

On the origin of high quality white light emission from hybrid organic/ inorganic light emitting diode using azide functionalized polyfluorene

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Electronic Supplementary Information

Experimental

Poly[(9,9-dihexylfluorene)-co-alt-(9,9-bis-(6-bromohexyl) (PFB): 2,7- Dibromo-9,9-bis-(6-bromo-hexyl)-9H-fluorene was prepared following the literature procedure.²² 2,7-Dibromo-9,9-bis-(6-bromo-hexyl)-9H-fluorene (975 mg, 0.150 mmol) and 9,9-Dihexylfluorene-2,7-bis(trimethyleneborate) (754 mg, 0.150 mmol) were suspended in a mixture of degassed THF (15 ml) and H₂O (7 ml). Pd(PPh₃)₄ (21.0 mg) and K₂CO₃ (2.49 g, 18.0 mmol) were added sequentially. The mixture was degassed again and heated at 80 °C for 48 h under argon and then poured into methanol. The precipitate was collected by filtration and dissolved in chloroform. The solution was washed with water and concentrated under reduced pressure. The concentrated solution was poured into methanol; the solid residue was collected by centrifugation and dissolved in THF. The solution was added into stirred large excess of MeOH. The precipitate was collected by filtration and dried under vacuum to obtain yellowish powder.

Yield: 1.1 g, 64%.

IR (KBr, cm⁻¹): 3065(CH-), 2935 (CH-), 2859(CH-), 1613(C=C-), 1571(C=C-), 727(C-Br).

¹H-NMR (400 MHz, CDCl₃): δ 7.85 (m, 12H), 3.32 (t, 4H, ³J_{H-H}=6 Hz), 2.16

(m, 4H), 1.71 (m, 4H), 1.22 (m, 24H), 0.84 (m, 14H).

Gel-permeation chromatography (GPC): M_n= 3.87 x 10³ g mol⁻¹, M_w= 2.04 x 10⁴ g mol⁻¹

(Polystyrene as standard).

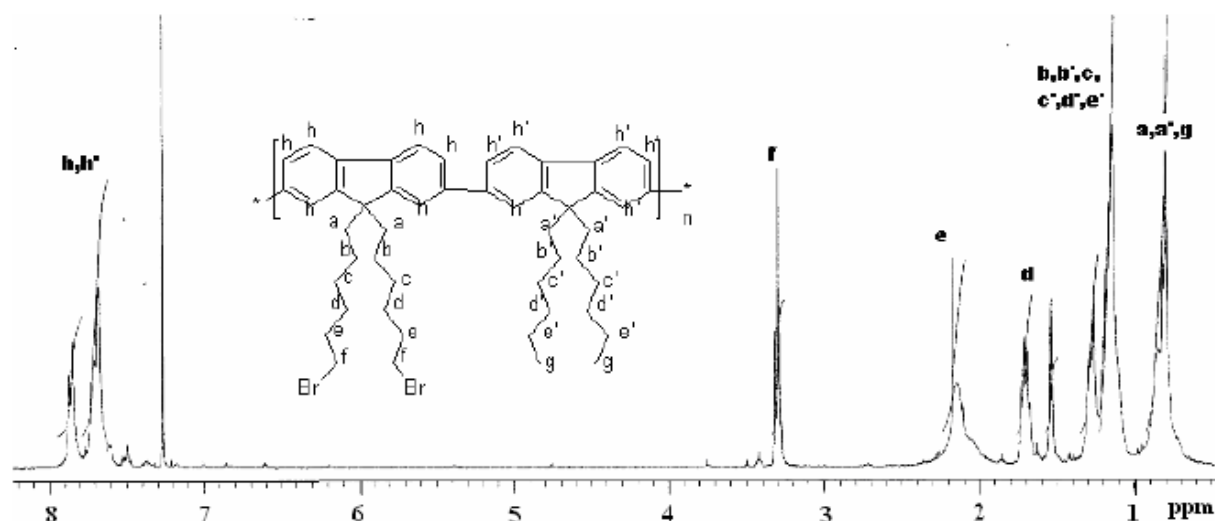


Fig. S1 The $^1\text{H-NMR}$ spectra of **PFB** (400 MHz, CDCl_3 , 25 °C)

Poly[(9,9-dihexylfluorene)-co-alt-(9,9-bis-(6-azidohexyl) fluorene)]:

PFB (300 mg, 0.36 mmol) and NaN_3 (60.0 mg, 1.08 mmol) were suspended in dry DMF (5 ml) and heated at 60 °C for 24 h. The mixture was poured into water (20 mL) and extracted with diethyl ether (50 mLx3). The combined organic layer was washed with water, dried over CaCl_2 and concentrated under reduced pressure. The residue was precipitated into methanol. The precipitate was collected by centrifugation and dried under vacuum to obtain yellow solid.

