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Effect of interconnection position of bicarbazole-triazine type bipolar host materials on the photophysical and device performances

^{3 Q1} Sung Moo Kim, Ju Hui Yun, Sung Yong Byeon, Sang Kyu Jeon, Jun Yeob Lee^{*}

4 **Q2** School of Chemical Engineering, Sungkyunkwan University, 2066, Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do, 440-746, Republic of Korea

A R T I C L E I N F O

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A B S T R A C T

Organic compounds prepared from 1- position activated 9-phenylcarbazole interconnected with diphenyltriazine functionalized carbazole were examined as bipolar host materials of phosphorescent and thermally activated delayed fluorescent organic light-emitting diodes. Interconnection position of the 9-phenylcarbazole was 1- position, and that of diphenyltriazine functionalized carbazole was changed from 1- position to 4- position. Main influence of the interconnection position was current density of the device and 2- or 3- position interconnection increased current density of the devices. All host materials derived from the 1- position activated 9-phenylcarbazole performed well as the host of phosphorescent and thermally activated delayed fluorescent organic light-emitting diodes.

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⁵ Introduction

 $\frac{6}{7}$ Host materials of organic light-emitting diodes (OLEDs) play a ⁷ key role of assisting light emission of emitters by transporting $\frac{8}{100}$ carriers to the emitters (charge transing) or transferring emission ⁸ carriers to the emitters (charge trapping) or transferring emission
9 ⁹ energy to emitters (energy transfer) $\left[1-4\right]$ $\left[1-4\right]$ $\left[1-4\right]$. Although no photon is
10 directly generated by the best materials the best material is as 10 directly generated by the host materials, the host material is as 11 important as the emitters because carrier balance and exciton 11 important as the emitters because carrier balance and exciton 12 formation are governed by the bost material Many works 12 formation are governed by the host material. Many works reporting host materials touched those functions of host in the ¹³ reporting host materials touched those functions of host in the $\frac{14}{2}$ $\frac{14}{15}$ emitting layer [5–[8\].](#page--1-0)

 15 In many publications, bipolar host materials were of main 16 interest to receprehens based on the knowledge that binelar 16 interest to researchers based on the knowledge that bipolar 17 showton is researched for equal that $\frac{1}{2}$ showton is researched for equal that $\frac{1}{2}$ showton is researched. ¹⁷ character is essential for carrier balance, efficient exciton genera-
 $\frac{18}{100}$ tion and carrier injection [0, 14] Many binelar hect materials were 18 tion, and carrier injection $[9-14]$ $[9-14]$. Many bipolar host materials were
19 mildleted in the literature as examplified in several rayiou papers ¹⁹ published in the literature as exemplified in several review papers
²⁰ and many of them were compatible with emitters [15,16]. Conserver 20 and many of them were compatible with emitters $[15,16]$. General 21 21 chemical structure of the reported bipolar host materials was a
22 degree assetter host hose structure, and the regineering of the 22 donor–acceptor backbone structure, and the engineering of the $\frac{23}{22}$ 23 donor and acceptor moieties offered various compounds which 24 24 have the energy level, carrier mobility, and emission energy 25 continued for the best materials [17]. One of the donor acceptor ²⁵ required for the host materials [\[17\]](#page--1-0). One of the donor–acceptor $\frac{26}{100}$ type building blocks is carbazele triazing type backbone structure ²⁶ type building blocks is carbazole–triazine type backbone structure
 $\frac{27}{27}$ which takes advantage of bole transport character of carbazole and which takes advantage of hole transport character of carbazole and

E-mail address: [leej17@skku.edu](undefined) (J.Y. Lee).

