

应用于稳定有机磷光二极管的三嗪基电子传输材料

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Triazine-based electron-transport material for stable phosphorescent organic light-emitting diodes

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Abstract: An organic electron-transport compound for phosphorescent OLEDs is reported, which possesses the advantages of low molecular weight, enhanced glass transition temperature and electron mobility upon doping with 8-hydroxyquinolitolithium (Liq) as well as facile synthesis and purification. The analytically pure NaAN-*m*-TRZ ($m/z = 611.73$) is obtained through coupling the 4, 6-diphenyl-1,3,5-triazin-2-yl unit via a 1,3-phenylene linker with 10-(naphth-2-yl)-anthracen-9-yl moiety. The residual bromo intermediate could be easily removed by column chromatography and/or recrystallization from CH_2Cl_2 , hence eliminating a high-risk factor for OLED stability. Thermal analyses show that it exhibits a T_g of 157 °C and decomposition temperature of 353 °C at 1% weight loss. NaAN-*m*-TRZ has a HOMO level of -5.76 eV determined by the ultraviolet photoelectron spectroscopy measurement and an estimated LUMO level of -2.84 eV. Doping NaAN-*m*-TRZ with 50% (mass fraction) Liq yields impressive electron mobility of $6.23 \times 10^{-5} \sim 7.19 \times 10^{-4} \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ @ $E = (2 \sim 5) \times 10^5 \text{ V} \cdot \text{cm}^{-1}$ using space-charge-limited current model, which contributes to suppressing triplet-polaron annihilation in the phosphorescent OLEDs. Consequently, based on the single NaAN-*m*-TRZ : Liq electron-transport layer, the top-emission green phosphorescent OLED involving $\text{Ir}(\text{ppy})_2(m\text{-mbppy})$ produces extraordinary durability with projected lifetime t_{97} of 2 567 h @ $1\,000 \text{ cd} \cdot \text{m}^{-2}$ as well as a luminous efficiency of $72.2 \text{ cd} \cdot \text{A}^{-1}$ and power efficiency of $81 \text{ lm} \cdot \text{W}^{-1}$ @ $1\,000 \text{ cd} \cdot \text{m}^{-2}$.

Key words: triazines; anthracenes; low molecular weight; glass transition temperature; electron mobility

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应用于稳定有机磷光二极管的三嗪基电子传输材料

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摘要: 本文报道了一类面向有机电致磷光器件应用的电子传输材料, 其具有易合成纯化、分子量低、玻璃化转变温度高以及经 8-羟基喹啉锂(Liq)掺杂, 电子迁移率高等优点。通过 1,3-亚苯基, 4,6-二苯基-1,3,5-三嗪-2-基单元与 10-(萘基-2-基)-蒽-9-基偶联, 得到分析纯的 NaAN-*m*-TRZ($m/z=611.73$)。残留的含溴中间体可以容易地通过柱层析和/或由 CH_2Cl_2 重结晶去除, 从而避免了高风险卤代杂质对于 OLED 稳定性的影响。热分析表明, 其 T_g 为 157 °C; 在失重率为 1% 时, 分解温度为 353 °C。根据紫外光电子能谱测量, NaAN-*m*-TRZ 的 HOMO 能级为 -5.76 eV, 其 LUMO 估算为 -2.84 eV。利用空间电荷限制电流模型, 经由质量分数为 50% Liq 掺杂的 NaAN-*m*-TRZ 的电子迁移率高达 $6.23 \times 10^{-5} \sim 7.19 \times 10^{-4} \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ @ $E = (2 \sim 5) \times 10^5 \text{ V} \cdot \text{cm}^{-1}$, 有助于抑制磷光 OLED 器件中的三重态-极化子湮灭。因此, 基于 Liq:NaAN-*m*-TRZ 的单层电子传输层, 顶发射绿光磷光器件展现出高稳定性, 预计寿命 t_{97} 约为 2 567 h @ 1 000 $\text{cd} \cdot \text{m}^{-2}$; 发光效率、功率效率分别为 72.2 $\text{cd} \cdot \text{A}^{-1}$, 81 $\text{lm} \cdot \text{W}^{-1}$ @ 1 000 $\text{cd} \cdot \text{m}^{-2}$ (绿光发光材料为 $\text{Ir}(\text{ppy})_2(m\text{-mbppy})$)。

