Novel Red Electroluminescent Material with Indandion Pyran Molecular Backbone

Dong Uk Kim, Yoon-Heung Tak*, Yoon-Soo Han*, Sang-Dae Kim*,Ki-Beom Kim*, Tae-Jeong Kim, Jeong-Ju Baek***, Lee-Soon Park*****

Department of Science Education, Daegu National University of Education, 1797-6, Taemyung-2 Dong, Nam-Gu,Taegu 705-715, South Korea

*** LG Electronics Inc.**

**** Department of Industrial Chemistry, Kyungpook National University**

***** Department of Polymer Science, Kyungpook National University**

Phone : +82-53-620-1344, E-mail : dkim@taegu-e.ac.kr

Abstract

Novel red organic electroluminescent (EL) dye, RED was developed for an application to the emission layer of EL device. Well known red material DCJTB was also used for comparison . Two kinds of devices were fablicated; one is ITO/ CuPc / TPD / 0.5% RED-1 in Alq3/ Alq3/ Li2O/ Al and the other is ITO/ CuPc / TPD / 0.5% DCJTB in Alq3/ Alq3/ Li2O / Al. External quantum efficiency of the EL device with RED was two times higher than that of the device with DCJTB. The maximum EL peak was detected at 635nm in the RED EL device.

1. Introduction

Recently organic electroluminescent (EL) research has been active both on the basic science and application to flat panel display. DCJTB shown in Fig.1 is one of well known red-emitting materials in which two cyano groups as an electron withdrawing group and one amino group as an electron donating group are connected though π -bond in the molecular backbone. Because of these two kinds of groups, this compound is expected to have not only charge transport and injection capabilities but also the high emission efficiency. In this study, we focused on developing red fluorescent materials with high efficiency and durability under the working conditions of EL device.

2. Experimental

2. 1 Material design and Device Fabrication

On the basis of molecular structure of DCJTB, a new compound 4-(1',3'-indandione)-2-p-piperidine-styryl-6-methyl-4H-pyran, RED (Fig.1) was designed.

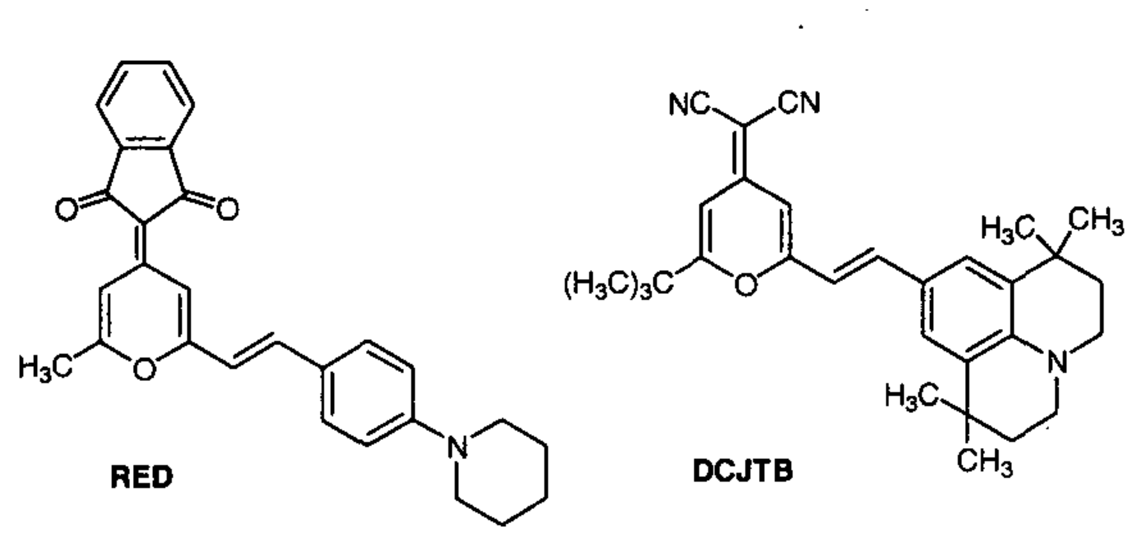


Fig. 1. Molecular structures of RED and DCJTB

The synthetic route to RED is briefly shown in Figure 2. The detailed synthetic methods and analytical data of RED will be published elsewhere.

