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Pyridine based *meta*-linking deep-blue emitter with high conjugation extent and electroluminescent efficiencies

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We designed and synthesized a bipolar deep-blue emitter 2,6-bis(4-(1-(4-(*tert*-butyl)phenyl)-1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)pyridine (**26BTPIPy**) based on a *meta*-linking D- π -A- π -D stucture. Comparing to its *para*-linking analogue (**25BTPIPy**), the *meta*-linking in **26BTPIPy** effectively shortens molecular conjugated length and restricts intramolecular charge transfer. Interestingly, unlike most other *meta*-linking emitters, a high fluorescent yield can be maintained in **26BTPIPy**. This may be attributed to a relatively planar structure at the benzenepyridine-benzene joint in **26BTPIPy** leading to considerable overlapping of its frontier molecular orbitals. These suitable combination in properties endow **26BTPIPy** with efficient deep-blue emission and good bipolar carrier tranporting characteristics. An organic lightemitting device using **26BTPIPy** as emitter shows a low turn-on voltage (2.8 V), deep-blue emission with color index of (0.15, 0.09) and high current and external quantum efficiencies (4.16 cd A⁻¹ and 5.15%). Besides, a bilayer device using **26BTPIPy** as both emitting and electron-transporting material also gives high performance with current efficiency of 4.22 cd A⁻¹ and color purity of (0.15, 0.11).

Keyword: meta-linkage, conjugation, pyridine, deep-blue electroluminescence

1. Introduction

Blue emitter in organic light-emitting diodes (OLEDs) is of vital importance for full-color display and lighting applications.¹ Among emitters of all colors, blue emitter has the widest energy gap,² especially deep-blue emitters often possess energy gaps > 3 eV. This often leads to poor carrier injection and transportation. An effect stragegy for remediating the electrical properties of deep-blue emitter is to combine electron-donating (D) and electron-accepting (A) moieties to form a D-A or D- π -A molecule. Because donor group often possesses hole

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transporting ability and its shallow energy level of the highest occupied molecular orbital (HOMO) is beneficial to hole injection, while acceptor group will help in electron transporting and its deep energy level of the lowest unoccupied molecular orbital (LUMO) facilitates electron injection.³⁻⁵ Concurrently, there is often considerable intramolecular charge transfer (ICT) in such D-A and D- π -A molecules. This would deteriorate color purity of the deep-blue materials with spectral red-shift and broadening.⁶⁻⁹ Besides, to function as an efficient emitter, high photoluminescent quantum yeild (ϕ_{PL}) is necessary. To achieve this, many emitters adopt a *para*-linking mode to guarantee effective conjugation and thus larger overlapping of molecular frontier orbitals for high ϕ_{PL} . However, linear extension of π system often increases emission wavelength and results in higher probability of π - π stacking intermolecularly. These will undermine the deep-blue color purity and quench emission.^{10, 11} These contradictory effects among electrical properties and fluorescent efficiency against color purity explain why the development of deep-blue emitters is still considerably lagging behind.

To restrict conjugation length and suppress ICT effect of molecules for deep-blue emissions, *meta*-linkage mode of benzene ring is a commonly used strategy.¹²⁻¹⁷ For instance, sky-blue emitter BTPE with an electroluminescent (EL) peak at 488 nm shows 36 nm hypochromatic shift when adopting *meta*-linking to be *m*TPE-*m*TPE ($\lambda_{max, EL} = 452 \text{ nm}$).¹⁵ Blue emitter TPA-PPI with a Commission Internationale de L'Eclairage (CIE) coordinates (0.15, 0.11) fails to match the National Television System Committee (NTSC) blue standard (0.14, 0.08), but its *meta* analogue *m*TPA-PPI shows good CIE coordinates of (0.161, 0.049).¹⁸ Unfortunately, accompanying with the shortening of emission wavelength, the conjugated nodes between *meta*-positions of benzene ring also hinder delocalization of molecular frontier orbitals and most of the *meta*-derivatives have small overlaps between their HOMOs and LUMOs, leading to low ϕ_{PL} .^{15, 18-21}

Herein, we apply both the D- π -A- π -D structure and the *meta*-linking strategy to design a new emitter 2,6-bis(4-(1-(4-(*tert*-butyl)phenyl)-1*H*-phenanthro[9,10-*d*]imidazol-2-yl)phenyl)pyridine (**26BTPIPy**) (Fig. 1a), to endow this molecule with bipolar feature and deep-blue emission. For comparison, its *para* analogue 2,2'-(pyridine-2,5-diylbis(4,1-phenylene))bis(1-(4-(*tert*-butyl)phenyl)-1*H*-phenanthro[9,10-*d*]imidazole) (**25BTPIPy**) is also synthesized. **26BTPIPy** shows shortened conjugation length and restricted ICT as expected from its *meta* architecture. To our surprise, **26BTPIPy** still maintains a high fluorescence quantum yield of 79%, which is considerably higher than those observed in most other emitters with *meta* architecture.