关键词: 三嗪; 蒽; 低分子量; 玻璃化转变温度; 电子迁移率

中图分类号: TP394.1; TN383+.1 **文献标识码:** A **doi:** 10.37188/CJLCD.2020-0237

1 Introduction

Organic electron-transport materials (ETMs) are an integral part of organic light-emitting diodes^[1], which critically influence the performance parameters such as the OLED efficiency, working voltage and lifetime. It is of considerable interest to develop high-mobility neat or doped ETMs with low molecular weight and increased thermal and morphological stability (e. g. $T_g > \text{ca. } 120 \text{ }^\circ\text{C}$). Such ETMs may be sublimable at a reduced temperature and likely survive the prolonged vacuum deposition processes and meet the display purposes.

In this context, we present an electron-transport molecular glass 2-(3-(10-(naphth-2-yl)anthracen-9-yl)-phenyl)-4,6-diphenyl-1,3,5-triazine (NaAN-*m*-TRZ, $m/z = 611.73$), which nicely shows a low molecular weight and yet a high T_g of 157 °C. Among others, 1,3,5-triazine (TRZ) is a desirable electron-deficient heterocyclic building block to construct electron-transport materials for

optoelectronics because of its high electron affinity and electrochemical stability^[2-3], and moreover effective doping with a lithium complex 8-hydroxyquinolatolithium (Liq)^[4-5]. On the other hand, anthracene (AN) is a fused aromatic ring of easy accessibility and modification at the 9,10-positions. Due to the intrinsically non-planar chemical structures, properly 9,10-disubstituted anthracenes are prone to form glasses^[6-11] and play an essential role in the current OLED technology as the host materials for the blue fluorescent dopants^[6-10]. For instance, the widely studied bipolar host 2-methyl-9,10-di(2-naphthyl)anthracene (MADN) exhibits a T_g of 120 °C and HOMO/LUMO level of -5.5/-2.5 eV^[8]. In a p-i-n bottom-emission OLED involving MADN and the blue dopant *p*-bis(*p*-*N,N*-diphenylaminostyryl)benzene, we demonstrated a noticeable lifetime t_{95} of ca. 160 h @ 1 000 $\text{cd} \cdot \text{m}^{-2}$ ^[12].

Based on the ultraviolet photoelectron spectroscopy measurement, NaAN-*m*-TRZ showed a

HOMO level of -5.76 eV. Introducing the 1,3,5-triazinyl moiety led to lowering the LUMO level to approximately -2.84 eV, relative to MADN and 9,10-di(2-naphthyl)anthracene ($E_{\text{HOMO}} = -5.8$ eV, $E_{\text{LUMO}} = -2.6$ eV)^[6-7]. The electron-only device (ITO/NaAN-*m*-TRZ:50% (mass fraction) Liq/Al) provided a high electron-mobility value of $6.23 \times 10^{-5} \sim 7.19 \times 10^{-4} \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ @ $E = (2 \sim 5) \times 10^5 \text{ V} \cdot \text{cm}^{-1}$. As a single Liq-doped electron-transport layer, NaAN-*m*-TRZ afforded efficient top-emission green phosphorescent OLED (PHOLED) with a luminous efficiency of $72.2 \text{ cd} \cdot \text{A}^{-1}$ and a power efficiency of $81 \text{ lm} \cdot \text{W}^{-1}$ and a low voltage of 2.8 V @ $1\,000 \text{ cd} \cdot \text{m}^{-2}$. In particular, the projected lifetime t_{97} reached $2\,567 \text{ h}$ @ $1\,000 \text{ cd} \cdot \text{m}^{-2}$, implying that NaAN-*m*-TRZ would be promising for OLED technology.

2 Experiments

2.1 Materials and instructions

All procedures involving air-sensitive reagents were conducted under dry nitrogen. 2,4-diphenyl-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-1,3,5-triazine and 10-bromo-9-(2-naphthyl)-anthracene were obtained according to the literature methods^[4,13-14]. All starting materials were purchased commercially and used directly without further purification unless otherwise stated.

