Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

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Su-Mi Park [a], Je-Jung Yun [a], Gwang-Chae Oh [a], Sung-Hee Son [a], Nam-Kook Park [a], Eun-Mi Han [a], Sung-Hoon Kim [b] & Young-Seek Yoon [c]

[a] Photonics and Optical Technology Research Institute & Faculty of Applied Chemical Engineering, Chonnam National University, Gwangju, Korea

[b] Dept. of Dyeing Engineering, Kyungpook National University, Daegu, Korea

[c] Energy & Environment Research Team, SK Corporation, Daejeon, Korea

Version of record first published: 15 Jul 2010

To cite this article: Su-Mi Park, Je-Jung Yun, Gwang-Chae Oh, Sung-Hee Son, Nam-Kook Park, Eun-Mi Han, Sung-Hoon Kim & Young-Seek Yoon (2003): ORGANIC ELECTROLUMINESCENCE CHARACTERISTICS OF NOVEL PHENYLAMINE DERIVATIVES, Molecular Crystals and Liquid Crystals, 405:1, 19-25

To link to this article: http://dx.doi.org/10.1080/15421400390263857

Mol. Cryst. Liq. Cryst., Vol. 405, pp. 19–25, 2003

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400390263857

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ORGANIC ELECTROLUMINESCENCE CHARACTERISTICS OF NOVEL PHENYLAMINE DERIVATIVES

*Su-Mi Park, Je-Jung Yun, Gwang-Chae Oh, Sung-Hee Son, Nam-Kook Park, and Eun-Mi Han**
Photonics and Optical Technology Research Institute & Faculty of Applied Chemical Engineering, Chonnam National University, Gwangju, Korea

Sung-Hoon Kim
Dept. of Dyeing Engineering, Kyungpook National University, Daegu, Korea

Young-Seek Yoon
Energy & Environment Research Team, SK Corporation, Daejeon, Korea

In this paper, we report the optical and electrical characteristics of organic electroluminescent diodes (OELDs) using phenylamine derivatives. The novel hetero-cyclic bis-styryl dyes, 2,2′-(1,4-phenylenedivinylene)bis-3,3′-dimethyl-indoline (PDV-DMI) and 2,2′-(1,4-phenylenedivinylene)bis-8-acetoxyquinoline (PDV-AQ) were synthesized according to phase-transfer catalysis (PTC). The structure of fabricated OELDs was ITO anode/PEDOT/TPD/PDV-DMI or PDV-AQ/Al cathode. The brightness of the EL diodes with PDV-DMI or PDV-AQ had a maximum peak about 3700 nW/cm^2 at 156 mA/cm^2 and 6000 nW/cm^{2}at 130 mA/cm^2, respectively. The maximum EL peaks from PDV-DMI and PDV-AQ are at 615 nm and 592 nm which are corresponding to red and orange emission, respectively. The CIE coordinates of PDV-DMI and PDV-AQ are $x = 0.5635$, $y = 0.4277$ and $x = 0.4725$, $y = 0.4640$, respectively.

Keywords: bis-styryl dye; electroluminescence; organic electroluminescent diodes (OELDs)

This study was financially supported by Chonnam National University in the program, 1999.
*Corresponding author. Tel.: +82-62-530-1829, E-mail: emhan@chonnam.ac.kr

1. INTRODUCTION

Since the pioneering work of Tang and Vanslyke [1] on organic electroluminescent diodes (OELDs), many efforts have been devoted to prepare OELDs for enhancing performance. OELDs have been widely investigated for their potential applications in a wide visible region and in flat-panel displays driven at low voltage. In order to realize full-color flat-panel displays, it is necessary to develop efficient red-light-emitting devices. A few red-light-emitting devices have been reported [2–5], but all of them contains an organic layer doped with small amount of a red fluorescent dye, and most of these devices have very broad peaks because of the varying circumstances of the dopant molecules. Therefore, the development of independent red emitting materials are necessary to achieve full color displays. In this paper, we synthesized novel red emitting phenylamine derivatives and investigated their electroluminescent characteristics for OLEDs.

2. EXPERIMENTAL

We studied OELDs using the novel hetero-cyclic bis-styryl dyes, 2,2′-(1,4-phenylenedivinylene)bis-3,3′-dimethylindoline (PDV-DMI) and 2,2′-(1,4-phenylenedivinylene)bis-8-acetoxyquinoline (PDV-AQ). Figure 1 lists the molecular structures of the organic materials used in this study. The PDV-DMI and PDV-AQ were synthesized according to the method in references [6,7]. N,N′-diphenyl-N,N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine (TPD) has been used most widely as the hole transport layer in organic electroluminescence (EL) devices, which was purchased from TCL Co. LTD.