Theoretical study showed that *meta*-linkage at 2- and 6-position of pyridine ring has less steric hindrance because the missing hydrogen atom comparing to a benzene ring (Fig. 1b). This leads to a more planar benzene-pyridine-benzene structure and more conjugation. Both HOMO and LUMO of **26BTPIPy** are well delocalized, which is conducive to achieving larger ϕ_{PL} . A non-doped OLED using this material as emitter achieved deep-blue emission with CIE coordinates of (0.15, 0.09) and high efficiencies: current efficiency (CE) of 4.16 cd A⁻¹ and external quantum efficiency (EQE) of 5.15% are obtained, which are comparable to some high-efficiency *para*-linking emitters. Moreover, **26BTPIPy** was found to be a good bifunctional material. A bilayer device with **26BTPIPy** as emitter and electron transporting material still presented high efficiency (CE: 4.22 cd A⁻¹ and EQE: 4.26%).

2. Experiment

2.1. Synthetic procedures

All reagents and solvents were purchased from commercial sources and used as received without further purification unless otherwise stated. Specific details of the new compounds' synthetic routes are summarized in ESI.

2.2. General procedures

¹H NMR was recorded with a Varian Gemin-400 or -300 spectrometer. Mass spectra were recorded on a PE SCIEX API-MS spectrometer. Elemental analysis (C, H, N) was performed using a Vario EL III CHNS elemental analyzer. UV-vis absorption and photoluminescence (PL) spectra were measured on a Perkin-Elmer Lambda 950 UV/vis Spectrometer and a PerkinElmer LS50 fluorescence spectrometer, respectively. Absolute ϕ_{PL} was measured with a LabsphereTM integrating sphere using a monochromatized Xe lamp (NewportTM) as the exciting source (at 365 nm). Thermogravimetric analysis (TGA) and differential scanning calorimetric (DSC) were performed on a TA Instrument TGAQ50 and a TA Instrument DSC2910, respectively. Cyclic voltammetry (CV) was carried out in nitrogen-purged CH₂Cl₂ (positive scan) at room temperature using a CHI voltammetric analyzer. Tetrabutylammonium hexafluorophosphate (TBAPF₆) (0.1 M) was used as the supporting electrolyte. The measurements were carried out at a scan rate of 100 mV s⁻¹ with a conventional three-electrode configuration consisting of a glassy carbon working electrode, a platinum wire auxiliary electrode, and a saturated calomel reference electrode calibrated by ferrocene/ferrocenium (Fc/Fc⁺). For the theoretical calculation, geometrical properties was optimized at B3LYP/6-31g(d) level using the Gaussian 09 program.

Molecular orbitals were obtained at the same level of theory. Devices were fabricated on precleaned ITO-coated glass substrates with a sheet resistance of 15 Ω square⁻¹. After a 15 min UVozone treatment, the ITO substrates were immediately transferred into a deposition chamber with a base pressure of 5 × 10⁻⁶ torr for organic and metal deposition. Current density-Voltage (*J–V*) characteristics and EL luminescence properties of the devices were recorded with a Keithley 2400 SourceMeter and a Spectrascan PR650 photometer respectively.

3. Results and discussion

3.1. Synthesis and characterization

Scheme S1 in ESI summarizes the synthetic routes of **26BTPIPy** and **25BTPIPy**. Two steps of reactions are involved in the synthesis process, including a Suzuki-coupling^{22, 23} reaction to link the intermediates 4,4'-(pyridine-2,6-diyl)dibenzaldehyde (26BCHOPy) and 4,4'-(pyridine-2,5-diyl)dibenzaldehyde (25BCHOPy), and a "one-pot"²⁴ reaction to add phenanthroimidazole (PI) endcaps to 26BCHOPy and 25BCHOPy. The products were isolated with moderate yields and their molecular structures were confirmed with ¹H NMR, mass spectrometry and elemental analysis (see ESI).

