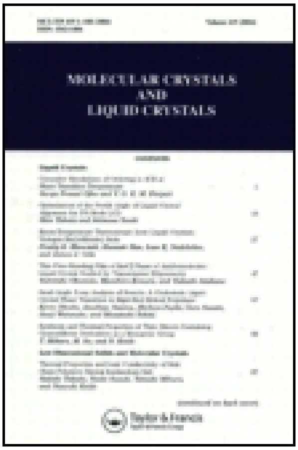


Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

The Characteristics of the Monomer Fluorene Derivative in Electroluminescent Devices

Jiwon Shin [a] , Donsoo Choi [a] & Dong-Myung Shin [a]
[a] Department of Chemical Engineering, Hong-Ik University, 72-1, Sangsu-dong, Mapo-gu, Seoul, 121-791, Korea

To cite this article: Jiwon Shin, Donsoo Choi & Dong-Myung Shin (2001): The Characteristics of the Monomer Fluorene Derivative in Electroluminescent Devices, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 370:1, 17-22

To link to this article: http://dx.doi.org/10.1080/10587250108030029

Mol. Cryst. and Liq. Cryst., 2001, Vol. 370, pp. 17-22

The Characteristics of the Monomer Fluorene Derivative in Electroluminescent Devices

JIWON SHIN, DONSOO CHOI and DONG-MYUNG SHIN

Department of Chemical Engineering, Hong-Ik University,
72-1, Sangsu-dong, Mapo-gu, Seoul, 121-791, Korea

Abstract

The fluorene derivative included in polymers has been reported to emit highly efficient blue luminescence electroluminescent devices (ELDs). The monomer fluorene derivative is advantage of over the polymers in term of easy processability and long term stability. The characteristic emission peaks observed at around 500nm from the devices with and without 8-Hydroxyquinoline aluminum salt (Alq_3) was studied. The fluorescence from 2-(4-biphenylyl)-5(4-tert-butyl-phenyl)-1,3,4-oxadiazole (PBD) and fluorene derivative did not extend over 500nm. The low energy transition at 500nm observed from the ELDs, was very similar with the results obtained from the device of ITO/CuPc/TPD/PBD/Al. The characteristic low energy peaks can be resulted from the local electric field generated by the space charge under the high electric field. The device stability was improved when the PBD layer layered over the fluorene derivative. The improvement can be correlated with the smooth surface of PBD over the fluorene derivative.

Keywords electroluminescent devices (ELDs), the fluorene derivative, aggregation, excimer, electroluminescence spectrum

INTRODUCTION

For full-color and large-area flat panel displays, efficient ELDs emitting three primary colors, i.e., blue, green and red, are required. Although all three colors have been demonstrated in polymer ELDs, the ELDs using the monomer by thermal evaporation method need to design efficient blue emitting material. In usual letter, The ELDs using polymer fluorene derivatives showed blue emission. But the ELDs have aggregation in electroluminescence peak because of exciplex formation between the hole transport layer and electron transport layer and showed bathochromic shift. The bathocromic shift observed with blue emission monomer is of interest. We fabricated ELDs using the fluorene derivative, which has high fluorescence quantum efficiency and exhibits pure blue emission, which can be very important for device application [1~3]. The fluorene derivative did not emit light when it was in the single and double layer without carrier (hole and electrons) transport layer. The particular devices showed linear J-V (current density-voltage) curve. We analyzed the emission spectra with Gaussian fittng analysis.

EXPERIMENTAL

The fluorene derivative was supplied from Alabama University [3]. The fluorene derivative was further purified by the sublimation method [4]. The basic structure that we studied was ELDs structure: Anode/HTL/Emission layer/ETL/Cathode [5].

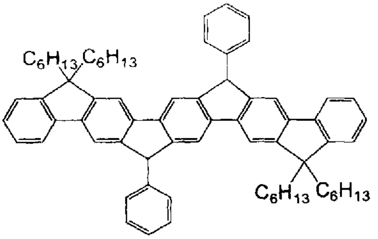


FIGURE 1 Molecular structure of fluorene derivative.

Device 1: ITO/TPD (40nm)/fluorene (30nm)/Alq_3 (30nm)/LiF (0.6nm)/Al (200nm)

Device 2: ITO/TPD (40nm)/fluorene (50nm)/ Alq_3 (10nm)/ LiF (0.6nm)/Al (200nm)

Device 3: ITO/TPD (40nm)/fluorene (50nm)/PBD (10nm)/ LiF (0.6nm)/Al (200nm)

TPD (N,N'-Diphenyl-N,N'-di(m-tolyl)-benzidine) was used as a whole transport material. Alq_3 and PBD were used as electron transport materials. All organic materials were evaporated at 10^{-6} torr by means of ultra high vacuum (UHV) system. Ultraviolet-visible (UV-VIS) absorption spectra of the fluorene derivative were measured using a HP 8452 UV-VIS spectrophotometer. The PL and EL spectra were measured by PERKIN ELMER Luminescence spectrometer LS50B. The electrical characteristics of EL devices were determined by programmable Keithley 236 SMU electrometer.

RESULTS AND CONCLUSION

Broad PL band at around 500nm observed from the fluorene derivative was removed after purification with train sublimation method. The Fig 2 showed that the band width of the fluorene derivative becomes narrow and has maximum at 437nm.