The patterned indium-tin-oxide (ITO)-coated glass (30/sq.) was sonicated in a detergent solution followed by a de-ionized water rinse, acetone, trichloroethylene and isopropyl alcohol. After drying, the PEDOT (polyethylene dioxythiophene) was formed on the ITO-coated glass substrate by spin-cast technique. And then TPD, PDV-DMI or PDV-AQ, and Al were deposited by vacuum thermal evaporation under a vacuum of about 2×10^{-6} torr.

The schematic cross-sectional view of the fabricated device is shown in Figure 2. The cell structure is an ITO anode/PEDOT/TPD(50 nm)/PDV-DMI or PDV-AQ(50 nm)/Al cathode(150 nm). The emissive materials are PDV-DMI and PDV-AQ. The hole conducting buffer polymer is PEDOT and the hole transport agent is TPD.

Elemental analysis were recorded on a Carlo Elba Model 1106 analyzer. Mass spectra were recorded on a Shimadzu QP-1000 spectrometer using electron energy of 70 eV and the direct prove EL method. IR spectra were measured with a Nicolet Magna 550 IR spectrometer. Melting points were determined using an Electro-thermal IA 900 apparatus and are

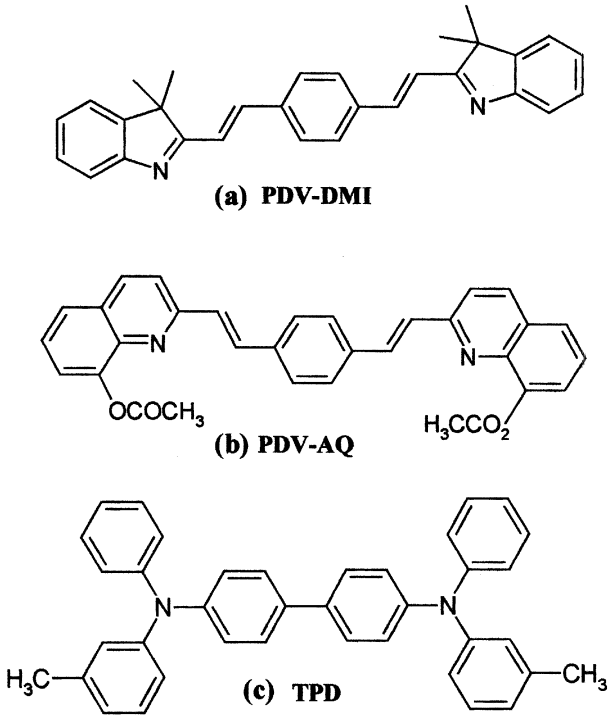

FIGURE 1 Molecular structures of the materials used in this study, (a) 2,2′-(1, 4-phenylene-divinylene)bis-3,3′-dimethylindoline (PDV-DMI), (b) 2,2′-(1,4-phenylenedivinylene)bis-8-acetoxyuinoline acetoxyquinoline (PDV-AQ), (c) N,N′-diphenyl-N,N′-bis(3-methylphenyl)1,1′-bi-phenyl-4,4′-diamine (TPD).

uncorrected. UV-Vis absorption was measured for molecule thin films using UV-Vis. Spectrometer.

Electrical and optical output measurements for OELDs were performed using a Keithley 2400 Source meter and Newport-1830C Optical power meter. The EL and photoluminescence (PL) spectra were taken with a monochrometer (PI instrument Spectra-pro 300i). The Commission International De L'Eclairage (CIE) coordinates were measured with Spectroradiometer (Minolta CS-1000).

3. RESULTS AND DISCUSSION

The novel hetero-cyclic bis-styryl dyes, PDV-DMI and PDV-AQ were synthesized according to phase-trasfer catalysis (PTC).

The UV-Vis absorption and normalized PL spectra of PDV-DMI and PDV-AQ thin films on glass substrates are shown in Figure 3. In the PDV-DMI