3.2. Thermal property

Thermal properties of **26BTPIPy** and **25BTPIPy** were evaluated with TGA and DSC under N₂ atmosphere. Fig. 2 gives the corresponding results and the key data are summarized in Table 1. Both these materials possess high decomposition temperature (T_d , 5% weight loss) of 519 and 499 °C for **26BTPIPy** and **25BTPIPy** respectively. The *meta*-linking compound is slightly better than the *para*-linking one in term of T_d . This maybe because the *meta*-linkage mode reduces the free rotation possibility and stretching vibration length compared to its *para*-counterpart. Thus a more rigid structure endows the *meta*-linking material with a higher T_d . Besides, DSC shows that **26BTPIPy** has a glass-transition temperature (T_g) as high as 204 °C, which is high enough to guarantee its morphological stability in thin-film device application. We did not observe obvious endothermic peak through the whole measuring process (two-cycle scanning between 50 and 420 °C) of **25BTPIPy**, indicating no obvious phase change occurred. Overall, both materials show good thermal stabilities for OLED applications.

3.3. Photophysical property

Fig. 3a shows absorption spectra of **26BTPIPy** and **25BTPIPy** in dichloromethane (DCM) (10^{-5} mol L⁻¹) as well as their PL spectra in DCM and as thin films on quartz substrates. Key

photophysical parameters of the two emitters are also listed in Table 1. A similar sharp absorption peak at around 260 nm were observed in both compounds, which is attributed to the π - π * transition of benzene ring.²² However, their broad absorptions ranging from 330 ~370 nm are quite different. The 347 nm absorption peak of 26BTPIPy should be ascribed to π - π * transition of the PI units^{19, 24} and the 367 nm absorption peak is originated from the absorption of the whole molecule skeleton.²⁵ Generally, the use of *meta*-linking mode in molecular modification often results in hypochromic shift in emission spectrum due to the suppression of conjugated effect. In our molecules, this conjugation suppression effect also works. Comparing to the spectrum of **25BTPIPy**, there are obvious blue shifts in absorption peak (367 nm vs 372 nm) and onset (397 nm vs 413 nm) positions, evidencing a shortened conjugated length. PL peaks of 26BTPIPy (427 nm) and 25BTPIPy (452 nm) in solution (Fig. 3a) show the same trend as their absorptions. PL spectra of the emitters in neat film are peaked at 438 nm and 457 nm respectively, which are redshifted by \sim 5-11 nm from their solutions. Besides, the solvatochromic PL spectra (Fig. 3b) shows that **25BTPIPy** has stronger ICT character (peaked at 416 nm with full width at half maximum (FWHM) of 47 nm in hexane; 474 nm with 78 nm-FWHM in acetonitrile) than 26BTPIPy (401 nm with 52-nm FWHM in hexane; 434 nm with 66-nm FWHM in acetonitrile), indicating the suppressed ICT nature. Therefore, meta-linking mode is effective in achieving bluer emission and suppressing ICT redshifts in our pyridine-based system. Interestingly, ϕ_{PL} of **26BTPIPy** in solution and solid state are reasonably high (0.90 in solution and 0.79 in neat film), which is comparable to its *para*-counterpart (0.96/0.83) and surpass those of most other meta-linking molecules (e.g. 0.70/0.59 and 0.55/0.35 for m-BBTPI¹⁹ and Z-BBPI²⁰ respectively). Comparing absorption spectra of m-BBTPI (an analogue molecule of 26BTPIPy with its pyridine spacer replaced with a benzene ring) and 26BTPIPy (see Fig. S2 in ESI), an obvious redshift from *m*-BBTPI (peaks: 334 nm; onset: 386 nm) to 26BTPIPy can be observed, demonstrating a higher conjugation extent in **26BTPIPy**. It is reported that ϕ_{PL} will increase with conjugation extent in similar molecular system.^{26, 27} Considering the very similar structure of *m*-BBTPI and **26BTPIPy** (Fig. 1a), we speculated that the better conjugation may be responsible for the higher ϕ_{PL} in the present *meta*-architecture molecule. From their absorption onset, we estimated the optical energy gaps of 26BTPIPy and 25BTPIPy to be 3.12 eV and 3.00 eV. Combined with 26BTPIPy and 25BTPIPy's HOMO energy levels of -5.52 eV and -5.50 eV

obtained from CV measurements, LUMO energy levels are projected to be -2.40 eV and -2.50 eV respectively.

