An alternative way to use the triplet energy of fluorescent dyes in OLED via an external iodide

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Abstract
An unusual heavy atom effect (HAE) has been identified in an organic light emitting device (OLED) containing polyvinylcarbazole (PVK) as the host, red fluorescent dye 2-{2-methyl-6-[2-(2,3,6,7-tetrahydro-1H,5H-pyrido[3,2,1-ij]quinolin-9-yl)-vinyl]-pyran-4-yldiene}-malononitrile (DCM2) as the emitter, and non-emitting 1,8-diiodooctane (RI) as a heavy atom source instead of a rare metal. The enhanced fluorescence induced by iodide is caused by energy transfer from both the singlet and triplet states of PVK to the singlet states of DCM2. These results suggest an alternative possibility for using the triplet energy of fluorescent materials with external heavy atoms rather than conventional phosphorescent dyes containing rare heavy metal atoms.

Keyword: external heavy atom effect · triplet · singlet · iodide · organic light-emitting device

1. INTRODUCTION

Heavy atoms such as Pt,[1] Ir,[2] Os,[3] and Re[4] centers coordinated to phosphorescent dyes can induce significant spin-orbit coupling. Using this approach, nearly 100% internal quantum efficiencies have been obtained.[5-7] Another method is to use a phosphor-sensitizer containing heavy atoms in the device,[4,8] allowing use the triplet energy of the host fluorescent molecules. However, expensive rare metals are required in both of the above approaches. It is known that some inexpensive heavy atoms, e.g., iodine and bromine, can also induce a HAE,[9-11] but this has not been exploited in OLEDs to date.

Here we introduce a HAE induced by inclusion of non-radiative iodide into a host-guest fluorescent OLED to harvest both the singlet and triplet energy of fluorescent molecules as an alternative to expensive phosphorescent rare metal complexes. To date, such a HAE induced by external iodide in an OLED has not been reported. Direct energy transfer from the triplet state of the host fluorescent dye to the singlet state of the guest fluorescent dye was observed. This indicates an alternative way of using the triplet energy of fluorescent materials in OLEDs without using expensive rare metals.

2. EXPERIMENTAL AND RESULTS

A direct energy transfer from triplet to singlet between two fluorescent dyes has been identified in an organic light emitting device (OLED) containing polyvinylcarbazole (PVK) as the host, the red fluorescent dye 2-{2-methyl-6-[2-(2,3,6,7-tetrahydro-1H,5H-pyrido[3,2,1-ij]quinolin-9-yl)-vinyl]-pyran-4-yldiene} malononitrile (DCM2) as the emitter, and non-emitting 1,8-diiodooctane (RI) as a heavy atom source instead of a rare metal. The intensity of electroluminescence (EL) of DCM2 changes with the concentration of RI, with a maximum EL intensity obtained for DCM2 at a concentration of 0.25% of RI as shown in Fig. 1. Photoluminescence (PL) spectra of PVK-DCM2 films show increased singlet emission from DCM2 in the presence of iodide at 12K as shown in Fig. 2. The enhanced fluorescence induced by iodide is caused by energy transfer from both the singlet and triplet states of PVK to the singlet states of DCM2.

Figure 1. EL spectra of devices: ITO/PEDOT:PSS/PVK :1% DCM2 :x% (x = 0, 0.25, 0.58, 1.00, and 5.00)RI /BCP(30 nm)/LiF(0.5 nm)/Al(100 nm), which were normalized to the emission of PVK (around 400 nm).

Figure 2. PL spectra of PVK:0.3% DCM2 (Film I) and PVK:0.2% DCM2:0.3% RI (Film II)
3. SUMMARY

An unusual HAE was induced by the presence of external iodide in a system containing a fluorescent PVK host and fluorescent DCM2 guest. The intensities of the EL and PL peaks of DCM2 relative to those of PVK show a similar tendency as the content of iodide is varied, which indicates that direct energy transfer occurs from the triplet excited state of PVK to the singlet excited state of DCM2 induced by external heavy atoms of iodine. This result suggests an alternative way to use the triplet energy of fluorescent materials without using electrophosphorescent dyes containing rare metals.

4. ACKNOWLEDGEMENTS

This work was financially supported by the National Basic Research Program of China (2009CB930504), NSFC (grants 61177020, 10934001, 60907015, and 11121091), and Beijing Municipal Science and Technology Project (Z10110305 0410002).

5. REFERENCES