^1H NMR and ^{13}C NMR measurements were performed on Bruker 400 MHz and 126 MHz DRX spectrometers respectively with tetramethylsilane (TMS) as the internal reference, deuterated chloroform (CDCl_3) as the solvent. The mass spectrum was measured by Waters ACQUITY TQD liquid chromatography-mass spectrometry using an APCI ion source. The elemental analysis was conducted on vario EL cube. Thermogravimetric analysis (TGA) was measured by Netzsch TG 209 at a heating rate of $20 \text{ }^\circ\text{C} \cdot \text{min}^{-1}$ under a nitrogen flow. Differential scanning calorimetry (DSC) testing was carried on a Netzsch DSC 204

thermal analyzer under a nitrogen flow with a heating and cooling rate of $10 \text{ }^\circ\text{C} \cdot \text{min}^{-1}$ and $20 \text{ }^\circ\text{C} \cdot \text{min}^{-1}$, respectively. UV-Vis absorption spectra were measured on a Shimadzu UV-2600 ultraviolet-Visible spectrophotometer. Photoluminescence spectra were measured on a HORIBA Fluorolog-3 fluorescence spectrophotometer. Ultraviolet photoelectron spectroscopy (UPS) characterization was performed on a thermal ESCALAB 250 X-ray photoelectron spectrometer.

2.2 Synthesis of 2-(3-(10-(2-naphthyl)anthracen-9-yl)phenyl)-4,6-diphenyl-1,3,5-triazine (NaAN-*m*-TRZ)^[15]

Under nitrogen atmosphere, the catalyst Pd(PPh_3)₄ (100 mg, 0.086 mmol) was quickly added to a mixture of 10-bromo-9-(2-naphthyl)anthracene (2.5 g, 6.52 mmol), 2,4-diphenyl-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine (2.84 g, 6.52 mmol), Na_2CO_3 aqueous solution (2 mol/L, 7 mL, 14 mmol), ethanol (7 mL) and toluene (60 mL). The reaction was heated and stirred at $90 \sim 100 \text{ }^\circ\text{C}$ for 14 h. After being cooled to room temperature, the crude product was concentrated and distilled water was added. The organic layer was extracted with CH_2Cl_2 , separated, dried over anhydrous MgSO_4 , filtered and concentrated under reduced pressure. The crude product was subject to column chromatography over silica gel using petroleum ether/dichloromethane (5 : 1 volumn ration) as elute to afford a light yellow solid. Yield: 3.6 g (90%). R_f (10-bromo-9-(2-naphthyl)anthracene) = 0.9; R_f (NaAN-*m*-TRZ) = 0.5. ^1H NMR (400 MHz, CDCl_3) δ : 9.02~8.99 (m, 1H), 8.93~8.91 (m, 1H), 8.77~8.75 (m, 4H), 8.10 (dd, $J = 8.4, 3.6 \text{ Hz}$, 1H), 8.05~8.02 (m, 2H), 7.96~7.93 (m, 1H), 7.86~7.82 (m, 1H), 7.80~7.74 (m, 5H), 7.69~7.64 (m, 1H), 7.63~7.52 (m, 8H), 7.39~7.32 (m, 4H). ^{13}C NMR (126 MHz, CDCl_3) δ : 171.76, 171.65, 139.67,

137.27, 136.72, 136.65, 136.53, 136.13, 135.49, 133.44, 132.80, 132.55, 131.65, 130.29, 130.09, 130.02, 129.55, 129.02, 128.93, 128.62, 128.30, 128.13, 128.03, 127.93, 127.11, 126.98, 126.48, 126.27, 125.34, 125.24. MS (APCI): m/z 612.34 (100%) $[M+H]^+$ Calcd.: 612.24. Anal. calcd.: C 88.35, H 4.78, N, 6.87; Found: C 88.04, H 4.68, N 6.66 for $C_{45}H_{29}N_3$. HPLC purity: 99.98%.