3.4. Theoretical calculation

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For a better understanding of the relationship between the molecular structures and properties of **26BTPIPy** and **25BTPIPy**, quantum chemistry calculations were performed using B3LYP method with a basic set of 6-31g(d). As shown in Fig. 4, the dihedral angle between pyridine ring and the phenyl ring connected to its 5-position is 35.8°, which is similar to that of two benzene rings (e.g. 36.7° in *m*-BBTPI). But the twist angle decreased to 19.3° between pyridine and its adjacent benzene rings at 2- and 6-position in 26BTPIPy. This will enhance conjugation as suggested by previous report.²⁸ Distributions of molecular orbital electron cloud further support this point. Both the HOMO and the LUMO of 26BTPIPy are delocalized over the whole molecular skeleton with considerable overlap comparable to that of its para analogue, 25BTPIPy. In fact, in most *meta*-linking molecules, the HOMO is often confined by the *meta*linking node^{14, 29, 30} and mostly localizes on only one side of the node. The unusual delocalization in **26BTPIPy** is in accordance with the above discussed interesting photophysical properties and can explain its high ϕ_{PL} .^{31, 32} More carefully, we manipulated the twisting angle at 2- and 6position in simulation and observed the change in orbital distribution of 26BTPIPy. As shown in Fig.5, increase of twisting does not significantly change the HOMO distribution of **26BTPIPy** until 60°. Similarly, in the case of *m*-BBTPI, twist angle change also induce little variation of HOMO distribution (Fig. S4). Therefore, we proposed the electronic resonance³³ between position 2 and 6 of pyridine ring may be another important factor to enhance the conjugation extent of *meta* molecule (Scheme 1). Because of the larger electronegativity of N atom in the pyridine ring, its adjacent C atoms (position 2 and 6) show some extent of positive charge. Assuming single electron transfer of CT transition from donor to pyridine acceptor, electronic resonance effect could move the electron from one side to the other, which thus helps the electronic communication of the two donor parts and benefits conjugative effect. Therefore, electronic resonance effect in the *meta*-linking **26BTPIPy** helps to maintain high conjugation extent and emission efficiency.

3.5. Electrical properties

To investigate the electrical properties of the two D- π -A- π -D structure molecules, we fabricated hole- and electron-only devices with configurations of indium tin oxide (ITO)/4,4'-bis[N-(1-

(1)

naphthyl)-*N*-phenylamino]-biphenyl (NPB) (20 nm)/**26BTPIPy** or **25BTPIPy** (50 nm)/NPB (20 nm)/Al (100 nm) and ITO/1,3,5-tris(1-phenyl-1*H*-benzimidazol-2-yl)-benzene (TPBI) (20 nm)/**26BTPIPy** or **25BTPIPy** (50 nm)/TPBI(20 nm)/LiF (1 nm)/Al (100 nm), respectively. Fig. 6 are *J*-*V* plots of these devices. Both molecules show obvious bipolar transporting capacities.³⁴, ³⁵ Devices with **26BTPIPy** show higher currents for both hole and electron, especially the electron current, indicating that **26BTPIPy** has better charge transporting abilities.

3.6 Electroluminescent properties

Motivated by their good optical and electrical properties, we used these materials as emitters to fabricate non-doped OLEDs with configurations of ITO/hexaazatriphenylene hexacarbonitrile (HATCN) (5 nm)/NPB (60 nm)/4,4',4"-tris(carbazol-9-yl)-triphenylamine (TCTA) (5 nm)/26BTPIPy or 25BTPIPy (20 nm)/TPBI (35 nm)/LiF (1 nm)/Al (120 nm). HATCN is used as hole injection layer and TCTA is a buffer layer to prevent leakage of exciton into the hole transporting layer (HTL, NPB),¹⁹ while TPBI is used as electron transporting material. Fig. 7a is the current density-voltage-luminescence (J-V-L) characteristics of the two devices, from which turn-on voltages (voltage at 1 cd m⁻²) of 2.8 and 3.0 V for 26BTPIPy- and 25BTPIPy-based devices were obtained respectively. As discussed above, 26BTPIPy has better carrier transporting abilities, leading to higher current density in the 26BTPIPy-based device comparing to the 25BTPIPy device. 26BTPIPy-based device achieved maximum CE and EQE (Fig. 7b) of 4.16 cd A⁻¹ and 5.15%, while the corresponding efficiencies for the **25BTPIPy**-based device were 6.22 cd A⁻¹ and 4.72% respectively. Deep-blue emission with CIE coordinates of (0.15, 0.09) was obtained from the **26BTPIPy**-based device. This EL emission with peak at 440 nm showed no observable change from 3 to 8 V (Fig 7c). Linear increase of EL luminescence with current density (inset of Fig. 7c) suggests minimal involvement of triplet-triplet annihilation and current induced fluorescence quenching.^{25, 36} For the **25BTPIPy**-based device, EL emission peaked at 460 nm displays color coordinates of (0.15, 0.16) which was in accord with PL emission of 25BTPIPy. In these multi-layer devices, we found the EQE of the 26BTPIPy-based OLED is higher than that of the 25BTPIPy-based device, although the 26BTPIPy displays relatively lower ϕ_{PL} in solid film. Theoretically, the EQE of a device can describe as,

