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White organic electroluminescence based on a new boron complex

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Abstract

A bright blue boron complex BPh_2(pybm) containing 2-(2-pyridyl)benzimidazole ligand was designed and synthesized by using N, N-bidentate ligand instead of N, O-bidentate one such as 8-quinolinol. For three-layer LED devices with the configuration of ITO/NPB/BPh_2(pybm)/Alq_3/LiF/Al, the white light emission covering the whole visible region from 400 to 750 nm with the maximum brightness of 110 cd/m^2 and the luminous efficiency of 0.8 cd/A was observed.

Keywords: boron complex, white, electroluminescence.

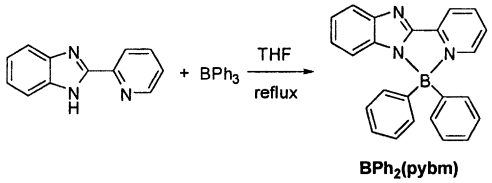
1. Introduction

Recently, white organic light emitting diodes have attracted much attention, because their potential applications in the backlights of laptop computers and portable panel light sources. In the literatures, several strategies including double-layer devices and multi-layer devices have been developed to realize highly efficient white organic electroluminescence[1-3]. Nevertheless, there still remains a need for developing new organic light-emitting materials for the white emission.

In this paper, we present a new boron complex BPh_2(pybm) containing N,N-bidentate ligand instead of N,O-bidentate one such as 8-quinolinol, and find that this boron complex emits bright blue light and can be used to fabricate white electroluminescent devices.

2. Experimental

BPh_2(pybm) was synthesized according to Scheme 1. Triphenyl boron (0.48 g, 2 mmol) was added to 20 mL of THF solution containing 2-(2-pyridyl)benzimidazole (Hpybm) (0.39 g, 2 mmol) under N_2. The mixture was stirred at reflux for 4 h. After the mixture was cooled to room temperature, it was concentrated by vacuum and the residue was recrystallized from dichloromethane/hexane, yielding colorless crystals (0.52 g, yield 72.6 %). ^{1}H NMR in $CDCl_3$ (δ, ppm): ^{1}H NMR 8.59 (d, 1H); 8.42 (d, 1H); 8.20 (t, 1H, J = 8Hz); 7.89 (d, 1H, J = 8Hz); 7.54 (t, 1H); 7.40 (d, 1H); 7.30-7.19 (m, 12H).



Scheme 1. The synthetic route of BPh_2(pybm).

3. Results and discussion

The boron complex BPh_2(pybm) was prepared by the reaction of Hpybm with equivalent triphenyl boron. This complex emitted bright blue color in solution and as thin film upon irradiation by UV light. The UV-vis absorption and photoluminescent spectra of BPh_2(pybm) in $CHCl_3$ solution and in solid film are shown in Fig. 1. The absorption maximum peaks at 360 nm with a small shoulder at 325 nm was observed, corresponding to π–π^* transition of the resulting complex. Its PL spectrum exhibits the maximum peaks at 444 nm (in solution) and 481 nm (as solid film), corresponding to blue light emission.

Compared with similar boron complex containing 2-(2-pyridyl) indole (the emission maximum at 516 nm), in which the un-coordinated nitrogen atom in the ligand is replaced by a CH group, its emission peak is about 35 nm blue-shifted, indicating that the introduction of the heteroatoms such as N, O into the backbone of the ligand provided the best way to alter π–π^* transition energy for fine-tuning the emission color without distorting the molecular shape[4].

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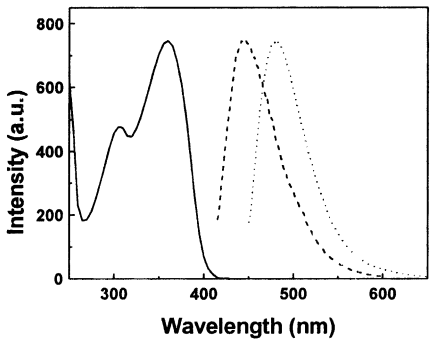

Fig. 1. The UV-vis spectrum in $CHCl_3$ solution (solid line), PL spectrum in $CHCl_3$ solution (dashed line) and PL spectrum in solid film (dotted line).

