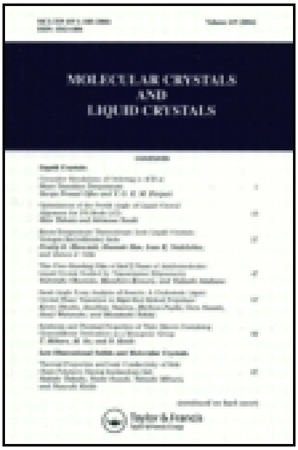

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Blue Electroluminescence from 1,3-Diphenyl-5-(2-Pyrenyl)-2-Pyrazoline

Xi-Cun Gao [a] , Hong Cao [a] , Lian-Qi Zhang [b] , Bao-Wen Zhang [b] & Chun-Hui Huang [a]

[a] State Key Laboratory of Rare Earth Materials Chemistry and Applications Peking University, Beijing, 100871, China

[b] Institute of photographic Chemistry, Chinese Academy of Sciences, Beijing, 100101, China

Version of record first published: 24 Sep 2006

To cite this article: Xi-Cun Gao, Hong Cao, Lian-Qi Zhang, Bao-Wen Zhang & Chun-Hui Huang (1999): Blue Electroluminescence from 1,3-Diphenyl-5-(2-Pyrenyl)-2-Pyrazoline, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 337:1, 333-336

To link to this article: http://dx.doi.org/10.1080/10587259908023445

Mol. Cryst. and Liq. Cryst., 1999, Vol. 337, pp. 333-336
Reprints available directly from the publisher
Photocopying permitted by license only

Published by license under the
Gordon and Breach Science Publishers imprint.
Printed in Malaysia

Blue Electroluminescence from 1,3-Diphenyl-5-(2-Pyrenyl)-2-Pyrazoline

XI-CUN GAO[a], HONG CAO[a], LIAN-QI ZHANG[b],
BAO-WEN ZHANG[b] and CHUN-HUI HUANG[a]

[a]*State Key Laboratory of Rare Earth Materials Chemistry and Applications Peking University, Beijing 100871, China and* [b]*Institute of photographic Chemistry, Chinese Academy of Sciences, Beijing 100101, China*

1,3-diphenyl-5-(2-pyrenyl)-2-pyrazoline (DPP) has been synthesized and used as the emitter material in the electroluminescence (EL) devices. The blue emission from DPP in the indium-tin-oxide (ITO)/diamine/DPP/8-hydroxyquinoline aluminum (ALQ)/Al device is electric strength dependent and is explained by the electron tunneling injection model. The energy levels used in this model were determined by thin film electrochemistry. The device shows blue electroluminescence with luminance 2400 cd/m^2 at 18 V and efficiency 0.23 lm/W at 1.27 mA/cm^2.

Keywords: blue electroluminescence; pyrazoline derivative

INTRODUCTION

Considerable efforts have been devoted to organic electroluminescence (EL) since 1987[1,2]. Seeking new material with high EL performance is very important to the success of EL device. Blue emitting material is more desirable because EL of other colors can be deduced from a blue emitting EL device. In this paper, we report a new blue emitting material, 1, 3-diphenyl-5-(2-pyrenyl)-2-pyrazoline, DPP. The melting point of DPP is high, 258 °C. The atomic force microscopy (AFM) image shows that DPP forms stable amorphous thin film.

Experimental

The synthesis of DPP is reported elsewhere[3]. Preparation of the EL devices was performed by successively thermally evaporating the organics onto ITO (30 Ω/□) molybdenum crucibles with rates in the range of 0.1-0.3 nm/s below a pressure of 1×10^{-5} Torr. The aluminum cathode was evaporated from a tungsten wire basket at higher rates (0.8-1.2 nm/s) in a single vacuum run. The layer thicknesses were controlled *in vacuo* by an IL-1000 quartz crystal monitor, and were also measured by a Dektak^{3} surface profile measuring system. The energy levels of TPD, DPP and ALQ were determined by thin film electrochemistry [3] and absorption spectroscopy.

