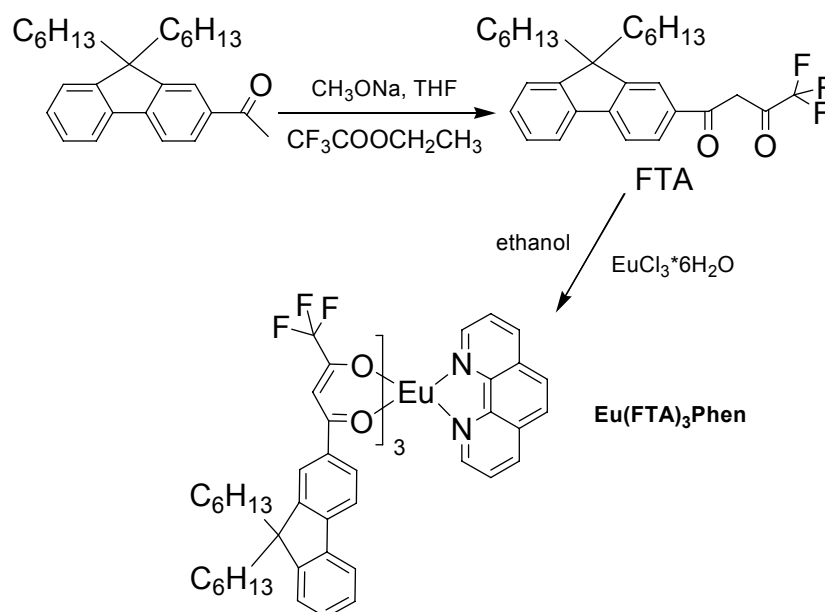


Supporting information for:

## Bright red light-emitting electroluminescence devices based on a novel europium complex doped into polyvinylcarbazole

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## Experimental

### General methods

Ethyl trifluoroacetate, phenanthroline, 2-acetylfluorene and  $\text{EuCl}_3 \cdot 6\text{H}_2\text{O}$  were purchased from Aldrich and Acros.

NMR spectra were recorded on Bruker DRX 400 spectrometer. Elemental analyses were performed on Vario EL elemental analysis instrument (Elementar Co.). UV-Vis spectra were recorded with a HP 8453 spectrophotometer. Photoluminescence (PL) spectra in solution were taken by using a Fluorolog-3 spectrofluorometer (Jobin Yvon). Thermogravimetric analyses (TGA) and differential scanning calorimetry (DSC) were conducted on a NETZSCH TG 209 under a heating rate of  $10\text{ }^\circ\text{C}/\text{min}$  and a nitrogen flow rate of  $20\text{ mL}/\text{min}$ .

### Device fabrication and characterization

The PLEDs were fabricated on indium tin oxide (ITO) covered glass substrates. Patterned ITO coated glass substrates were cleaned with acetone, detergent, distilled water and isopropanol, subsequently in an ultrasonic bath. After treatment with oxygen plasma, 150 nm of PEDOT: PSS (Batron-P 4083, Bayer AG) from water solution was spin-coated onto the substrate followed by drying in a vacuum oven at  $80\text{ }^\circ\text{C}$  for 8 h and evacuation at room temperature for PEDOT coating. The PVK and PBD were dissolved into chlorobenzene solution and  $\text{Eu}(\text{FTA})_3\text{Phen}$  was dissolved into chloroform solution. A mixture of PVK: 30 wt% PBD and  $\text{Eu}(\text{FTA})_3\text{Phen}$  was spin-cast on the top of PEDOT: PSS. Typically, the thickness

of the emitting layer was around 80 nm. If necessary, the TPBI layer (45 nm) was deposited before a thin layer of Ba (4 nm) with a 200 nm thick Al capping layer was deposited through a shadow mask in a chamber with a base pressure of around  $10^{-4}$  Pa. Device fabrication was carried out in a controlled atmosphere dry-box under  $N_2$  circulation. Current density ( $J$ )-voltage ( $V$ )-luminance ( $L$ ) data were collected using a Keithley 236 source measurement unit and a calibrated silicon photodiode. PL in thin film was measured under excitation from the 325 nm line of a HeCd laser. The luminance ( $cd\ m^{-2}$ ) were measured by a silicon photodiode and calibrated using a PR-705 SpectraScan Spectrophotometer (Photo Research). Photoluminescence spectra and electroluminescence spectra were recorded using a CCD spectrophotometer (Instaspec 4, Oriel).

