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

Study on the Optical and Electrical Properties of Eu Complex in Organic Electroluminescent Devices

Sang Pil Lee [a], Jun Ho Kim [a], Han Sung Lee [a], Jung Soo Kim [a], Young Kwan Kim [b], Hyun Sue Hoe [c], Seung Hee Lee [c] & Tae Hyoung Zyung [d]

[a] Department of Electrical & Control Engineering, Hong-Ik University, 72-1, Snagsu-Dong, Mapo-Gu, Seoul, 121-791, KOREA

[b] Department of Chemical Engineering, Hong-Ik University, 72-1, Snagsu-Dong, Mapo-Gu, Seoul, 121-791, KOREA

[c] Department of Industrial Chemical Engineering, Hong-Ik University, 72-1, Snag-su Dong, Mapo-Gu, Seoul, 121-791, KOREA

[d] Electronic and Telecommunication Research Institute, Yusong, P.O Box 106, Taejon, 305-600, KOREA

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2000, Vol. 349, pp. 409-412
Reprints available directly from the publisher
Photocopying permitted by license only

Study on the Optical and Electrical Properties of Eu Complex in Organic Electroluminescent Devices

SANG PIL LEE[a], JUN HO KIM[a], HAN SUNG LEE[a], JUNG SOO KIM[a], YOUNG KWAN KIM[b], HYUN SUE HOE[c], SEUNG HEE LEE[c] and TAE HYOUNG ZYUNG[d]

[a]*Department of Electrical & Control Engineering, Hong-Ik University, 72–1, Snagsu-Dong, Mapo-Gu, Seoul 121–791, KOREA,* [b]*Department of Chemical Engineering, Hong-Ik University, 72–1, Snagsu-Dong, Mapo-Gu, Seoul 121–791, KOREA,* [c]*Department of Industrial Chemical Engineering, Hong-Ik University, 72–1, Snag-su Dong, Mapo-Gu, Seoul 121–791, KOREA and* [d]*Electronic and Telecommunication Research Institute, Yusong, P.O Box 106, Taejon 305–600, KOREA*

A novel europium complex, $Eu(TTA)_3(TPPO)$ was synthesized and its photoluminescent and electroluminescent characteristics were investigated with a device structure of ITO/TPD/$Eu(TTA)_3(TPPO)$/Alq_3/Al, where a sharp emission at the wavelength of 615 nm was observed.

Keywords: Organic electroluminescent devices; Europium complexes

INTRODUCTION

Organic electroluminescent devices (OELDs) are of great interest because of their efficient emission in the visible region and their possible application to a new type of flat-panel full-color display. These devices are an injection type and show a low driving voltage of less than 10V[1,2]. Europium (Eu) complex is one of the promising candidate for sharp red emissive materials in

OELDs[3,4]. Since Eu complexes emit red light at 615nm from Eu^{3+} ion via an intramolecular energy transfer from the triplet of the organic ligand to the 4f energy state of the Eu^{3+} ion, the theoretical internal quantum efficiency is principally not limited. Sano et al. reported that the luminance of the device using the Eu complex as a dopant was higher than that of the device using the Eu complex as a emitting material[5]. In this study, we synthesized a novel Eu complex, $Eu(TTA)_3(TPPO)$ [tris-(4,4,4-trifluoro-1-(2-thienyl)-butane-1,3-dionate)-triphenyl phosphine oxide europium(III)], which was used as a red emissive material in OELDs. Electrical and EL characteristics of this Eu complex was investigated.

EXPERIMENTAL DETAILS

FIGURE 1 shows the molecular structures of the materials and the configurations of the OELDs used in this study, respectively. The OELDs were prepared as follows: The Eu complex was used as the emitting layer (EML) between a hole-transporting layer (HTL), TPD and a electron-transporting layer (ETL), Alq_3.

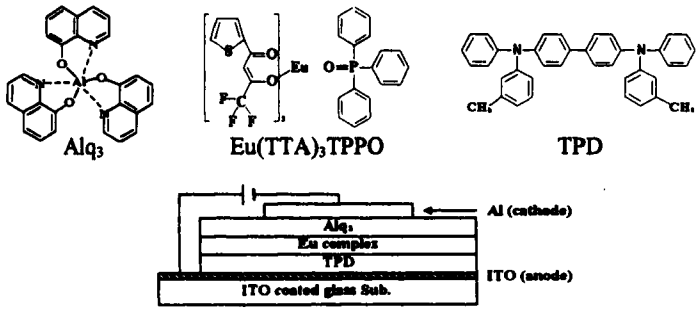


FIGURE 1 The molecular structures of the material and configuration of the OLEDs in this study.

