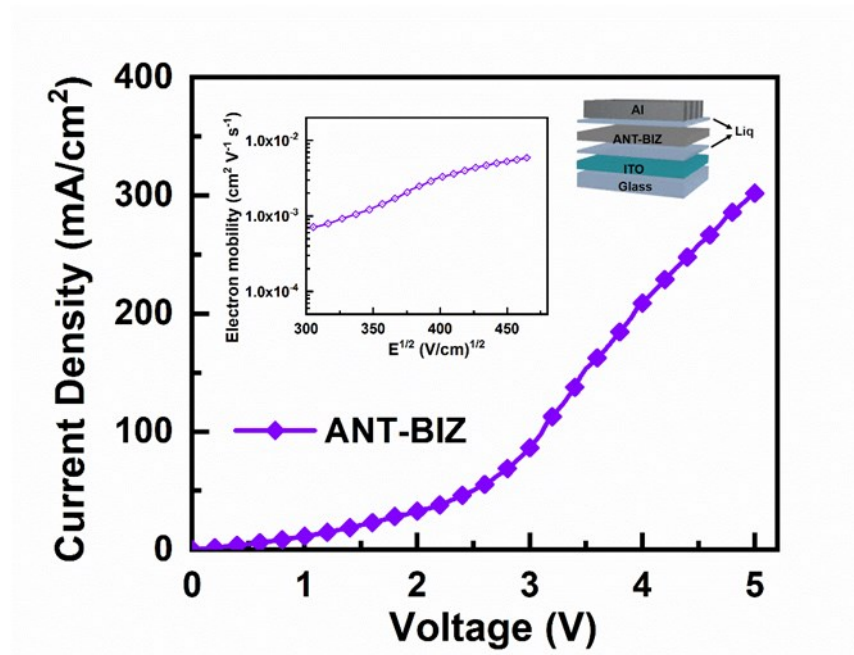


Fig S14. J-V curves of the electron-only devices and comparative field dependence mobility of ANT-BIZ (Inserted figure)

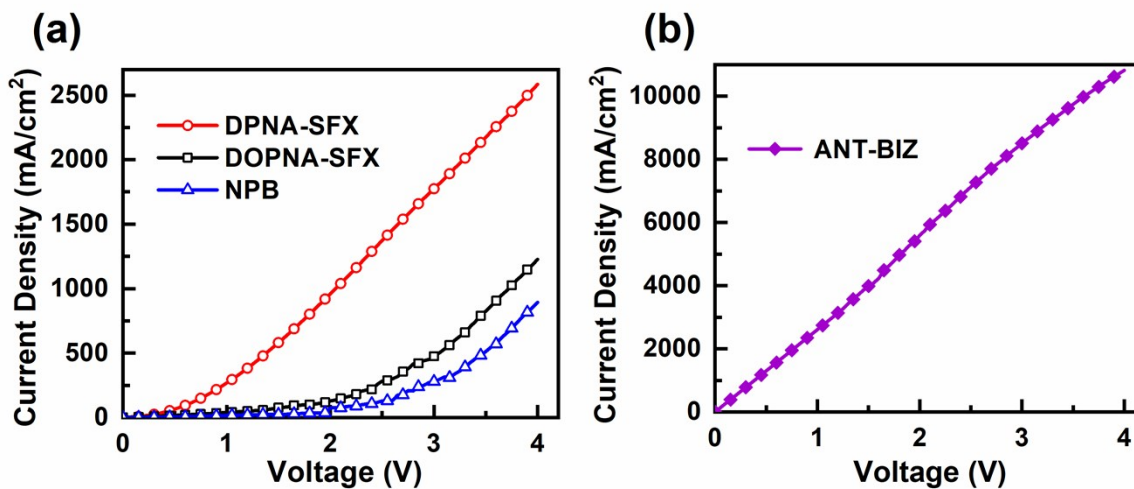


Fig S15. J-V curves of the (a) hole-only devices (ITO/HAT-CN (5 nm)/ HTM (30 nm)/ Spiro-3-BFP (10 nm)/Al) (b) electron-only devices (ITO/ANT-BIZ (70 nm)/Liq (2.5 nm)/Al (100 nm))