2.3 Device fabrication and characterizations

To evaluate the potential of NaAN-*m*-TRZ as a doped electron transport layer, top-emission green phosphorescent OLED (PHOLED) was prepared. Patterned indium-tin oxide (ITO, 15 Ω /square)-coated glass substrates were washed with deionized water, detergent, acetone, deionized water, and 2-isopropanol successively in an ultrasonic bath. After drying in a stream of nitrogen, ITO substrates were placed in a vacuum (4×10^{-5} Pa) organic-metal composite evaporation coating instrument to evaporate the organic layer and metal electrode through a mask. For the vapor deposition of doped layers, the vapor deposition speed of each component is controlled by their independent quartz crystal oscillators. In the deposition of n-doped electron transport layers (ETM : Liq), deposition rate of both ETM and Liq is 0.05 nm/s. After preparation, the devices were encapsulated immediately using epoxy resin and glass sheets under a nitrogen atmosphere. The effective emission area of the device is 9 mm², which is determined by the overlapping area of the anode and cathode. The EL spectra and CIE coordinates of the encapsulated devices are measured by the Konica Minolta CS2000 spectroscopy system. The current density (J)-voltage (V)-luminance (L) curves of the device were measured by a computer-controlled source meter (Keithley 2400) and a multimeter (Keithley 2000) with calibrated silicon photodiode. The luminance decay characteristic curves of devices were measured under a

constant current driving. Before testing, the device was aged at a current density of 20 mA $\cdot$ cm⁻² for 24 h. All measurements were performed at room temperature in an atmospheric environment. The hole-injection material OMET-P008 was available from Eternal Material Technology, EMT; the exciton blocking material EBL and host materials of the emitting layer HOST1 and HOST2 were available from e-Ray Optoelectronics Technology Co., Ltd., while the green phosphorescent dopant Ir (ppy)₂ (*m*-mbppy) from Lumtec. The light extraction layer CP501 was available from Toray Industries, Inc.

The electron mobility of 50% (mass fraction) Liq-doped NaAN-*m*-TRZ film was measured with electron-only device (ITO/ETM : Liq (150 nm, 1 : 1 mass ratio)/Al) *via* the space-charge-limited current (SCLC) method.

3 Results and discussion

3.1 Synthesis

NaAN-*m*-TRZ was facilely prepared in ca. 90% yield by the Suzuki coupling of 2,4-diphenyl-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine^[4] with 9-bromo-10-(naphthalen-2-yl)-anthracene (Fig.1). Due to the considerable difference of molecular polarity, the residual bromo intermediate could be easily removed from the target compound by the mixed eluent of petroleum ether/CH₂Cl₂ (5 : 1 volum ratio) *via* column chromatography. Moreover, the target compound can be recrystallized from CH₂Cl₂, in which the bromo intermediate is highly soluble, thus ensuring further separation^[4-5,16]. The analytically pure NaAN-*m*-TRZ obtained was used directly

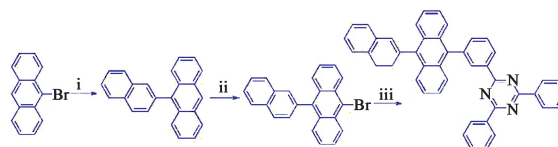


Fig.1 Synthetic route to NaAN-*m*-TRZ

for device characterizations without sublimation.

Fig.1 shows the synthetic route to NaAN-*m*-TRZ: (i) 2-naphthaleneboronic acid, Pd(PPh₃)₄, K₂CO₃ aqueous solution, ethanol, toluene, 90 °C; (ii) *N*-bromosuccinimide, DMF, reflux; (iii) 2,4-diphenyl-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine, Pd(PPh₃)₄, 2 mol/L Na₂CO₃ aqueous solution, ethanol, toluene, 90 °C.

3.2 Thermal properties

NaAN-*m*-TRZ exhibited a decomposition temperature (T_d) of 353 °C, defined at an initial weight loss of 1% (Fig.2(a)). Differential scanning calorimetry (DSC) measurement revealed a glass transition temperature (T_g) of 157 °C (Fig.2(b)). With regard to the ternary triphenylphosphine oxide-2,6-pyridinylene-triazine molecular conjugate BPTRZ-Py-TPO ($m/z = 814.91$, $T_g = 123$ °C) we reported previously^[5], it is noteworthy that NaAN-*m*-TRZ showed a remarkably increased T_g despite its lower molecular weight.