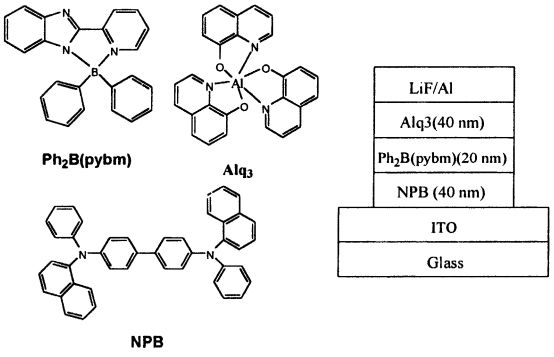

Fig. 2. The EL device strucutre and molecular structures of Ph_2B(pybm), NPB and Alq_3.

To investigate the electroluminescent properties of BPh_2(pybm), typical three-layer device with the configuration of ITO/NPB/BPh_2(pybm)/Alq_3/LiF/Al was fabricated by using BPh_2(pybm) as the emitter, NPB as the hole-transporting layer and Alq_3 as the electron-transporting layer. The device thickness of each layer and the molecular structures of NPB, Alq_3 and BPh_2(pybm) are described in Fig. 2. The electroluminescent spectrum was shown in Fig. 3. Interestingly, broader emission bands ranging from 400 to 750 nm were observed, indicating that the three-layer LED device emitted white light covering the whole visible light region. The band around 490 nm in EL spectrum can be attributed to the emission of BPh_2(pybm), because its emisson position is almost identical with that in PL spectrum of BPh_2(pybm). The emission band at 535 nm is assigned to the characteristics of Alq_3. The emission band centered at 610 nm can be attributed to the exciplex emission originated from the interface between NPB and BPh_2(pybm)[1]. Fig. 4 shows the voltage-current (*V-I*) and voltage-luminance (*V-L*) characteristics of the device. The turn on voltage was about 7 V and the maximum brightness and electroluminescent efficiency can reach 110 cd/m^2 and 0.8 cd/A, respectively.

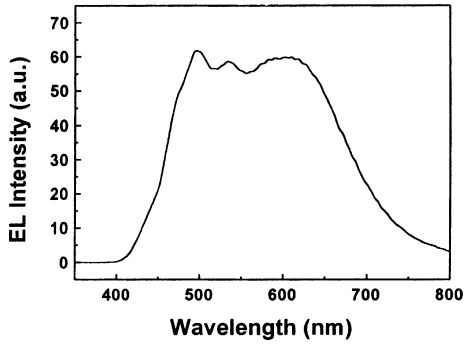

Fig. 3. The EL spectrum for a device with the configuration of ITO/NPB/BPh_2(pybm)/Alq_3/LiF/Al.

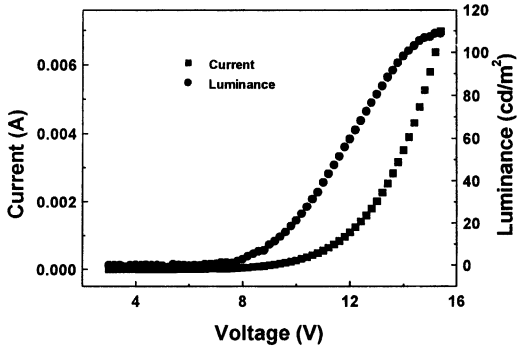

Fig. 4. The voltage-current (*V-I*) and voltage-luminance (*V-L*) characteristics of a device with the structure of ITO/NPB /BPh_2(pybm) /Alq_3/LiF/Al.

4. Conclusion

A white organic light-emitting diode was fabricated using a new class of boron complex containing N,N bidentate ligand. The white light comes from exciplex emission between NPB and BPh_2(pybm) interface in addition to the exciton emission from BPh_2(pybm) and Alq_3, respectively. It may be a promising candidate for LEDs.

Acknowledgements

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