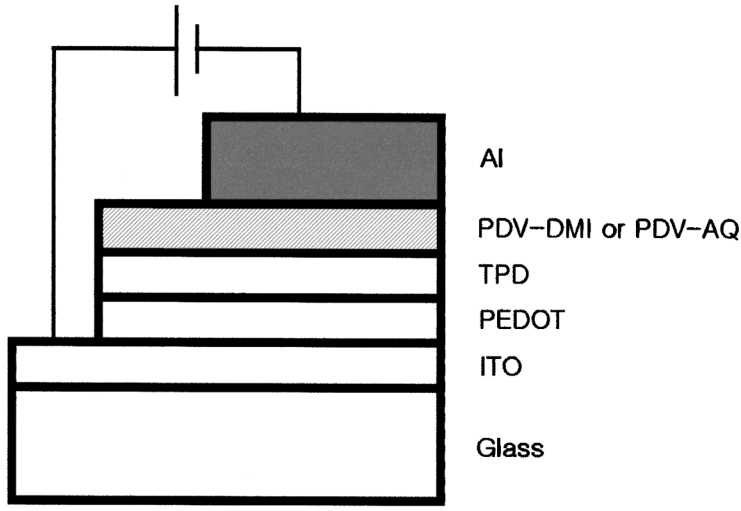

FIGURE 2 Schematic description of the OELD with PDV-DMI or PDV-AQ as an emissive material.

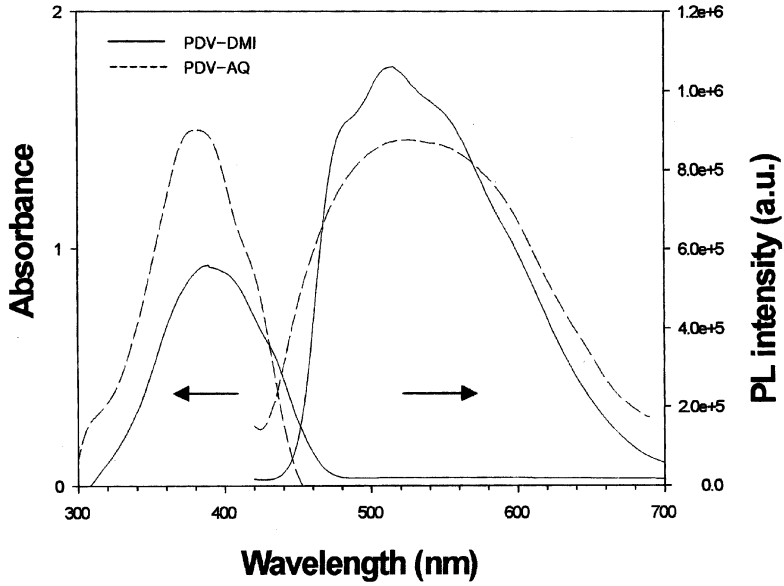

FIGURE 3 UV-Vis absorption and PL spectra of PDV-DMI and PDV-AQ thin films on glass substrates.

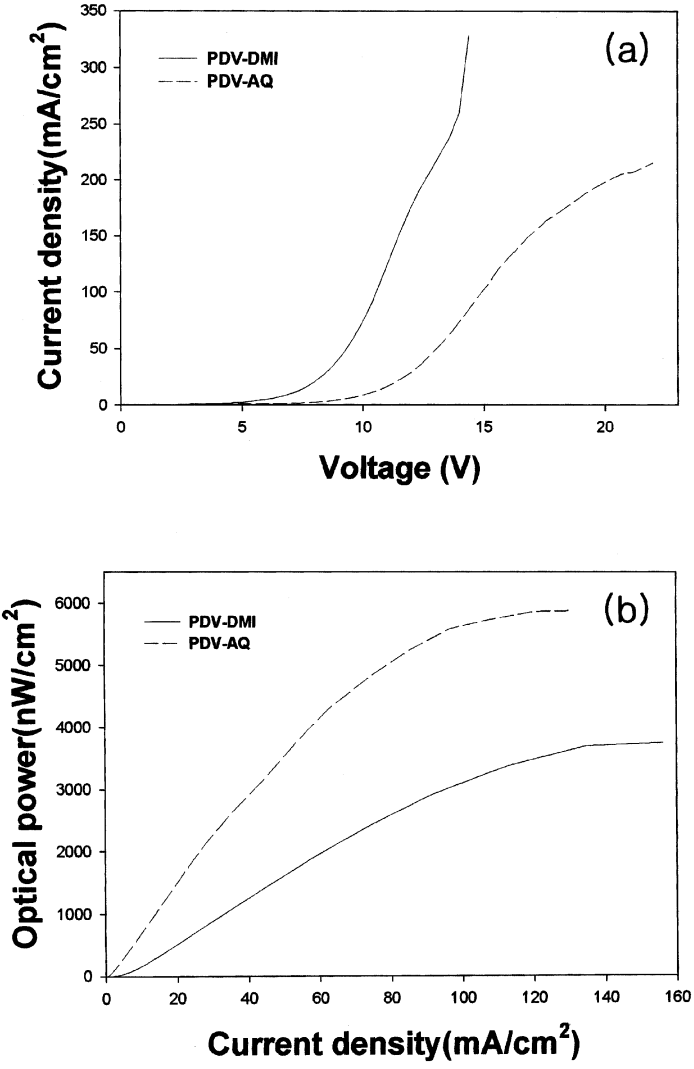

FIGURE 4 Current density-voltage-luminance characteristics of the EL devices (a) Applied voltage – current density characteristics of the EL devices with PDV-DMI and PDV – AQ, (b) Luminance – current density characteristics of the EL devices with PDV-DMI and PDV-AQ.