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electron transport character of triazine. Fundamentally, the 28
carbazola triazing building block is ideal as the core structure carbazole–triazine building block is ideal as the core structure 29
of the binolar bost materials because of good carrier injection 30 of the bipolar host materials because of good carrier injection, 30
carrier transport and chemical stability [18, 21]. Several modifica, 31 carrier transport and chemical stability $[18-21]$. Several modifica-
tion methods of the carbazole-triazine core were suggested and 32 tion methods of the carbazole–triazine core were suggested and 32
one example is to add an extra carbazole unit for intense hole 33 one example is to add an extra carbazole unit for intense hole 33
carrying property and thermal stability. A few compounds were 34 carrying property and thermal stability. A few compounds were 34
reported as the derivatives of the carbazole modified carbazole 35 reported as the derivatives of the carbazole modified carbazole– 35
triazing care and they showed satisfactory material and device 36 triazine core and they showed satisfactory material and device 36
results as the bosts of green phosphorescent OLEDs (PhOLEDs) 37 results as the hosts of green phosphorescent OLEDs (PhOLEDs) 37
[22, 24] It was reported that the properties of material and device 38 $[22-24]$ $[22-24]$. It was reported that the properties of material and device 38
norformances, were changed, by engineering, the substitution performances were changed by engineering the substitution 39
notition of diphopultriaring to expandle unit by different 40 position of diphenyltriazine to carbazole unit by different 40
connection structure and bighest esquaid molecular orbital 41 geometrical structure and highest occupied molecular orbital 41
(HOMO)/lowest unoccupied molecular orbital (HIMO) distributed 42 $(HOMO)/$ lowest unoccupied molecular orbital $(LUMO)$ distribu-
tion However chamical structure of the bosts was not diversified 43 tion. However, chemical structure of the hosts was not diversified $\frac{43}{12}$
and systematic evolution of the effect of chemical structure on $\frac{44}{12}$ and systematic exploration of the effect of chemical structure on $\frac{44}{15}$
the material and dovice parameters has not been reported the material and device parameters has not been reported. 45
Usering the sum authorities investigation of four and

Herein, we explain our systematic investigation of four $\frac{46}{12}$ carbazole modified carbazole–triazine type hosts prepared from $\frac{47}{1}$
1. nesition estimated 0 phonolecales intersecues to with $\frac{48}{1}$ 1- position activated 9-phenylcarbazole interconnected with $\frac{48}{120}$ diphopyltriazing functionalized carbazole. The change of the $\frac{49}{120}$ diphenyltriazine functionalized carbazole. The change of the 49
interconnect position between 1 position estimated 0 phopul 50 interconnect position between 1-position activated 9-phenyl-
carborals and carborals triaring core mostly affected carrier 51 carbazole and carbazole–triazine core mostly affected carrier 51
transport proportion of the bost materials. The interconnection of 52 transport properties of the host materials. The interconnection of 52
the carbagele unit via 2, or 2, position was advantageous for good 53 the carbazole unit via 2- or 3- position was advantageous for good 53
carrier, transport, properties, and, bigh, carrier, density, in, the 54 carrier transport properties and high carrier density in the 54
emitting layer. The synthesized host materials performed as the 55 Foresponding author. Fax: +82 31 299 4716.

Email address logi 7@klus edu (IV I co) and the emitting layer. The synthesized host materials performed as the

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2 S.M. Kim et al. / Journal of Industrial and Engineering Chemistry xxx (2016) xxx–xxx

 56 host materials in the green phosphorescent and thermally
 57 activated delayed fluorescent (TADE) devices activated delayed fluorescent (TADF) devices.