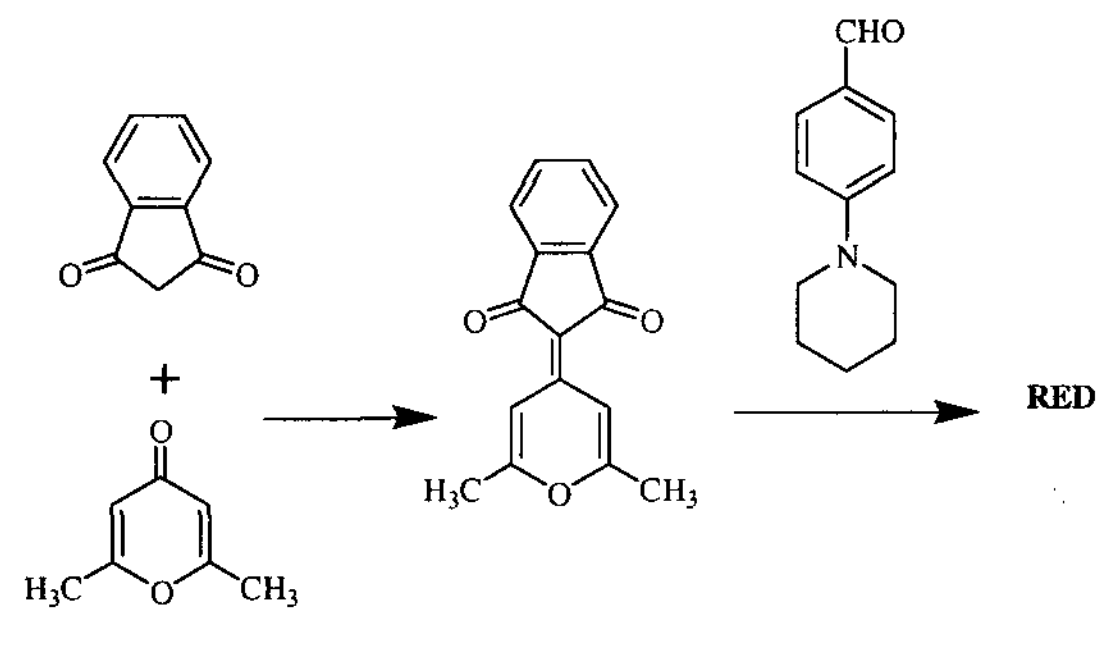
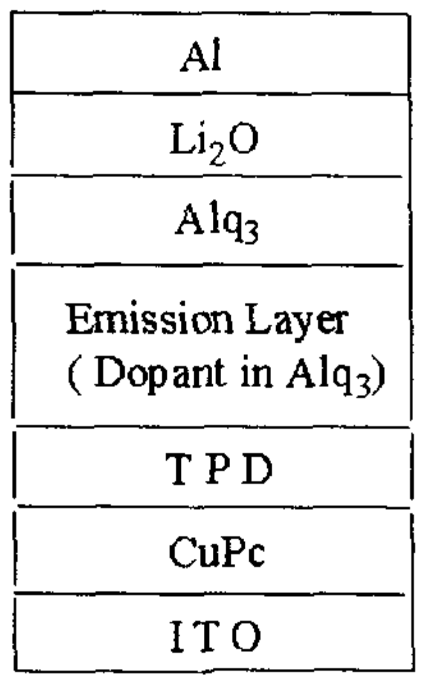
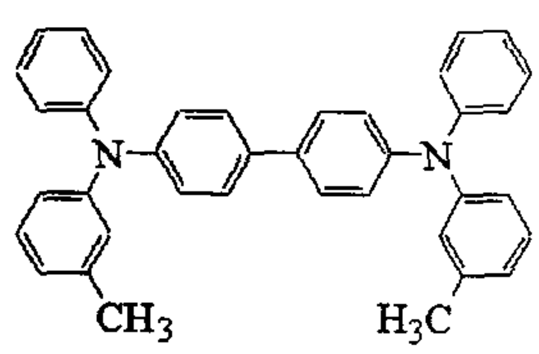