EQE = $\gamma \eta_{out} \phi_{PL} \eta_r$

where γ is recombination efficiency of hole and electron carriers, η_{out} is the light out-coupling efficiency and η_r is the ratio of radiative exciton. In fact, EQE depends on four factors. In our

case, the difference of ϕ_{PL} of the two molecules is not large (83 vs 79%), so the EQEs are mainly influenced by other three factors. For example, due to the hole transport is slightly better than electron transport in our molecules (Fig. 6), a thicker HTL layer was used in the device structure to balance charge transport. However, the electron transport of **26BTPIPy** is better than that of **25BTPIPy**, which may lead to higher γ in **26BTPIPy**-based OLED with the same device structure especially in the low bias region (where highest efficiency achieved). Besides, the efficiency roll-off of the **26BTPIPy**-based device is slightly larger than that of **25BTPIPy**-based device (10.3% vs 7.2% at 1000 cd m⁻²), implying that different γ can affect EQE performance. Key device performances data are summarized in Table 2. Noticeably, performance of **26BTPIPy** is among the best of *meta*-derivatives and even comparable to some high efficiency non-doped deep-blue materials with *para*-linkage.^{6, 15, 19, 20, 37-42}

Inspired by its excellent electron injection and transporting abilities, **26BTPIPy** were further used in both emitting and electron transporting layer to fabricate a simpler structured OLED: ITO/HATCN (5 nm)/NPB (60 nm)/TCTA (5 nm)/**26BTPIPy** (50 nm)/LiF (1 nm)/Al (120 nm). As shown in Fig. S5a, slight redshifts of EL emission (448 nm) was observed from the device. High device performance was still maintained in this simple device configuration, as shown in Fig. 8 and Table 2, with CE_{max} of 4.22 cd A⁻¹, EQE_{max} of 4.26% and CIE coordinates of (0.15, 0.11). These show that **26BTPIPy** can be used as a high performance bifunctional material. With the same structure, bilayer device using **25BTPIPy** in emitting and electron-transporting layer was also fabricated. However, the device efficiencies are far inferior to its corresponding multilayer device with a TPBI electron-transporting layer (Table 2).

4. Conclusion

In conclusion, we designed and synthesized a *meta* D- π -A- π -D molecule **26BTPIPy** as deepblue emitter for OLED applications. Comparing to its *para*-counterpart **25BTPIPy**, the material not only effectively suppresses ICT-induced redshifts and shortens conjugated length to give deep blue emission (CIE coordinates: (0.15, 0.09) vs (0.15,0.16)), but also keep high conjugation extent and high ϕ_{PL} . Superior electrical properties endows **26BTPIPy** with a better device performance than **25BTPIPy** (EQE: 5.15% vs 4.72%). Besides, **26BTPIPy** can be used as a bifunctional material and achieve high performance (CE: 4.22 cd A⁻¹, EQE: 4.26%) in doublelayer device. The outstanding character presented by this *meta* molecule can provide us with a good reference for future deep-blue emitter design for OLED.

Acknowledgements

We would like to appreciate Dr. Ji Zheng at Shantou University for the fruitful discussions. This work was supported by the National Natural Science Foundation of China (Project No. 51473138 and 51273108) and the National Basic Research Program of China (973 Program No. 2013CB834803).

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Fig. 1 a) Molecular structures of **26BTPIPy** and **25BTPIPy** (structures of *m*-BBTPI and BBTPI are also presented for comparison); b) Schematic of reduced hindrance in *meta*-linkage of pyridine ring



Fig. 2 TGA and DSC (inset) measurement of 26BTPIPy and 25BTPIPy.