#### Synthesis

**9,9-dihexyl-2-acetylfluorene.** To a solution of 20 mL of dimethylsulfoxide was added 3.68 g (17.7 mmol) of 2-acetylfluorene, 10 mL of 50 wt% NaOH solution was dropwise added into the mixture under vigor stirring. 13.5 g (82 mmol) of 1-bromohexane was added. After stirring for 5 days at room temperature, a large amount of water was added into the mixture and extracted with ether twice. The combined organic phase was dried over anhydrous  $MgSO_4$  and then filtered. The organic solvent was completely removed by rotary evaporation. The residue was purified by column chromatograph using hexane as eluent to give the purified title compound (4.70 g, 71 %).  $^1H$  NMR ( $CDCl_3$ , 400 MHz),  $\delta$  : 7.97-7.95 (d, 2H),

7.77 (m, 2H), 7.38 (m, 3H), 2.67 (s, 3H), 2.02 (m, 4H), 1.09 (m, 12H), 0.76 (t, 6H), 0.58 (q, 4H). GC-MS: 377.65 [M+1]<sup>+</sup>, 376.42 [M]<sup>+</sup>, 291.39 [M-C<sub>6</sub>H<sub>12</sub>]<sup>+</sup>, 207.33 [M-C<sub>12</sub>H<sub>26</sub>]<sup>+</sup>.

**4,4,4-Trifluoro-1-(9,9-dihexylfluoren-2-yl)butane-2,4-dione (FTA).** To a solution of ethyl trifluoroacetate (1.21 g, 8.5 mmol) in THF (25 mL) was added NaOCH<sub>3</sub> (0.54 g, 10 mmol). A solution of 9,9-dihexyl-2-acetylfluorene (1.34 g, 3.5 mmol) in 10 mL of THF was added dropwise over 10 min, and then refluxing for 5 hours. After 3 M HCl was added to the mixture, the mixture was extracted with dichloromethane and the organic layer was collected. The organic layer was washed with brine, dried over anhydrous MgSO<sub>4</sub> and filtered. The organic solvent was completely removed by rotary evaporation. The residue was purified by column chromatograph using hexane and ethyl acetate as eluent to give the yellowish solid of the title compound (1.25 g, 74 %). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ : 15.44 (s, 1H), 7.97-7.95 (dd, J<sub>1</sub>=1.62 Hz, J<sub>2</sub>=1.64 Hz, 1H), 7.93 (s, 1H), 7.78 (m, 2H), 7.40 (m, 3H), 6.65 (s, 1H), 2.03 (t, 4H), 1.09 (m, 12H), 0.79 (t, 6H), 0.59 (q, 4H). GC-MS: 473.68 [M+1]<sup>+</sup>, 472.68 [M]<sup>+</sup>.

**(1,10-phenanthroline)tris[4,4,4-Trifluoro-1-(9,9-dihexylfluoren-2-yl)butane-2,4-dione] europium (III) (Eu(FTA)<sub>3</sub>Phen).** Eu(FTA)<sub>3</sub>Phen was prepared by the conventional method. To a solution of FTA (0.504 g, 1.07 mmol) and 1,10-phenanthroline (62 mg, 0.35 mmol) in ethanol (15 mL), which had been neutralized with aqueous NaOH solution, was added dropwise an aqueous of EuCl<sub>3</sub>•

6H<sub>2</sub>O (127.7 mg, 0.35 mmol). Then, the mixture was stirred at 60 °C for 5 hours. The precipitated product was filtered, and the complex was re-crystallized with hexane/dichloromethane. The yellow-white solid was obtained (0.46 g, 75 %). <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz), δ : 10.61 (d, J=8.00 Hz, 2H), 10.13 (s, 2H), 8.78 (s, 2H), 8.59 (d, J=8.00 Hz, 2H), 7.55 (d, J=7.20 Hz, 3H), 7.37-7.29 (m, 12H), 7.21-7.26 (t, 2H), 6.95 (s, 2H), 6.67 (s, 2H), 3.65 (s, 3H), 2.05 (m, 12H), 1.24-1.15 (m, 36H), 0.82 (t, 18H), 0.53 (m, 12H). Anal. Calcd. for C<sub>99</sub>H<sub>110</sub>O<sub>6</sub>N<sub>2</sub>F<sub>9</sub>Eu: C 68.07, H 6.35, N 1.60 %; found C 68.00, H 6.47, N 1.35 %.