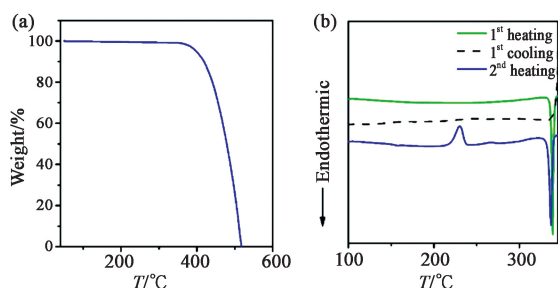


Fig.2 Thermogravimetric analysis (a) and DSC diagrams (b) of NaAN-*m*-TRZ

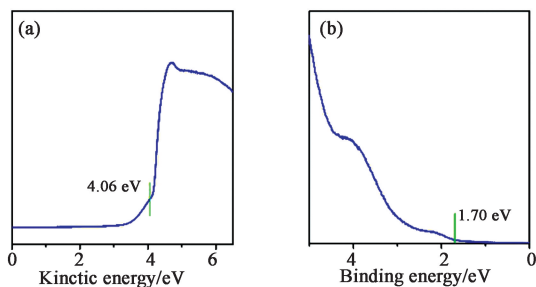


Fig.3 UPS spectra (a) at the low kinetic energy region and (b) at the valence band near the Fermi level for 10 nm NaAN-*m*-TRZ on ITO

3.3 HOMO/LUMO levels

The ultraviolet photoelectron spectroscopy measurement was performed to detect the HOMO level of NaAN-*m*-TRZ (Fig.3), yielding a value of -5.76 eV ($E_{\text{HOMO}} = -(\phi_{\text{ITO}} + \text{HOMO}_{\text{edge}})$). The LUMO level was then roughly calculated to be ca. -2.84 eV, according to $E_{\text{LUMO}} \approx E_{\text{HOMO}} + E_{\text{opt}}$. E_{opt} represents the optical bandgap of ca. 2.92 eV (Fig.4). Consequently, the presence of the 1,3,5-triazinyl moiety results in the reduction of the LUMO level and thus facilitates electron injection, relative to 9,10-di(2-naphthyl)-anthracene and 2-methyl-9,10-di(2-naphthyl)-anthracene (MADN)^[6-9].

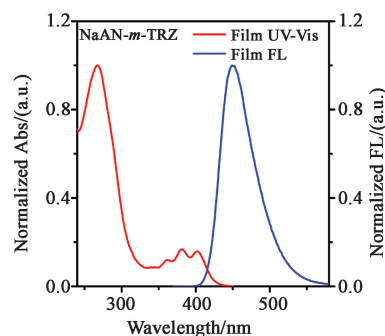


Fig.4 Normalized UV-vis absorbance (Abs) and fluorescence (FL) spectra of NaAN-*m*-TRZ as film on quartz, spin-cast from CHCl₃ solution (concentration: $10 \text{ mg} \cdot \text{mL}^{-1}$, spin speed: $2\,000 \text{ r/min}$). Excitation: 300 nm .

3.4 Electron-mobility measurement

The electron transport property of the Liq-doped NaAN-*m*-TRZ thin film was probed in the electron-only device (ITO/ETM : Liq (1 : 1 mass ratio, 150 nm)/Al, Fig.5(a)). The $\ln(J/E^2)$ versus $E^{1/2}$ followed a space-charge-limited current (SCLC) characteristic with field-dependent mobility (Fig. 5(b)). We can deduce the electron mobility value of $6.23 \times 10^{-5} \sim 7.19 \times 10^{-4} \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ at $E = (2 \sim 5) \times 10^5 \text{ V} \cdot \text{cm}^{-1}$ by fitting the $\ln(J/E^2)-E^{1/2}$ curve, which is substantially improved against the triazine derivatives TRZ-*m*-Phen and BPTRZ-Py-TPO^[4-5]. The zero-field electron mobility μ_0 and field-activation factor β of the NaAN-*m*-TRZ : Liq device

were $9.26 \times 10^{-7} \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ and $9.41 \times 10^{-3} (\text{cm} \cdot \text{V}^{-1})^{0.5}$, respectively.