⁵⁸ Experimental

⁵⁹ General information

60 Sodium tert-butoxide (NaO(t-bu)), tri-tert-butylphosphine (P
 $\frac{61}{2}$ (t bu)), tris(dibonzulidonos sotono)dipalladium(0) (Pd (dba)) ⁶¹ (t-bu)₃), tris(dibenzylideneacetone)dipalladium(0) (Pd₂(dba)₃),
⁶² tetrakis(triphopylphopphipa)palladium(0) (Pd(PPb)) (P&H Toch ⁶² tetrakis(triphenylphosphine)palladium(0) (Pd(PPh₃)₄) (P&H Tech
⁶³ Co.) 1-bromo-9-phenyl-9H-carbazole 2-(4.4.5.5-tetramethyl- 63 Co.), 1-bromo-9-phenyl-9H-carbazole, 2-(4,4,5,5-tetramethyl-
 64 13.2-dioxaborolan-2-vl)-9H-carbazole 3-(4.4.5.5-tetramethyl-⁶⁴ 1,3,2-dioxaborolan-2-yl)-9H-carbazole, 3-(4,4,5,5-tetramethyl-
⁶⁵ 12.2 dioxaborolan 2.yl) 0H carbazole 4 (4,4,5,5 tetramethyl-⁶⁵ 1,3,2-dioxaborolan-2-yl)-9H-carbazole, $4-(4,4,5,5-\text{tetramethyl-}\)$ 66 1,3,2-dioxaborolan-2-yl)-9H-carbazole, and 2-chloro-4,6-
 67 diphapyl 1.3.5 triazing (IH Trade) were used as received Sodium ⁶⁷ diphenyl-1,3,5-triazine (JH Trade.) were used as received. Sodium
⁶⁸ bydroxide (N2OH), toluene, and tetrahydrofuran (THF) (Duksan 68 hydroxide (NaOH), toluene, and tetrahydrofuran (THF) (Duksan 69 Sci. Co.) were also used as received.

 70 Basic analysis of the materials was similar to the analytical
 71 precedure in other works $[25, 27]$. Nuclear magnetic recononces 71 procedure in other works $[25-27]$ $[25-27]$. Nuclear magnetic resonance
72 (NMP) spectrawers obtained by Varian (UINMP) 400 MHz) Avance 72 (NMR) spectra were obtained by Varian (1 HNMR: 400 MHz), Avance- 73 500 (¹³C NMR: 125 MHz). Ultraviolet–visible (UV–vis) absorption 74 spectra were obtained by a Shimadzu UV-2501PC and fluorescence
75 spectra were obtained by Hitabi E 7000, Jow temperature PL ⁷⁵ spectra were obtained by Hitachi F-7000. Low temperature PL
 76 76 measurement of the synthesized materials was carried out at 77 K 77 using a dilute solution of materials in tetrahydrofuran. The mass
 78 spectra were obtained by a Waters Yove TO S spectrometer in API 78 spectra were obtained by a Waters Xevo TQ-S spectrometer in API
 79 mode. The HOMO energy layels were moasured with a cyclic 79 mode. The HOMO energy levels were measured with a cyclic 80 veltammetry (CV) CV measurement of erganic materials was carried 80 voltammetry (CV). CV measurement of organic materials was carried
81 voltin acetonity localition with total util ammonium perchlorate at ⁸¹ out in acetonitrile solution with tetrabutylammonium perchlorate at $\frac{82}{100}$ at M concontration. Pt was counteralestrade and Agwas used as the 82 0.1 M concentration. Pt was counter electrode and Ag was used as the standard material for ⁸³ reference electrode. Ferrocene was used as the standard material for $\frac{84}{100}$ the CV measurement the CV measurement.

⁸⁵ Synthesis

 86 9-Phenyl-9H,9'H-1,2'-bicarbazole (1) 1-Bromo-9-phenyl-9H-87 carbazole (1.56 g, 4.84 mmol), 2-(4,4,5,5-tetramethyl-1,3,2-dioxa-
88 borolan 2 yl) 0H carbazole (1.7 g, 5.80 mmol), NaOH (0.58 g 88 borolan-2-yl)-9H-carbazole (1.7 g, 5.80 mmol), NaOH (0.58 g, $\frac{89}{14.5}$ mmol) and $\frac{pd(pph)}{28\pi}$ (0.28 g, 0.24 mmol) were dissolved in ⁸⁹ 14.5 mmol) and Pd(PPh₃)₄ (0.28 g, 0.24 mmol) were dissolved in
⁹⁰ a mixed solvent of THE (40 ml) and water (20 ml) under a nitrogen 90 a mixed solvent of THF (40 ml) and water (20 ml) under a nitrogen
91 bubbling. The reaction mixture was continuously stirred for 3 h ⁹¹ bubbling. The reaction mixture was continuously stirred for 3 h
⁹² under reflux condition and then was cooled down to room 92 under reflux condition and then was cooled down to room
 93 tomperature At room tomperature it was diluted with other 93 temperature. At room temperature, it was diluted with ethyl
 94 $\frac{94}{100}$ acetate and washed with water using a separator funnel. The ethyl ⁹⁵ acetate layer was separated and was dried using anhydrous MgSO₄.