and the PDV-AQ thin film, the maximum peaks of UV-Vis absorption are at 389 nm and 380 nm, respectively. Normalized PL spectra of PDV-DMI and PDV-AQ thin films on glass substrates show a broad peak with long range. In the PDV-DMI and the PDV-AQ thin film, maximum peaks of PL spectra are at 503 nm and 516 nm, respectively.

Figure 4(a) shows the characteristics of applied voltage – current density of the EL devices with PDV-DMI and PDV-AQ. Turn-on voltages of the OELDs with PDV-DMI and PDV-AQ are about 4 V and 7 V, respectively. The current density of PDV-DMI and PDV-AQ has 330 mA/cm^2 and 85 mA/cm^2 at same voltagev of 14.5 V, respectively. That is the current density of PDV-DMI shows about four-times of PDV-AQ at 14.5 V.

The characteristics of luminance – current density of the OELDs with PDV-DMI and PDV-AQ are shown in Figure 4(b). The brightness of the EL diodes with PDV-DMI or PDV-AQ shows a maximum about 3700 nW/cm^2 at 156 mA/cm^2 and 6000 nW/cm^2 at 130 mA/cm^2, respectively. Although current density of PDV-DMI is higher about 1.2-times then that of PDV-AQ in maximum brightness, the luminescence characteristics of OLED with PDV-AQ is better about 1.6 times than that PDV-DMI. Figure 5 shows the normalized EL spectra of the OELDs with PDV-DMI (solid line) and PDV-AQ (dashed line). In the OLED with PDV-DMI and PDV-AQ, the maximum peaks of EL emission are located at 615 nm and 592 nm, which are corresponding to red and orange-red emission, respectively. Both of

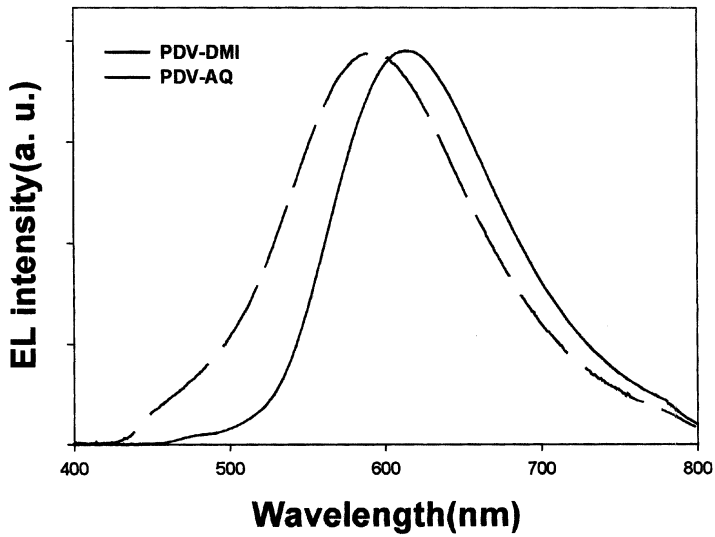

FIGURE 5 Electroluminescence spectra of the EL devices with PDV-DMI and PDV-AQ.

them show apparently red-shifted. The CIE coordinates of PDV-DMI and PDV-AQ are $x = 0.5635$, $y = 0.4277$ and $x = 0.4725$, $y = 0.4640$, respectively.

4. CONCLUSION

We reported the optical and electrical characteristics of novel phenylamine derivatives, PDV-DMI and PDV-AQ, as an emitting layer for OELDs. The brightness of the EL diodes with PDV-DMI or PDV-AQ had a maximum peak about 3700 nW/cm^2 at 156 mA/cm^2 and 6000 nW/cm^{2}at 130 mA/cm^2, respectively. The OELD with PDV-AQ shows the better emission property compared than one with PDV-DMI.

The maximum peaks in the EL spectra of PDV-DMI and PDV-AQ were at 615 nm and 592 nm, which are corresponding to red and orange-red emission, respectively. The CIE coordinates of PDV-DMI and PDV-AQ are $x = 0.5635$, $y = 0.4277$ and $x = 0.4725$, $y = 0.4640$, respectively.

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