Fig. 2. Synthetic route of RED

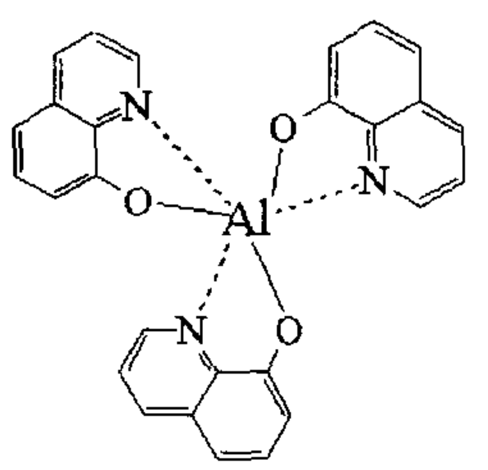
Figure 3 shows the EL device structure used in this experiment. The devices were fabricated by the thermal vacuum deposition method onto the Indium Tin Oxide (ITO) electrode. Copper-phthalocyanine (CuPc) and Li_2O (lithium oxide) were adopted as a hole injection layer and an electron injection layer, respectively. 4,4'-bis[(3-methyl phenyl) phenylamino] biphenyl (TPD) and 8-hydroxy quinolinato aluminum (Alq_3) were used as a hole transport layer and an electron transport layer, respectively. The emission layer was made by the co-deposition of RED (0.5%) or DCJTB (0.5%) in Alq_3 host matrix . Aluminium (Al) was deposited as a cathode electrode. The device configuration and thickness of the layers were as follows: ITO/ CuPc (30 nm) / TPD (30 nm) / 0.5% RED; 0.5% DCJTB in Alq_3 (20 nm) / Alq_3 (20 nm) / Li_2O (1 nm) / Al (200 nm).



Device Structure



TPD



Alq_3

Fig. 3. Device structure

3. Results and Discussion

Electro-optical characteristics of RED material were evaluated in comparison with DCJTB in the EL devices fabricated under same conditions. The structure of each device is as following ; RED device, ITO/CuPc/TPD/0.5% RED in Alq_3/Alq_3/Li_2O/Al and DCJTB device, ITO/CuPc/TPD/0.5% DCJTB in Alq_3/Alq_3/Li_2O/Al. The device structures and layer-thickness of two devices were exactly the same expect fluorescent dopants, RED and DCJTB.

Current density vs luminance characteristics of two devices are revealed in Figure 4. RED device exhibited luminance of 513 cd/m^2 at 20 mA/cm^2 under 8.1 voltage and DCJTB device showed about 498 cd/m^2 at the same current density. The brightness of RED was not less than that of DCJTB. In both devices the luminance intensity increased linearly with the increase of the current density.

The characteristics of current density vs power efficiency between the RED and DCJTB devices are shown in Figure 5. The power efficiency of 1.01 lm/W was observed in the RED device and that of 0.99 lm/W from the DCJTB device at the current density of 20 mA/cm^2.

The EL spectra of both devices are shown in Figure 6. The highest EL peak for RED and DCJTB devices appeared at 635 and 610 nm, respectively. This result indicate that the color purity of RED is better than that of DCJTB and closer to the deep red.