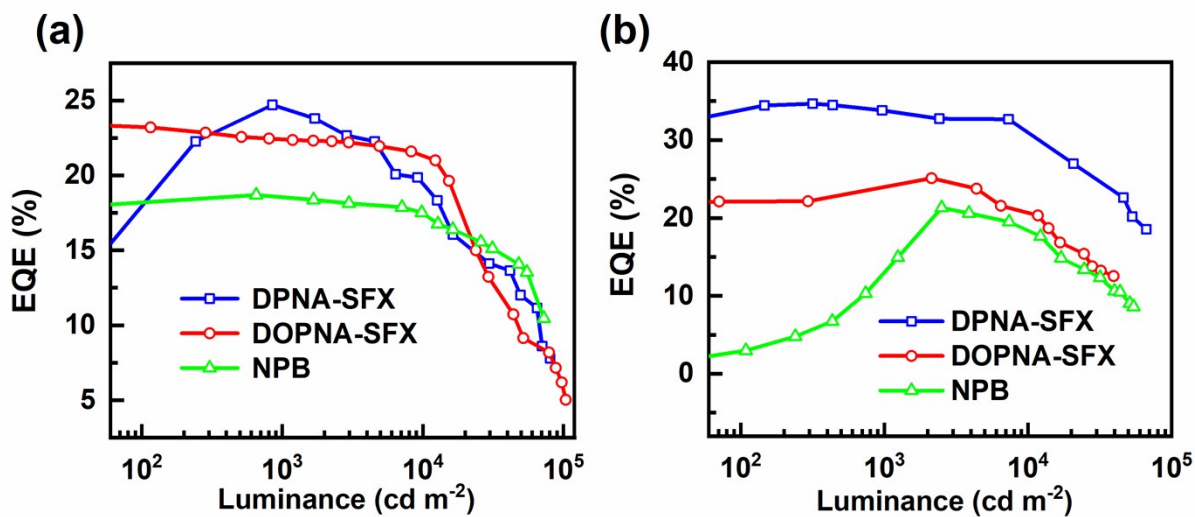


Fig S16. EQE-L curves of (a) Green PHOLED; (b) Red PHOLED up to 10^5 cd m^{-2}

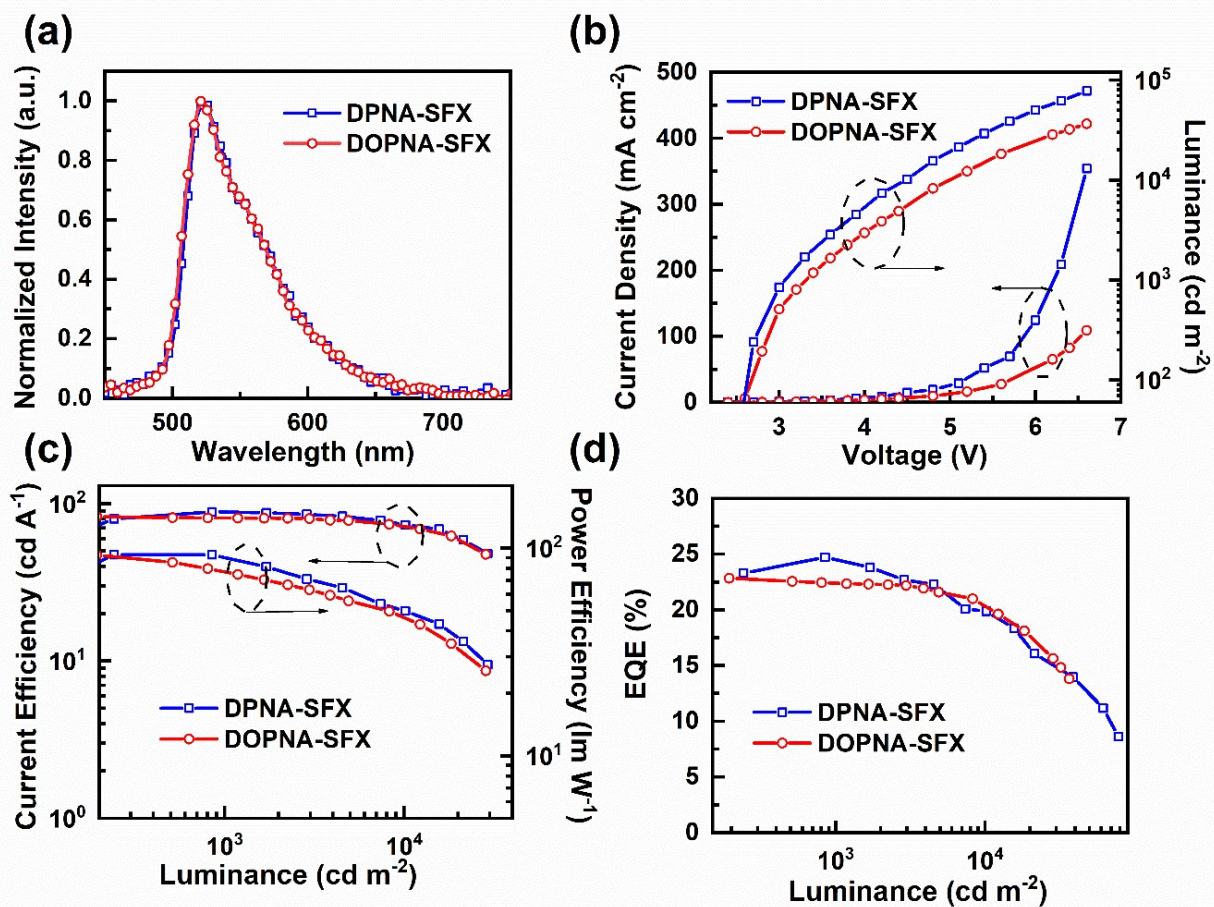


Fig S17. Device performances of green PHOLEDs collected in an integrating sphere: (a) EL spectra (4.0 V), (b) J-V-L curves, (c) CE-L-PE curves, (d) EQE-L curves