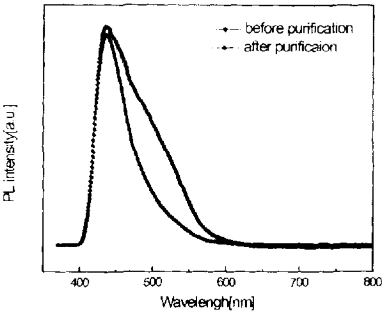
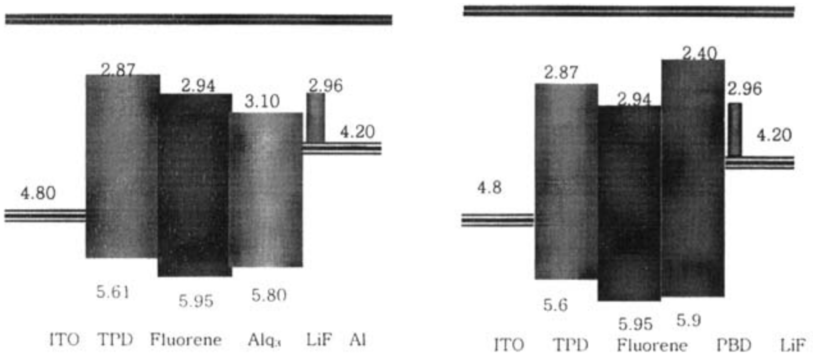


FIGURE 2. Photoluminescence (PL) of fluorene derivative.

The ELDs were fabricated with several different structures containing single layer (ITO/the fluorene derivative/Al), double layer (ITO/HTL/the fluorene derivative/Al) and multilayer (ITO/HTL /the fluorene derivative/ETL/Al). The single and double layer had linear J-V (current density-voltage) curve, which indicated that the device did not show diode character. The devices also did not emit light under electric filed. The lack of exciton formation may due to the fast transit time of holes through the single and double layer structure. The energy band diagram of devices was obtained by means of cyclic-voltammetry (CV) and constant current potentiometric stripping analysis (CPSA) method, in Fig 3. The energy band diagrams show that the device with Alq_3 incurs lower energy barrier for conducting electrons than that with PBD, which produce higher energy barrier for electron injection from aluminum. We compare the J-V characteristics of the devices with Alq_3 and those with PBD. The turn-on voltage is higher for the devices with PBD, which has higher energy barrier for electron injection. The EL spectra of device 1 and device 2 are similar. The turn-on voltage, 7V, and J-V characteristics are also very close. The device 3 without Alq_3,

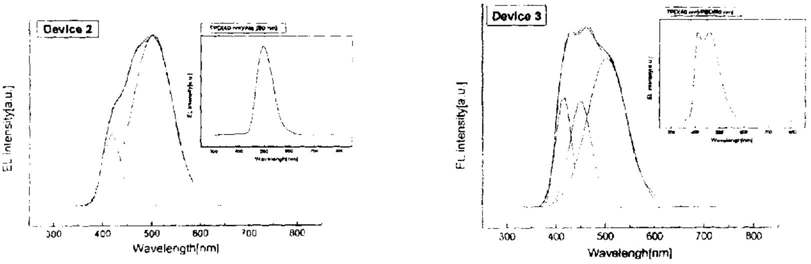


ITO/TPD/fluorene derivative/Alq_3
ITO/TPD/fluorene derivative/PBD
FIGURE 3. Energy band diagram of materials used for ELDs.

has 500nm emission, which can be characteristic emission form Alq_3. Figure 5 shows the relative intensity of 420nm, 460nm and 500nm of device 2 and 3 [6]. The large bathochromic shift of fluorene from 437nm to 500nm can be due to the formation of electric field induced dimer formation. When the thickness of HTL is 80nm, blue EL intensity of device was about 30% in comparison with green emission intensity. The relatively high green emission may due to the formation of the field-induced dimer on top of the emission from Alq_3. The field induced dimer formation is under investigation. The fluorene derivative formed crystalline after evaporation and the interface roughness of organic materials was reduced. The instability of PBD was improved with the layer of fluorene derivative [7].

In conclusion, the characteristic emission peaks observed at around 500nm from the devices with and without Alq_3. The fluorescence from PBD and fluorene derivative did not extend over 500nm. The characteristic low energy peaks can be resulted from the local electric field generated by the space charge under the high electric field. The device stability was improved when the PBD layer layered over the fluorene derivative. Also the fluorene derivative improved the morphology of the organic material in ELDs.

FIGURE 5. EL spectra and Gaussian fitting curves of device 2 and 3.



Acknowledgement

This work was supported by KRF.

REFERENCES

1. Olivier Stephan, Jean-Claude Vial, Synthetic Metals, **106**, 115(1999).

2. Xuezhing Jiang, Sen Liu, Hong Ma, Alex K.-Y. Jen, Appl. Phys. Lett., **76**, 1813(2000).

3. Chuanjun Xia, Seiji Inaoka, Rigoberto C. Advincula, Polymer Preprints, **41**, 859(2000).

4. Karl-Heinz Weinfurtner, Hisayoshi Fujikawa, Shizuo Tokito and Yasunori Taga, Appl. Phys. Lett., **76**, 2502(2000).

5. J.Kalinowski, G. Giro, M. Cocchi, V. Fattori and P.Di Macro, Appl. Phys. Lett., **76**, 2352(2000).

6. Won-Jun Song, Opt. Eng., **39**, 653(2000).

7. Homer Antoniadis, Mike Inbasekaran and Edmund P. Woo, Appl. Phys. Lett., **73**, 3055(1998).