3.5 OLED characterization

We characterized NaAN-*m*-TRZ as a single doped electron-transport layer in the top-emission green phosphorescent OLED: Ag/ITO/OMET-P008:p-dopant (4%)/HTL/EBL/HOST1 : HOST2 : Ir(ppy)₂(*m*-mbppy) (1 : 1 : 0.3)/ETM : Liq (1 : 1)/Mg : Ag(1 : 9)/CP501. Ir(ppy)₂(*m*-mbppy) = bis (2-phenylpyridine) (2-(4-methyl-3-phenylphenyl) pyridine) iridium (III) as the emitter. Commercially available OMET-P008, HTL, EBL, HOST1/ HOST2 and CP501 denoted respectively the hole-injection material, hole-transport layer, exciton-blocking layer, host materials and light-extraction layer^[5]. The current density (*J*)-voltage (*V*)-luminance (*L*), luminous efficiency (LE)-*L*, power efficiency (PE)-*L* characteristics and electroluminescence (EL) spectrum were shown in Fig.6. At a luminance of ca. 1 000 $\text{cd} \cdot \text{m}^{-2}$, $\text{LE} = 72.2 \text{ cd} \cdot \text{A}^{-1}$, EQE (external quantum efficiency) = 17.9%, $\text{PE} = 81.0 \text{ lm} \cdot \text{W}^{-1}$, $J = 1.31 \text{ mA} \cdot \text{cm}^{-2}$, and $V = 2.8 \text{ V}$. The EL spectrum originated from the iridium complex with an emission maximum at 528 nm and CIE coordinates (0.23, 0.71), close to the NTSC standard (0.21, 0.71).

The anthracene derivatives inherently possess low triplet energy^[10,17-19]. We recorded the photoluminescence spectrum of the NaAN-*m*-TRZ thin film after a delay of 0.1 ms upon excitation at 77 K and observed a maximal emission peak of 467~470 nm (Fig.7), which obviously stemmed from the triplet-

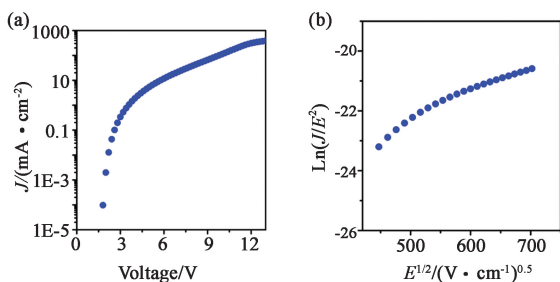


Fig.5 (a) *J*-*V* and (b) $\ln(J/E^2)$ - $E^{1/2}$ characteristics of the electron-only device: ITO/NaAN-*m*-TRZ : Liq(1 : 1 mass ratio, 150 nm)/Al.

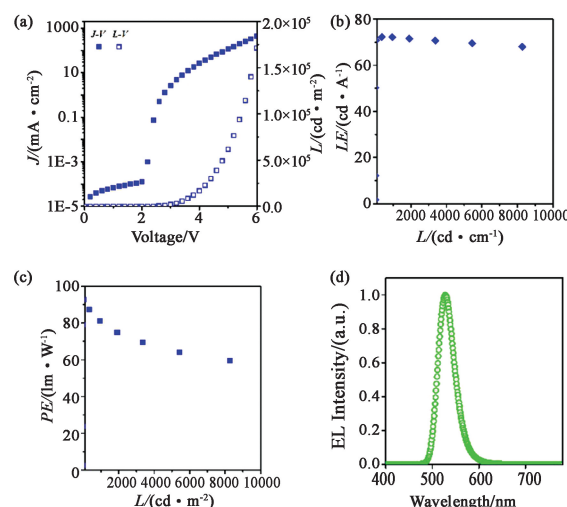


Fig.6 (a) *J*-*V*-*L*, (b) *LE*-*L*, (c) *PE*-*L* curves, and (d) EL spectrum of the top-emission green PHOLED (Ag/ITO/OMET-P008: p-dopant (100 nm, 4%)/HTL (15 nm)/EBL (5 nm)/HOST1 : HOST2 : Ir(ppy)₂(*m*-mbppy) (30 nm, 1 : 1 : 0.3)/NaAN-*m*-TRZ : Liq (30 nm, 1 : 1 mass ratio)/Al/ CP501).