The structure of the triple-layer OELD was a glass substrate/ITO anode/HTL (TPD = 40 nm)/EML (Eu complex = 5 nm)/ETL (Alq_3 = 30 nm)/cathode Al (150 nm). The organic layers and Al cathode were successively vacuum deposited onto indium-tin oxide (ITO)-coated glass (Samsung Corning Co., Ltd.) substrate at 5×10^{-6}Torr. The device area was $25mm^2$. All measurements were performed at room temperature in air.

RESULTS AND DISCUSSION

FIGURE 2 shows the EL spectrum of OELD with a device structure of glass substrate/ITO/HTL/$Eu(TTA)_3(TPPO)$/ETL/Al and the PL spectrum of $Eu(TTA)_3(TPPO)$ film itself. It can be seen that the sharp photo-luminescence peak in the spectrum of this complex has a half spectral bandwidth of about 5-7 nm. This means that the luminescent color purity is excellent and the color filter may not be necessary. Therefore, Eu complex can be best suited for the actual flat panel display application as a red emitting material if its high power efficiency level can be achieved.

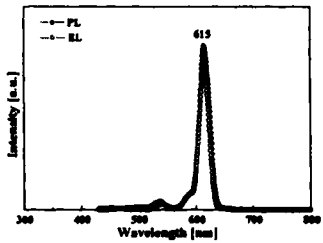
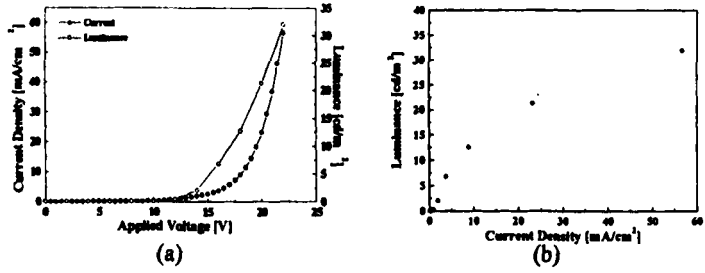


FIGURE 2 EL spectrum of an ITO/TPD/ $Eu(TTA)_3(TPPO)/Alq_3$/Al (open circle) and PL spectrum of $Eu(TTA)_3(TPPO)$ (solid circle).

It was shown in this figure that the EL spectrum of OELD containing $Eu(TTA)_3(TPPO)$ shows a sharp luminescence in a red region with maximum emission at about 615 nm, and almost coincides with its PL spectrum. The electrons injected from the Al cathode move to the lowest unoccupied molecular orbitals (LUMO) states of the Alq_3 and are transferred to the LUMO state of the ligand of $Eu(TTA)_3(TPPO)$. The injected holes from the ITO anode are transmitted to the highest occupied molecular orbital (HOMO) states of the ligand of $Eu(TTA)_3(TPPO)$ via LUMO state of TPD. Excitons are formed at the ligand sites of $Eu(TTA)_3(TPPO)$ and are transferred to the Eu^{3+} sites. The energy relaxation from ^5D to ^7F states in Eu^{3+} sites results in sharp emission at 615 nm. FIGURE 3 shows the dependence of the injection current and luminance on the applied voltage in triple-layer OELD under the forward bias condition. The current density increased super-linearly with increasing applied voltage under the forward bias condition. The emission intensity reaches 32 cd/m^2 at the injection current density of 56 mA/cm^2. The EL power efficiency at this condition was

calculated to be 3.7×10^{-2} lm/W at 16V and 3.7 mA/cm^2. The dependence of luminance on applied voltage is similar to that of injection current.



(a) (b)

FIGURE 3 Current density-voltage, luminance-voltage characteristics and luminance-current density characteristics of OELD with a ITO/TPD/ $Eu(TTA)_3(TPPO)/Alq_3/Al$ structure.

CONCLUSIONS

A novel volatile Eu complex was synthesized and its EL characteristics was investigated using a triple-layer OELD. A very sharp EL spectral band at the wavelength of 615 nm and bright red light with maximum luminance of 32 cd/m^2 were observed.

Acknowledgements

This work was fully supported by ETRI(Electronics and Telecommuncations Research Institute).

References

[1] C.W. Tang, S.A. VanSlyke, Appl. Phys. Lett. 51 (1987) 913.
[2] C.W. Tang, S.A. VanSlyke, C.H. Chen, J. Appl. Phys. 65 (1989) 3610.
[3] T. Tsutsui, N. Takada, S. Saito and E. Ogino, Appl. Phys. Lett. 65 (1994) 1868.
[4] J. Kido, H. Hayase, K. Hongawa, K, Nagai, K. Okuyama, Appl. Phys. Lett. 65 (1994) 2124.
[5] J. Sano, M. Fujita, T. Fujii, Y. Hamada, K. Shibata, K. Kuroki, Jpn. J. Appl. Phys. 34 (1995) 1883.