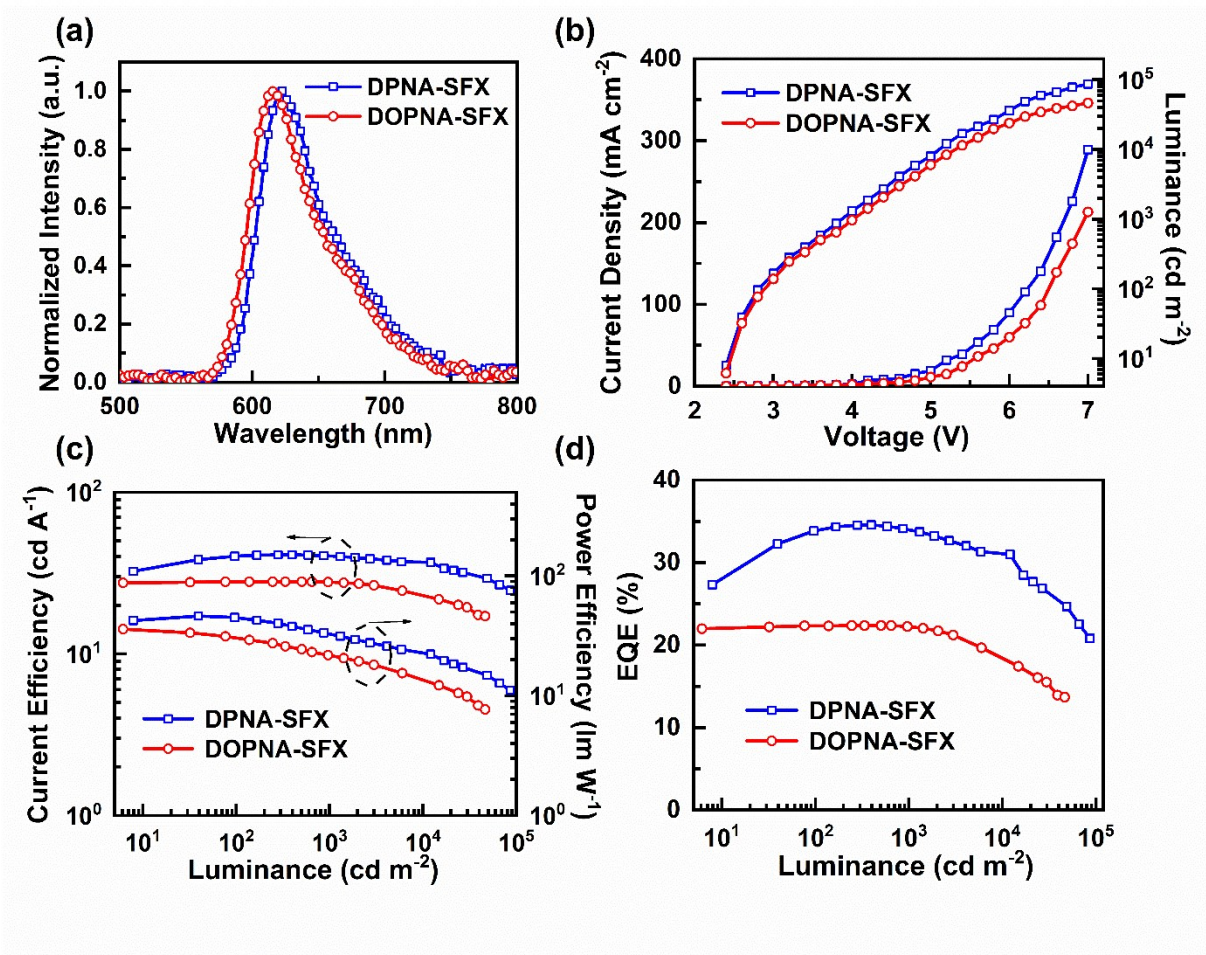


Fig S18. Device performances of red PHOLEDs collected in an integrating sphere: (a) EL spectra (4.0 V), (b) J-V-L curves, (c) CE-L-PE curves, (d) EQE-L curves

Table S1. Key electroluminescent properties of NPB-based green and red devices

| Devices | V_{on}^a (V) | CE^c (cd A ⁻¹) | | PE^d (lm W ⁻¹) | EQE^e (%) | CIE ^f |
|-----------|-------------------|---|---|---|---|------------------|
| | | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) | |
| NPB-green | 2.4 | 68.5/67.9/62.1 | 79.7/74.6/46.2 | 18.7/18.5/17.0 | (0.32, 0.62) | |
| NPB-red | 2.4 | 27.3/19.2/21.5 | 23.8/17.7/15.4 | 21.3/15.0/12.0 | (0.66, 0.34) | |

^a Turn-on voltage at 1 cd m⁻². ^b Maximum brightness at 7 V. ^c Current efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻² ^d Power efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻². ^e External quantum efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻² ^f CIE coordinates at 1000 cd m⁻²

Table S2. Key electroluminescent properties of blue devices

| Devices | V_{on}^a (V) | CE^c (cd A ⁻¹) | | PE^d (lm W ⁻¹) | EQE^e (%) | CIE ^f |
|-----------|-------------------|--|--|--|--|------------------|
| | | Max/10 ³ (cd m ⁻²) | Max/10 ³ (cd m ⁻²) | Max/10 ³ (cd m ⁻²) | Max/10 ³ (cd m ⁻²) | |