Yield: 205 mg, 75%.

IR (KBr, cm^{-1}): 3065(CH-), 2935 (CH-), 2859(CH-), 2100 ($-\text{N}_3$),

1613(C=C-), 1571(C=C-).

$^1\text{H-NMR}$ (400 MHz, CDCl_3): δ 7.78 (m, 12H), 3.17 (m, 4H), 1.95 (m, 4H), 1.7 (m, 4H), 1.20(m, 8H), 0.65 (m, 4H, f).

Gel-permeation chromatography (GPC): $M_n = 3.61 \times 10^3 \text{ g mol}^{-1}$, $M_w = 2.04 \times 10^4 \text{ g mol}^{-1}$

(Polystyrene as standard).

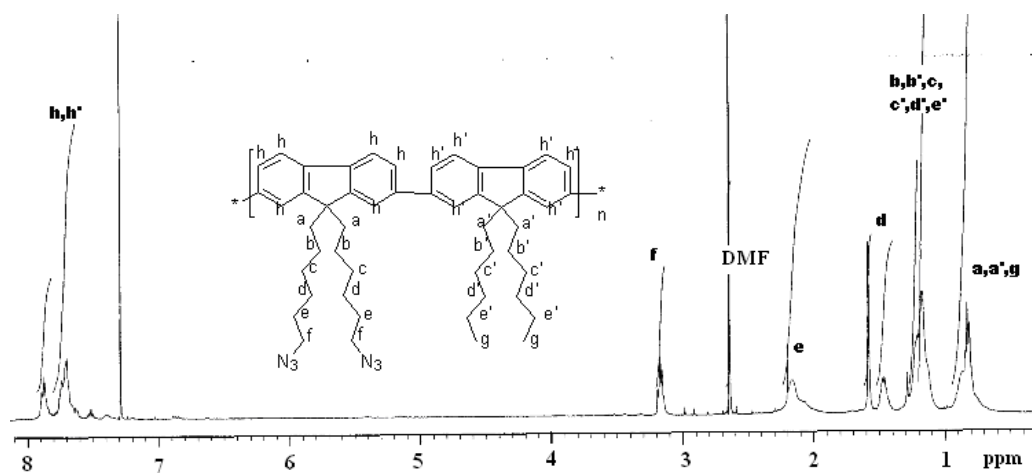


Fig. 2 The ¹H-NMR spectra of PFA (400 MHz, CDCl₃, 25 °C)

Device fabrication: The near-UV InGaN/GaN LED, used as the pump light source with an electroluminescence peak at 378 nm, was grown in a GaN dedicated metal organic chemical vapor deposition (MOCVD) reactor at Bilkent University Nanotechnology Research Center. The epitaxial growth started with a 25 nm thick nucleation layer, which was followed by the deposition of a 200 nm thick GaN buffer layer and the Si doped GaN n-layer. The active region consisted of a 5 period of InGaN/GaN quantum wells and barriers with thickness of ~2 nm and ~3 nm, respectively. The active region was capped with an AlGaN layer to serve as a hole blocking layer. Finally a Mg doped p-layer was grown as the top contact layer. The LEDs were fabricated by using standard semiconductor fabrication processes, including photolithography, metallization, reactive ion etching, and rapid thermal annealing. For the hybridization on the n-UV LEDs, the polymers were dissolved in THF at varying concentrations of 8-10 mg/mL and spin-coated to form films at a film thickness of approximately 1.5 μm. Here the n-UV LED platform that was intimately integrated with PFA and PFB films on the chip served as an efficient pump source for the excitation of these polymers to generate the optical spectra. For controlled UV exposure and heat treatment applications, polymers were integrated on thoroughly cleaned quartz. For the UV radiation

part, the samples of each polymer were radiated at 370 nm with a power of about 1 mW in 6 h periods. Heat treatment measurements were performed by in-situ heating single polymer films of PFA and PFB on a temperature controller plate up to desired temperatures.

Table S1. Chromaticity coordinates, color temperature, and color rendering indices of PF, PFB and PFA²¹

Samples	X	Y	T_c (K)	CRI
1 PF	0.2728	0.3159	9450	78
2 PFB	0.1828	0.1477	34463	53
3 PFA	0.2913	0.2770	9416	87
4 PFA	0.2554	0.2426	32371	91