Table 1	Summary	of the	physical	data o	of 26BTP I	[Py and	25BTPIPy
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compound	$T_{\rm d}^{\rm (a)}$	$T_{\rm g}^{\rm \ b)}$	HOMO ^{c)}	LUMO ^{d)}	$\lambda_{abs}^{e)}$	$\lambda_{\rm em}^{\rm e)/f}$	$arPhi_{ m f}({ m soln}/{ m film})^{ m g)}$
	[°C]	[°C]	[eV]	[eV]	[nm]	[nm]	%

26BTPIPy	519	204	-5.52	-2.40	347, 365	427/438	90/79
25BTPIPy	499	n.o.	-5.50	-2.50	372	452/457	96/83
<i>m</i> -BBTPI ^{h)}	512	190	-5.34	-2.13	334	406/432	70/59
BBTPI ^{h)}	481	192	-5.56	-2.48	367	427/448	93/82

^{a)} 5% weight loss temperature; ^{b)} n.o. = not observed; ^{c)} Detected via CV; ^{d)} Estimated by E_g from HOMO levels; ^{e)} Measured in dilute CH₂Cl₂ solution (10⁻⁵ mol L⁻¹); ^{f)} Measured in film; ^{g)} The fluorescence quantum yield in solution using a 10⁻⁶ mol L⁻¹ cyclohexane solution of 9,10-diphenylanthracene (0.90) as standard, and the solid state quantum yield on the quartz plate using an integrating sphere apparatus; ^{h)} data of these two compounds are taken from ref. 19.



Fig. 3 a) Absorption and PL spectra and b) comparison of solvatochromic effect of **26BTPIPy** and **25BTPIPy**.



Fig. 4 Optimized geometry of and calculated HOMO and LUMO distributions of **26BTPIPy** and **25BTPIPy**.



Fig. 5 Calculated HOMO distributions of **26BTPIPy** with arbitrary fixed twisting angle between the pyridine ring and two connected benzene rings.



Scheme 1 Electronic resonance between electron-deficient positions of pyridine ring.



Fig. 6 Current density versus voltage of the single carrier devices based on **26BTPIPy** and **25BTPIPy**.



Fig. 7 a) Current density-voltage-luminescence characteristic curves, b) Plots of current efficiency-luminance-EQE, c) and d) EL spectra at different voltages (inset is luminescence-current density plot) of **26BTPIPy** and **25BTPIPy**-based OLEDs.

Table 2. Key performance of new compounds-based devices

Device	V _{on} [V]	λ _{EL} [nm]	Luminescence _{max} [cd m ⁻²]	CE * [cd A ⁻¹]	EQE * [%]	PE* [lm W ⁻¹]	CIE [x, y]
Α	2.8	440	4416	4.16, 4.12, 3.61	5.15, 5.15, 4.62	4.35, 3.70, 1.95	(0.15, 0.09)
В	3	460	6762	6.22, 6.20, 5.70	4.72, 4.70, 4.38	5.89, 4.62, 2.89	(0.15, 0.16)
С	3	448	3019	4.22, 4.20, 3.78	4.26, 4.25, 3.96	4.34, 3.63, 1.83	(0.15, 0.11)
D	3	460	3150	3.42, 3.23, 2.89	2.47 ,2.38, 2.14	3.33, 2.44, 1.33	(0.16, 0.17)

Device structure: A and B: ITO/HATCN (5 nm)/NPB (60 nm)/TCTA (5 nm)/26BTPIPy or 25BTPIPy (20 nm)/TPBI (35 nm)/LiF (1 nm)/Al (120 nm); C and D: ITO/HATCN (5 nm)/NPB (60 nm)/TCTA (5 nm)/26BTPIPy or 25BTPIPy (50 nm)/LiF (1 nm)/Al (120 nm).

*The three values for each device are the efficiency at maximum, 100 and 1000 cd m⁻² respectively.



Fig. 8 a) Current density-voltage-luminescence characteristic curves, b) plots of current efficiency-luminance-EQE of the **26BTPIPy** and the **25BTPIPy**-based bilayer devices.

Pyridine based *meta*-linking deep-blue emitter with high conjugation extent and electroluminescent efficiencies

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A *meta*-linking pyridine based compound with high conjugation extent was reported as high efficiency deep-blue OLED emitter.