| DPNA-SFX | 2.8 | 17.93/14.87 | 15.63/8.04 | 8.70/6.40 | (0.17, 0.41) | |
| DOPNA-SFX | 2.8 | 17.39/13.67 | 16.06/7.40 | 8.17/5.88 | (0.17, 0.41) | |
| NPB | 2.8 | 16.00/14.58 | 14.79/8.18 | 7.53/6.25 | (0.17, 0.41) | |

Table S3. Key electroluminescent properties of green and red devices with different thickness of HTL (DPNA-SFX) and ETL (ANT-BIZ)

| Devices | HTL (nm) | ETL (nm) | CE^a (cd A ⁻¹) | | PE^b (lm W ⁻¹) | EQE^c (%) |
|---------|-------------|-------------|---|---|---|---|
| | | | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) | Max/10 ³ /10 ⁴ (cd m ⁻²) |
| Green | 30 | 50 | 55.7/48.1/51.5 | 32.4/34.0/24.1 | 15.3/13.2/14.2 | |
| Green | 50 | 50 | 57.4/48.2/- | 23.8/17.7/- | 15.8/13.3/- | |
| Green | 50 | 30 | 30.3/26.7/- | 19.0/10.5/- | 8.3/7.3/- | |
| Red | 30 | 50 | 22.6/9.1/- | 29.6/3.6/- | 19.1/7.7/- | |
| Red | 30 | 30 | 18.6/6.8/- | 24.4/2.6/- | 15.7/5.7/- | |

^a Current efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻². ^b Power efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻². ^c External quantum efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻².

^a Current efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻². ^b Power efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻². ^c External quantum efficiency at maximum values/ at 1000 cd m⁻²/at 10000 cd m⁻².