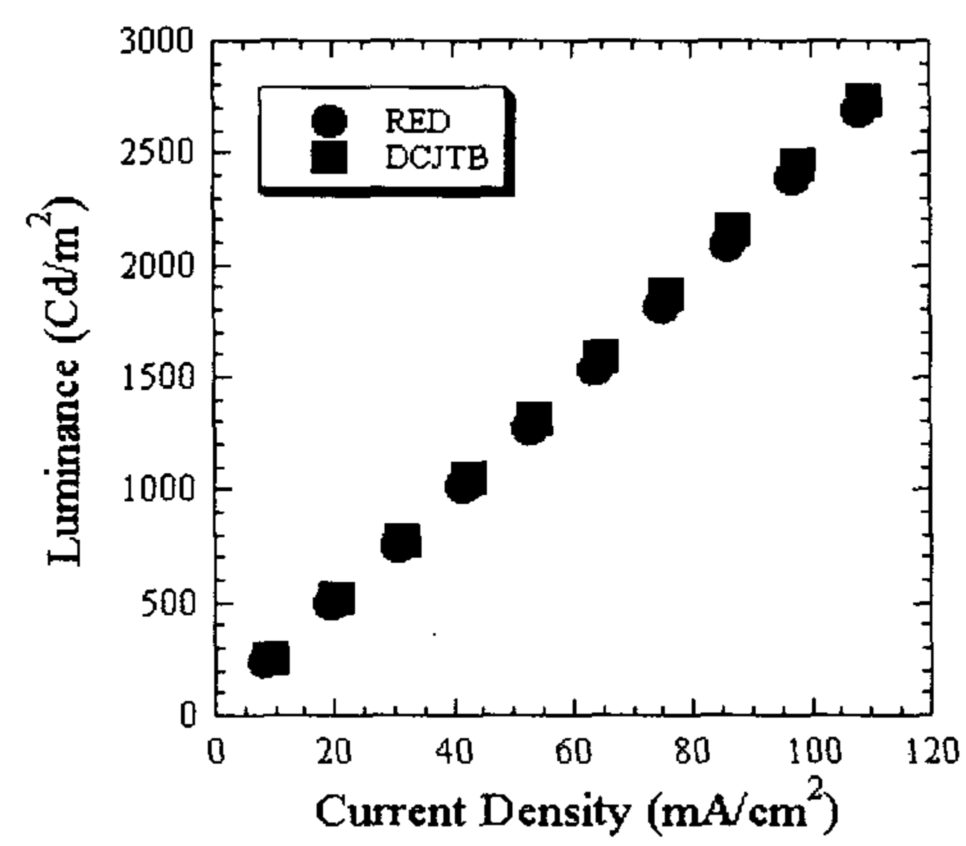


Fig. 4. Current density vs luminance characteristics of DCJTB and RED devices

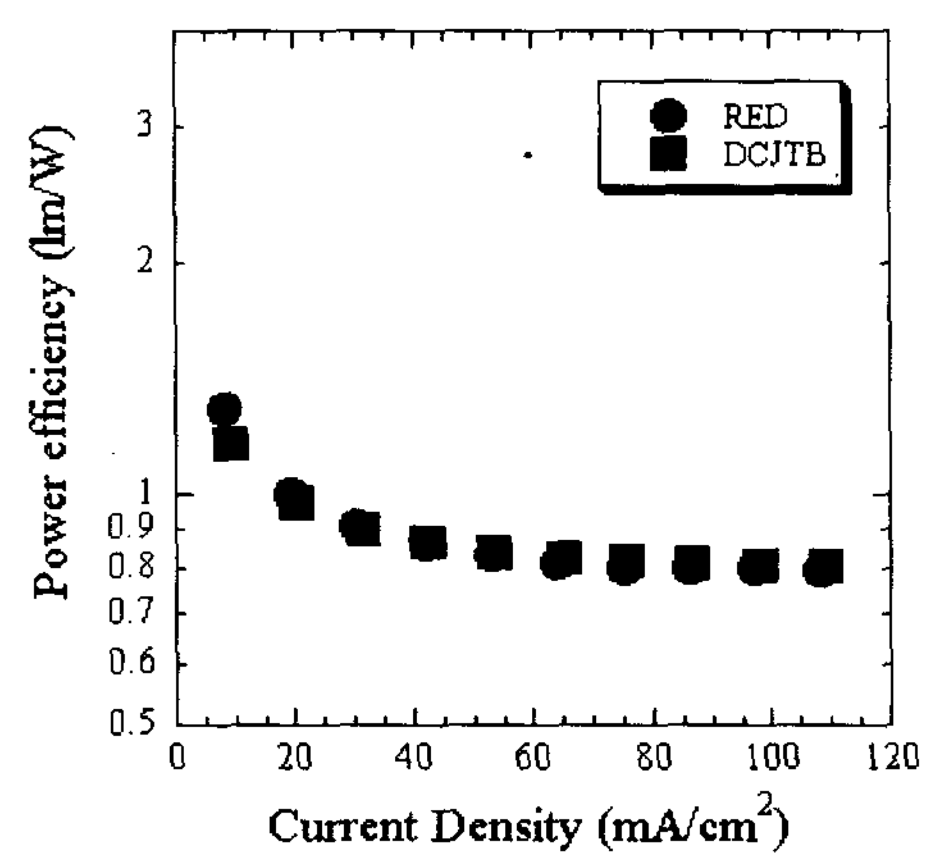


Fig. 5. Current density vs power efficiency characteristics of DCJTB and RED devices