⁹⁶ Evaporation of ethyl acetate after filtering off MgSO₄ produced a

⁹⁷ crude product which was purified by column chromatography on

⁹⁸ ci ⁹⁸ silica gel using an ethyl acetate/n-hexane eluent. Purified product $\frac{99}{12}$ was obtained as a white powder (1.8 x Viold 0.1%) was obtained as a white powder (1.8 g, Yield 91%). 100

¹H NMR (400 MHz, DMSO): δ 10.95 (s, 1H), 8.28 (d, 2H, 101 J = 7.2 Hz), 7.97 (d, 1H, J = 8.0 Hz), 7.67 (d, 1H, J = 8.0 Hz), 7.39 (m, 4H),
102 7 20 (m, 2H), 7.17 (d, 1H, J = 8.0 Hz), 7.14 (c, 1H), 7.08 (m, 2H), 6.05 (t, $\frac{102}{7.30}$ 7.30 (m, 2H), 7.17 (d, 1H, J = 8.0 Hz), 7.14 (s, 1H), 7.08 (m, 3H), 6.95 (t, $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7.17}$ $\frac{103}{7$ 2H, J = 7.6 Hz), 6.85 (d, 1H, J = 7.6 Hz), 6.78 (t, 1H, J = 6.8 Hz).

104
105 -(4,6-Diphenyl-1,3,5-triazin-2-yl)-9-phenyl-9H,9′H-1,2′- 105 bicarbazole (PCz2TCz) 9-Phenyl-9H,9'H-1,2'-bicarbazole (1.8 g, 106 4.42 mmol), 2-chloro-4,6-diphenyl-1,3,5-triazine (1.8 g)
 107 6.63 mmol), NaO(t-bu), (1.3 g, 1.3.2 mmol), P(t-bu), (50%) (0.18 g 107 6.63 mmol), NaO(t-bu) (1.3 g, 13.2 mmol), P(t-bu)₃ (50%) (0.18 g, 10.8 g, 1.8 mmol) and Pd₂(dba)₂ (0.20 g, 0.22 mmol) were dissolved in ¹⁰⁸ 0.44 mmol) and Pd₂(dba)₃ (0.20 g, 0.22 mmol) were dissolved in $\frac{109}{\text{t}}$ toluane (40 ml) under a nitrogen flow After refluxing the reaction ¹⁰⁹ toluene (40 ml) under a nitrogen flow. After refluxing the reaction
¹¹⁰ mixture for 2 h it was diluted with dishloromathane at room 110 mixture for 2 h, it was diluted with dichloromethane at room 111 temperature followed by washing with water. The dichlorom ¹¹¹ temperature followed by washing with water. The dichloro-
¹¹² methane layer was senarated dried using aphydrous MgSQ, and 112 methane layer was separated, dried using anhydrous MgSO₄, and 113 exaporated in vacuo. A crude product was obtained purified by 113 evaporated in vacuo. A crude product was obtained, purified by 114 column chromatography on silica gel using an ethyl acetately 114 column chromatography on silica gel using an ethyl acetate/n-
 115 havane eluent and sublimed under vacuum. A white powder was ¹¹⁵ hexane eluent, and sublimed under vacuum. A white powder was
¹¹⁶ enhanced as a final product (14g Yield 52%) obtained as a final product $(1.4 g, Yield 52%).$