RESULTS AND DISCUSSION

For the EL devices, we use DPP as light-emitting layer, N, N'-bis(3-methylphenyl)-N, N'-diphenyl benzidine (TPD) as hole transport layer and ALQ as electron transport layer. Figure 1(a) shows the absorption and photoluminescence spectra of DPP in thin film state. It is interesting that DPP's absorption spectra covers the whole 200~400 nm region, a result of the large π-π conjugation of the pyrene group and the n-π conjugation of the pyrazole group with the phenyl group.

Electroluminescence of the triple layer device, ITO/TPD/ DPP/ALQ/Al is electric field strength (EFS) dependent. That is, device with thinner organic layer exhibits blue emission from DPP layer independent of the drive voltage; device with thicker organic layers exhibits blue emission at high drive voltages but green emission at low drive voltages. Figure 1(b) shows the EL spectra of the triple layer device under different drive voltages (the thicknesses of the organics were kept constant so the EFS was proportional to the drive voltage). With increasing drive voltage, the EL emission gradually shifts from ALQ layer to DPP layer. The reason for this kind of electric strength dependent EL emission will be clear if the energy levels of each layer are compared.

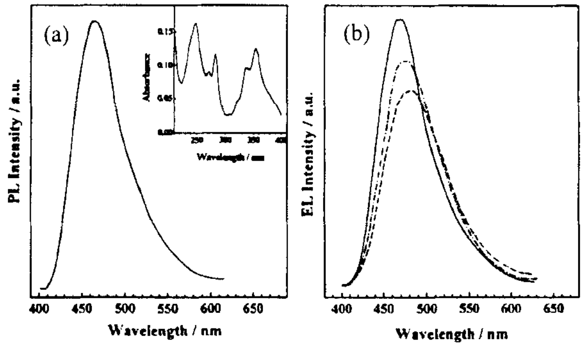

FIGURE 1 (a) Photoluminescence and absorption (inset) spectra of DPP in thin film state. (b) Electroluminescence spectra of the ITO/TPD /DPP/ALQ/Al device (each layer is 35 nm) under different drive voltages, 8V (– – –), 12V (– · – ·) and 16V (——).

Figure 2 shows the energy level diagram obtained from thin film cyclic voltammetry and absorption spectra. In this diagram, the ionization potential, IP (IP is derived from the oxidation potential of the film on ITO, in fact, the values here are just the formal IP values for comparison) of DPP is lower than that of TPD, so holes are easy to be injected into DPP layer. One may propose from the low IP of DPP that DPP be used as a hole transport material. This indeed had been tried and bright EL emission from ALQ was obtained in the double layered device. However, the efficiencies are quite low because the oxidation of the neutral DPP molecule and the reduction of the DPP$^+$ cation is irreversible in the cyclic voltammetry measurements. So, DPP is not a suitable hole transport material. From Fig. 2, the energy barrier (0.73 eV) for electrons being injected from ALQ layer into DPP layer is larger than the energy barrier (0.41 eV) for holes being injected from DPP layer into ALQ layer. So at low EFS electrons would be blocked in ALQ layer. If EFS were sufficiently high, electrons would overcome this barrier height by a tunneling effect[4] and move into DPP layer then recombine holes there and decay to emit light at 470 nm of DPP.

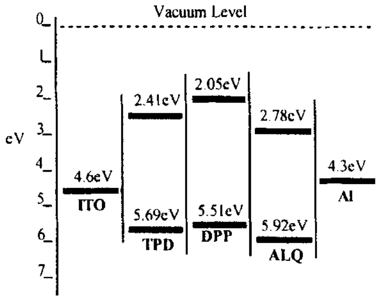

FIGURE 2 The energy level diagram of the ITO/TPD/DPP/ALQ/Al device.

At a drive voltage of 18 V, the luminance reaches to 2400 cd/m^2. At a current density of 1.27 mA/cm^2, the efficiency is 0.23 lm/W.

References

[1] C. W. Tang and S. A. Vanslyke, *Appl. Phys. Lett.*, **51**, 913 (1987).
[2] C. Adachi, S. Tokito, J. Tsutsui, S. Saito, *Jpn. J. Appl. Phys.* 2, **27**, 713 (1988).
[3] X. C. Gao, H.Cao, L.Q. Zhang, B.W. Zhang, Y. Cao, C.H. Huang, *J. Mater. Chem.*, in press.
[4] I. D. Parker, *J. Appl. Phys.*, **75**, 1659 (1994).