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Energy Relay Systems for Efficient Organic Light-Emitting Devices: Influence of Formation of Exciplex as Revealed by Photoexcitation

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ABSTRACT

We investigated potential of performance enhancement for organic light-emitting diodes (OLEDs) by an energy relay system through exciplex formed between a hole transport material (HTM) and an electron transport material (ETM) as revealed by photoexcitation. An enhancement of a dopant (Coumarin 6) emission occurred depending on combination of HTM and ETM, and the dependency can be explained by an overlap integral between an exciplex emission and an absorption of Coumarin 6 as a dopant. Possibility of performance enhancement by the energy relay system was suggested experimentally.

Keywords overlap integral; photoluminescence; excitation transfer; exciplex; organic light-emitting diode

INTRODUCTION

The laminate type organic light-emitting diodes (OLEDs) reported by Tang *et al* consist of hole transport materials (HTMs) and electron transport materials (ETMs). Generally speaking, the ETMs are electron acceptors, and the HTMs are electron donors. At the view points of efficient transport and injection of charge carriers, strong electron donors and acceptors are more preferable. In the case of combination of the strong donors and acceptors, however, exciplexes

or charge transfer complexes are formed between HTMs and ETMs. Ordinarily, formation of these complexes decreases quantum efficiency of OLEDs. If excitation transfer from these complexes to emitting materials sufficiently occurs, degree of freedom for device design can be enlarged widely. In this paper, we have suggested potential of an energy relay system through exciplex formed between the HTMs and the ETMs. We discuss the energy relay system in detail based on photoluminescence (PL) and absorption spectra of polymer dispersed films.

EXPERIMENT

Chemical structures used in this study are shown in FIGURE 1. Polymer dispersed films were prepared on a quartz substrate by spin coating from a solution containing PMMA (25mg), PBD (6.3mg), HTMs (100 mol% against PBD) and C6 (4 mol% against PBD) in 3 ml of dichloromethane. The thickness of the films was 100 nm. Excitation wavelength was set at 350 nm for measurements of PL spectra, at which absorption of PBD does not exist and HTMs are excited only.

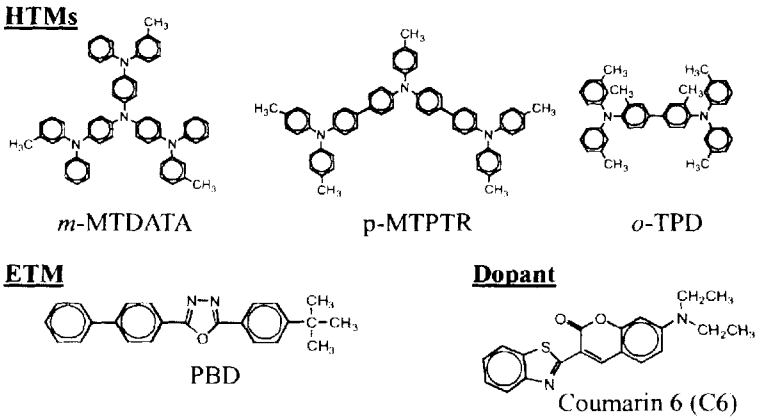

FIGURE 1 Molecular structures used in this study.

RESULT AND DISCUSSION

PL spectra of C6 doped films are shown in FIGURE 2. When PBD as an ETM was added into the system, the PL spectra of the all systems

were drastically changed.

PL spectra of mixture films of each HTM and PBD are shown in FIGURE 3 with an absorption spectrum of C6. It was confirmed from FIGURE 3 that all of combinations of HTMs and PBD were formed exciplex in PMMA matrix. In the followings, we discuss the spectral changing shown in FIGURE 2 at the viewpoint of overlap integral between the exciplex emissions and the absorption of C6.

In the case of *m*-MTDATA, the HTM emission at 420 nm was quenched by adding PBD into the system, and the exciplex emission came into the view at 520 nm. The overlap integral of the exciplex emission and the C6 absorption was small; excitation transfer to C6 through the exciplex hardly occurred.

In the case of *p*-MTPTR, decreasing of the HTM emission was same to the other systems, but the C6 emission at 490 nm increased. The overlap integral was large; excitation transfer through the exciplex occurred. Thus, potential of the energy relay system through exciplex formed between HTM and ETM was suggested.

On the other hand, in the case of *o*-TPD, an over all emission intensity decreased. Although the overlap integral of this system is large in similar to the *p*-MTPTR system, the C6 emission did not increase. In addition, the emission from C6 was observed on the

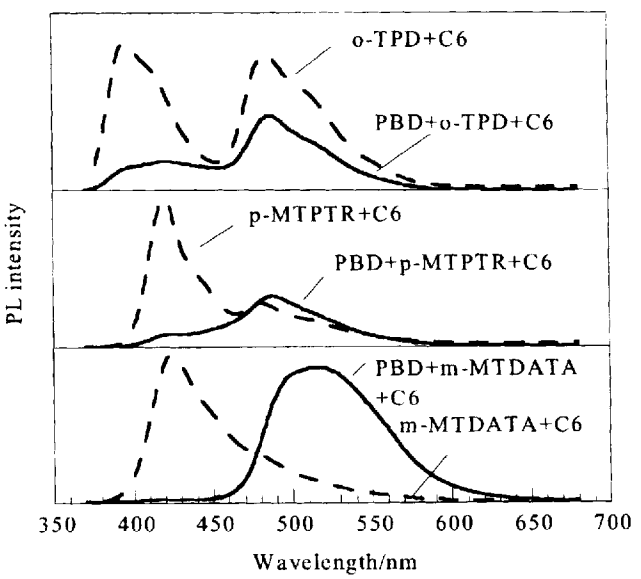

FIGURE 2 PL spectra of C6 doped films.

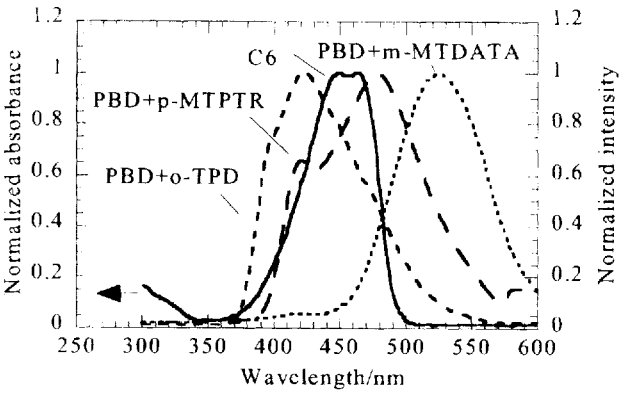

FIGURE 3 PL spectra of mixture films and absorption spectrum of C6.

system without PBD. Therefore, in this system, excitation transfer through the exciplex is inefficient as compared to a direct excitation transfer from o-TPD to C6. However, the C6 emission was observed, hence the energy relay through the exciplex occurred in this system.

CONCLUSION

We investigated potential of the energy relay system through exciplexes formed between HTMs and ETMs as revealed by photoexcitation. Increase of the dopant emission occurred depending on combination of HTM and ETM, and the enhancement can be explained by the overlap integral between exciplex emission and absorption of C6. Namely, possibility of performance enhancement by the energy relay system was suggested experimentally.

Acknowledgements

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