¹H NMR (400 MHz, DMSO): δ 9.08 (d, 1H, J = 8.0 Hz), 9.03 (s, 1H), ¹¹⁷ 8.55 (d, 4H, J = 8.0 Hz), 8.38 (d, 2H, J = 7.6 Hz), 8.16 (d, 1H, J = 7.6 Hz), 118 7.93 (d, 1H, J = 8.0 Hz), 7.64 (t, 1H, J = 7.6 Hz), 7.60 (m, 3H), 7.50 (t, 1H, ¹⁹ $J = 7.6$ Hz), 7.44 (t, 1H, J = 7.6 Hz), 7.34 (m, 7H), 7.15 (m, 1H), 6.98 (d, 120

2H, $J = 7.2$ Hz), 6.84 (m, 2H), 6.72 (m, 1H), ^{13}C , NMP (125 MHz, 121 2H, J = 7.2 Hz), 6.84 (m, 2H), 6.73 (m, 1H). ¹³C NMR (125 MHz, ¹²¹
CDCL): $\frac{8}{3}$ 172 45 165 18 142 62 120 50 128 70 128 60 128 42 $[CDC]_3$: δ 172.45, 165.18, 142.62, 139.50, 138.79, 138.60, 138.43, 122
128.22, 126.27, 122.82, 120.21, 128.00, 128.20, 127.66, 127.55, 126.02, 123 ¹²³ 138.33, 136.27,132.83,129.21,128.90,128.30, 127.66,127.55,126.92, ¹²⁴ 126.86, 126.45, 126.30, 125.52, 124.93, 124.43, 123.60, 123.45, 120.46, 120.31, 120.25, 119.81, 119.75, 119.61, 118.61, 118.24, 110.61. 125
MS (API+) m/z; 640.9 $[(M+H)^+]$ $MS (API+) m/z: 640.9 [(M+H)⁺]$ 126

9-Phenyl-9H,9'H-1,3'-bicarbazole (2) Synthetic method of 127 2 was the same as that of 1 except the 1-bromo-9-phenyl-9H-
carborals $(2.7 \times 8.28 \text{ mm})$ and $(2.4455 \text{ t}$ extramathul 12.2 carbazole (2.7 g, 8.38 mmol) and 3-(4,4,5,5-tetramethyl-1,3,2-
diovaboralary 3 vl) 0H carbazole (2.0 g 10.1 mmol) starting mate dioxaborolan-2-yl)-9H-carbazole (3.0 g, 10.1 mmol) starting mate-
rials A beige powder was obtained as a product (2.0 g, Vield 50%) 131 rials. A beige powder was obtained as a product $(2.0 g, Yield 59%)$.
¹H NMP (400 MHz, DMSO): 8.1113 (c, 1H) 8.43 (d, 1H, I – 8.4 Hz).

¹H NMR (400 MHz, DMSO): δ 11.13 (s, 1H), 8.43 (d, 1H, J = 8.4 Hz), ¹³² 8.32 (d, 1H, J = 7.2 Hz), 8.11 (t, 1H, J = 8.0 Hz), 7.77 (d, 1H, J = 8.4 Hz), 133 7.76 (d, 1H, J = 8.4 Hz), 7.63 (m, 4H), 7.45 (m, 6H), 7.33 (m, 2H), 7.23 ¹³⁴
(t, 1H, J = 7.6 Hz), 7.14 (t, 1H, J = 8.0 Hz), MS (ABL) m/m, 400.0 J(M (t, 1H, J = 7.6 Hz), 7.14 (t, 1H, J = 8.0 Hz). MS (API+) m/z: 409.9 [(M 135 $+H$)⁺] 136 $+H$ ⁺