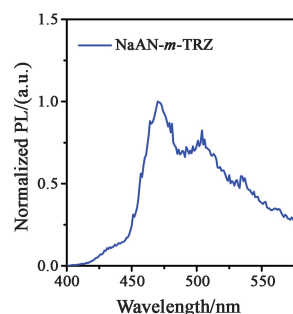


Fig.7 Normalized photoluminescence (PL) spectrum of NaAN-*m*-TRZ, recorded after a delay of 0.1 ms at 77 K in solid state. Excitation: 310 nm.

triplet annihilation^[10,17-19]. Therefore, the E_{triplet} was estimated between 1.32~1.8 eV. We note that under analogue conditions, the BPTRZ-Py-TPO : Liq OLED showed a higher luminous efficiency of $77.4 \text{ cd} \cdot \text{A}^{-1}$ (corresponding to an EQE of 18.7%) @ ca. 1 000 $\text{cd} \cdot \text{m}^{-2}$, which features an increased triplet energy of 2.88 eV and yet reduced electron mobility^[5]. This points to the presumption that to some extent, triplet energy transfer from Ir(ppy)₂(*m*-mbppy) to the doped electron layer NaAN-*m*-TRZ : Liq may

occur^[20]. Therefore, an exciton blocking layer should be placed between the phosphorescent emitter layer and the doped electron-transport layer NaAN-*m*-TRZ : Liq and the results shall be reported in due course.

Finally, we stressed the top-emission green PHOLED under a constant current at an initial luminescence of ca. 3 000 cd · m⁻² (Fig.8). Generally, hole transport is predominant in an OLED. Thanks to the enhanced electron mobility and hence suppressed triplet-polaron annihilation in the phosphorescent emitting layer^[4,5,21], the lifetime t_{97} was extended to about 400 h.

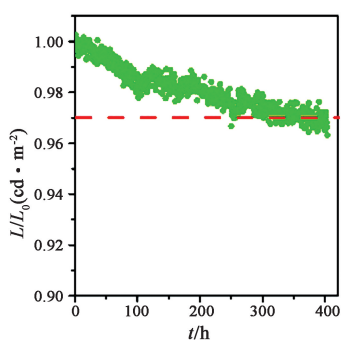


Fig.8 Luminescence decay characteristic of the encapsulated top-emission green PHOLED (Ag/ITO/OMET-P008:p-dopant(147 nm, 4%)/HTL (15 nm)/EBL (5 nm)/HOST1 : HOST2 : Ir(ppy)₃ (*m*-mbppy) (30 nm, 1 : 1 : 0.3)/NaAN-*m*-TRZ : Liq(30 nm, 1 : 1 mass ratio)/Mg : Ag(15 nm, 1 : 9)/CP501 (70 nm)). The initial luminance was set as ca. 3 000 cd · m⁻². Prior to testing, The OLED aged at a current density of 20 mA · cm⁻² for 24 h.

$$t_{97}(1\,000\text{ cd/m}^2)=t_{97}(3\,000\text{ cd/m}^2)\times\left(\frac{3\,000}{1\,000}\right)^n. \quad (1)$$

According to Eq (1), the extrapolated t_{97} @ 1 000 cd · m⁻² was remarkable as ca. 2 567 h, assuming $n=1.7$ ^[22].

4 Conclusion

In summary, we have described facilely available 1,3,5-triazine-based electron-transport molecular anthracene NaAN-*m*-TRZ ($m/z = 611.73$). The residual bromo intermediate 9-bromo-10-(naphthalen-2-yl)-anthracene, a fatal risk factor for the OLED stability, could be easily removed by column chromatography and/or recrystallization, due to its low molecular polarity and high solubility in weakly polar solvents such as CH₂Cl₂. NaAN-*m*-TRZ exhibits a T_g/T_d of 157/353 °C at 1% weight loss and HOMO/LUMO level of -5.76/-2.84 eV. The Liq-doped NaAN-*m*-TRZ possesses outstanding electron mobility of $6.23 \times 10^{-5} \sim 7.19 \times 10^{-4}$ cm² · V⁻¹ · s⁻¹ @ $E = (2-5) \times 10^5$ V · cm⁻¹. The top-emission green phosphorescent OLED comprising the single NaAN-*m*-TRZ : Liq electron-transport layer provides an EQE of 17.9% (72.2 cd · A⁻¹) and 81 lm · W⁻¹ @ ca. 1 000 cd · m⁻² and CIE (0.23, 0.71). The projected operational stability t_{97} amounted to ca. 2 567 h @ 1 000 cd · m⁻². Our finding shall stimulate further interest in this sort of materials for optoelectronics.

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