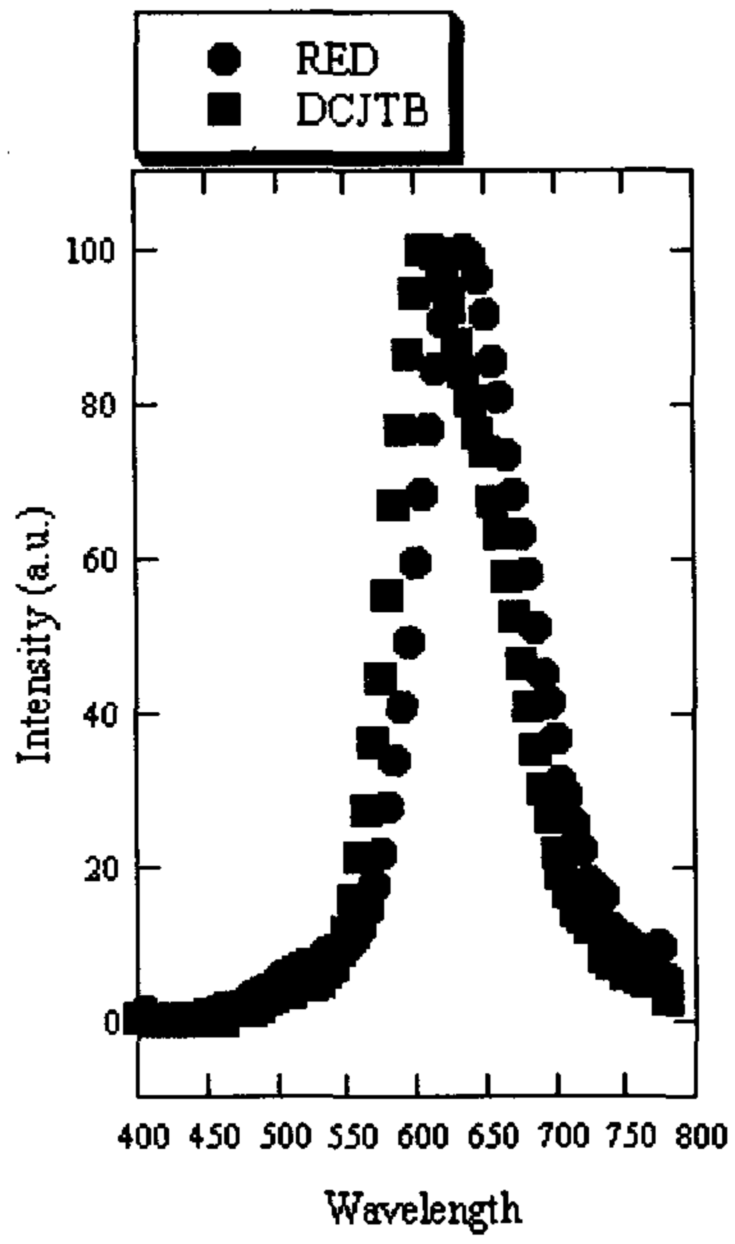


Fig. 6. EL spectra of DCJTB and RED devices

4. Conclusion

We developed a novel RED material, which was evaluated to be an excellent red emission material in EL device. This high performance was considered to be due to the bipolar characteristics of RED molecular structure

5. Acknowledgements

This work was supported by grant No. (R12-2002-055-01003-0) from the Basic Research Program of the Korea Science & Engineering Foundation

6. Reference

[1] C. W. Tang and S. A. VanSlyke, Appl. Phys. Lett., 51 (1987) 913.

[2] C. Adachi, S. Tokito, T. Tsutsui, and S. Saito, Jpn. J. Appl. Phys., 27 (1988) L296.

[3] J. H. Burroughes, D. D. C. Bradley, A. R. Brown, R. N. Marks, K. Mackay, R. H. Friend, P. L. Burns, and A. B. Holmes Nature, 347 (1990) 539.

[4] D. Braun and A. J. Heeger, Appl. Phys. Lett., 58 (1991) 1982.

[5] P. E. Burrows, V. Bulovic, S. R. Forrest, L. S. Sapochak, D. M. McCarty, and M. E. Thompson, Appl. Phys. Lett., 65 (1994) 2922.

[6] C. Hosokawa, H. Higashi, H. Nakamura, and T. Kusumoto, Appl. Phys. Lett., 67 (1995) 3853.

[7] A. Shoustikov, Y. You, and M. E. Thompson, IEEE J. Sel. Top. Quan. Ele., 4 (1998) 3.