9'-(4,6-Diphenyl-1,3,5-triazin-2-yl)-9-phenyl-9H,9'H-1,3'- $^{\rm 137}$ **bicarbazole (PCz3TCz)** Synthetic procedure of PCz3TCz was the ¹³⁸ same as that of PCz2TCz except for the 9-phenyl-9H,9'H-1,3'- 139 bicarbazole (2.0 g, 4.91 mmol) reactant. Purification by column 140
shows test why column a disk because the shown and 141 chromatography on silica gel using a dichloromethane/n-hexane 141
cluent produced a white pougler as a target material (1.0 g Vield 142 eluent produced a white powder as a target material (1.9 g, Yield 142
 61%) **61%**). 143

¹H NMR (400 MHz, CDCl₃): δ 9.15 (d, 1H, J = 8.0 Hz), 8.76 (m, 5H), ¹⁴⁴ 8.23 (t, 2H, J = 8.0 Hz), 7.86 (d, 1H, J = 8.0 Hz), 7.69 (s, 1H), 7.64 (m, 145

6U), 7.58 (m, 1H), 7.47 (d, 1H, J = 7.2 Hz), 7.41 (m, 2H), 7.32 (m, 2H) 6H), 7.58 (m, 1H), 7.47 (d, 1H, J = 7.2 Hz), 7.41 (m, 3H), 7.33 (m, 2H), 146
7.28 (m, 1H), 710 (d, 2H, I = 7.6 Hz), 6.91 (t, 2H, I = 8.0 Hz), 6.70 (t, 1H, 147 7.28 (m, 1H), 7.10 (d, 2H, J = 7.6 Hz), 6.91 (t, 2H, J = 8.0 Hz), 6.70 (t, 1H, ¹⁴⁷
L = 7.6 Hz), ¹³C, NMR (125 MHz, DMSO); $\frac{8}{17178}$, 164 48, 141 87 $J = 7.6$ Hz). ¹³C NMR (125 MHz, DMSO): δ 171.78, 164.48, 141.87, ¹⁴⁸
138.46 138.03 137.34 136.68 135.48 133.61 133.22 129.18 129.03 149 ¹⁴⁹ 138.46,138.03, 137.34, 136.68, 135.48, 133.61,133.22,129.18, 129.03, 128.77, 128.37, 127.96, 127.42, 127.18, 126.73, 126.36, 126.04, 125.91, 150
125.10, 124.28, 122.46, 122.62, 120.80, 120.41, 120.25, 120.22, 120.11, [15] 125.10, 124.38, 123.46, 122.63, 120.89, 120.41, 120.35, 120.23, 120.11, 151
110.57, 117.13, 116.18, 100.01, MS (ABL) m/z; 640.8 $^{1}(M+H)^+$ 152 119.57, 117.13, 116.18, 109.91. MS (API+) m/z: 640.8 $[(M+H)⁺]$ 152

9-phenyl-9H,9'H-1,4'-bicarbazole (3) 1-Bromo-9-phenyl-9H- 153 carbazole $(1.5 g, 4.66 mmol)$ and $4-(4.4,5,5-$ tetramethyl-1,3,2-
dioxaboralan $2 y l$) $9H$ carbazole $(1.54 g, 9.75 mmol)$ were used dioxaborolan-2-yl)-9H-carbazole (1.64 g, 9.75 mmol) were used 155
in the same synthetic procedure of 1. The product was obtained as a 156 in the same synthetic procedure of 1. The product was obtained as a 156
heige powder (1.45 g Vield 76%) beige powder (1.45 g, Yield 76%).
¹⁵⁷ beige powder (1.400 MHz, DMSO): \$ 11.00 (c, 111), 8.20 (d, 111 ¹⁵⁸

