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High efficiency thermally activated delayed fluorescence and its application for OLED

Keigo Sato[1,2], Ayataka Endo[2] and Chihaya Adachi[1,2*]

[1]*Center for Organic Photonics and Electronics Research (OPERA), 744 Motooka, Nishi, Fukuoka, Japan*
[2]*Center for Future Chemistry. & Dep. Appl. Chem., Kyushu Univ., 744 Motooka, Nishi, Fukuoka, Japan*
[*]*Chihaya Adachi: k-sato@cstf.kyushu-u.ac.jp*

1. Introduction

In organic light emitting diodes (OLEDs), exciton generation by current results in 25% of singlet excitons (S_1) and 75% of triplet excitons (T_1), respectively. Therefore, in general, OLEDs that use fluorescence materials can produce only 25% singlet excitons. To improve efficiency of exciton production at a S_1 level, we employed the mechanism of thermally activated delayed fluorescence (TADF)[1] for OLEDs[2]. To realize high TADF efficiency, we need materials that have a small energy gap between S_1 and T_1 levels. In this study, we developed a novel triazin derivative (PIC-TRZ) having a very small energy gap between S_1 and T_1 excited states, ΔE_{1-3}, that realizes efficient up-conversion of triplet excitons into a singlet state.

2. Result and Discussion

In this study, we fabricated thin films of 6wt%-PIC-TRZ:host for PL analysis and OLEDs with PIC-TRZ:host as an emitter layer. The fluorescence and phosphorescence spectra of PIC-TRZ are shown in Fig. 1. We observed the overlap between the fluorescence and phosphorescence (T=5 K) spectra with their 0-0 transition peaks at 466 nm (S_1=2.66 eV) and 483 nm (S_1=2.55 eV), respectively, indicating the realization of very small ΔE_{1-3}=0.11 eV. The PL quantum efficiency increased with increasing the T_1 level of host materials and the highest PL quantum efficiency of 39% was obtained in a 6wt%-PIC-TRZ: 9,9'-(l,3-phenylene)bis-9H-carbazole (m-CP) film. The film showed intense delayed fluorescence with the same spectrum of the prompt fluorescence (Fig. 2), although the neat PIC-TRZ film resulted in no appreciable TADF. This result shows that suppression of concentration quenching and energy transfer between guest and host T_1 levels is crucial to improve TADF efficiency. We also fabricated an OLED device using 6wt%-PIC-TRZ: m-CP as an emitting layer. The OLED showed external EL quantum efficiency of 5.1% (Fig. 3). When we use a conventional fluorescence material having Φ_{PL}=39% as an emitter, the theoretical $\Phi_{EL(ext)}$ resulted in the small value of 2%. Thus, the OLED is surely exceeding the limitation of singlet exciton production rule, indicating significant contribution of TADF.

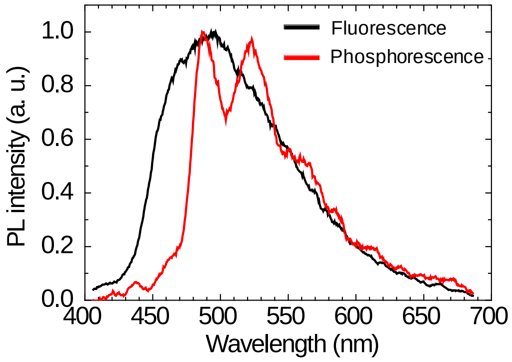

Fig. 1 Fluorescence and phosphorescence spectra of PIC-TRZ film

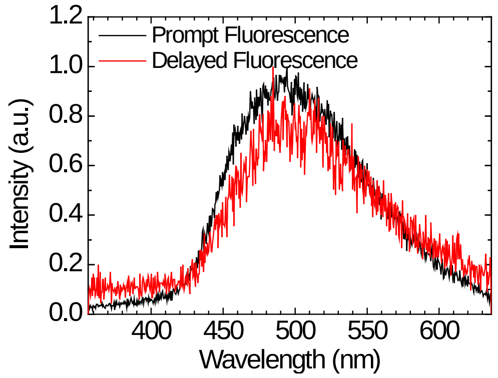

Fig. 2 Fluorescence and delayed fluorescence spectra of PIC-TRZ: m-CP film

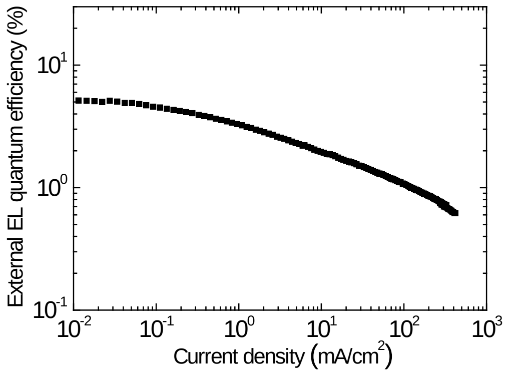

Fig. 3 EQE-current density characteristics in ITO/ α-NPD (40 nm)/m-CP (10 nm)/6wt%-PIC -TRZ:m-CP (20 nm)/BP4mPy (40 nm)/ LiF (0.8 nm)/Al (100 nm)

3. References

[1] Valeur, B., Molecular Fluorescence, Wiley-VCH, Weinheim, 2002, p.41

[2] A. Endo, M. Ogasawara, A. Takahashi, D. Yokoyama, Y. Kato and C. Adachi, *Adv. Mater.*, **21**, 4802 (2009)

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