 1 H NMR (400 MHz, DMSO): δ 11.00 (s, 1H), 8.39 (d, 1H, 158 $J = 6.4$ Hz), 8.31 (d, 1H, $J = 6.4$ Hz), 7.42 (m, 3H), 7.34 (d, 1H, 159
 $J = 8.0$ JJz), 7.37 (m, 3H), 7.17 (t, 1H, $J = 8.0$ JJz), 7.13 (m, 3H), 6.82 (m, 160 $J = 8.0$ Hz), 7.27 (m, 2H), 7.17 (t, 1H, $J = 8.0$ Hz). 7.12 (m, 2H), 6.82 (m, 10^{10}
 $J = 6.2$ (t, 1H, $J = 8.0$ Hz), 6.46 (d, 1H, $J = 7.6$ Hz), 6.28 (m, 1H), 5.06 161 4H), 6.62 (t, 1H, J = 8.0 Hz), 6.46 (d, 1H, J = 7.6 Hz), 6.38 (m, 1H), 5.96 ¹⁶¹ $(m, 1H)$. 162
 N (4.6 Diphopyl 12.5 triazin 2 yl) 0 phopyl 0H 0/H 14/ 163

9'-(4,6-Diphenyl-1,3,5-triazin-2-yl)-9-phenyl-9H,9'H-1,4'- $^{\rm 163}$ **bicarbazole (PCz4TCz)** 9-Phenyl-9H,9^{*r*}H-1,4^{*r*}-bicarbazole (1.45 g, 164 3.56 mmol) was a reactant in the synthetic procedure of PCz2TCz. A 165
white pour expected as a terror product (1.2 α Viold 56%) 166 white powder was obtained as a target product $(1.3 g, Yield 56%)$.
¹H NMP (400 MHz, DMSO): $\frac{8}{3}$ 8 00 (4, 1H 1–72 Hz) 8 77 (4, 1H 167

¹H NMR (400 MHz, DMSO): δ 8.99 (d, 1H, J = 7.2 Hz), 8.77 (d, 1H, ¹⁶⁷ $J = 7.6$ Hz), 8.69 (d, 4H, J = 7.6 Hz), 8.46 (d, 1H, J = 7.2 Hz), 8.34 (d, 1H, ¹⁶⁸
 $J = 7.6$ Hz), 7.72 (m, 6H), 7.48 (m, 4H), 7.20 (m, 2H), 7.16 (d, 1H $J = 7.6$ Hz), 7.73 (m, 6H), 7.48 (m, 4H), 7.29 (m, 2H), 7.16 (d, 1H, 10^{169} $J = 7.6$ Hz), 6.94 (t, 1H, J = 7.6 Hz), 6.88 (m, 1H), 6.83 (d, 1H, J = 7.6 Hz), 170
6.70 (m, 1H), 6.74 (t, 1H, J = 7.2 Hz), 6.50 (d, 1H, J = 8.0 Hz), 6.42 (m, 171 6.79 (m, 1H), 6.74 (t, 1H, J = 7.2 Hz), 6.50 (d, 1H, J = 8.0 Hz), 6.42 (m, ¹⁷¹
1H), 6.05 (m, 1H), ¹³C NMP (125 MHz, CDCL); 8, 172 59, 165, 31 1H), 6.05 (m, 1H). ¹³C NMR (125 MHz, CDCl₃): δ 172.59, 165.31, ¹⁷²
142.69, 139.18, 138.86, 138.26, 137.15, 136.54, 133.81, 133.96, 129.34, 173 ¹⁷³ 142.69,139.18,138.86,138.26,137.15,136.54,133.81,132.96,129.34, ¹⁷⁴ 129.07,128.42,128.05,127.87,127.59,127.29,126.90,126.57,126.18, 125.71, 125.21, 124.48, 124.42, 123.26, 123.09, 121.88, 120.34, 175
120.23, 120.13, 120.07, 117.04, 116.24, 110.35, MS (ADL) m/z; 640.0 120.23, 120.13, 120.07, 117.04, 116.24, 110.35. MS (API+) m/z: 640.9 177
 177 $[(M+H)^+]$ 177

Device fabrication and measurements **Device** fabrication and $\frac{178}{2}$

The phosphorescent devices were constructed on a 150 nm 179
als indicates with suita (TC) spated substants which we also need 180 thick indium tin oxide (ITO) coated substrate which was cleaned

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