# Luminance Characteristics of a Novel Red-Light-Emitting Device Based on Znq2 and Dye

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In this study, a novel red emitting organic electroluminescent (EL) device was fabricated with the bis(8-oxyquinolino)zinc II (Znq2) doped dye as an emitting layer. The Znq2 was synthesized successfully from zinc chloride ($ZnCl_2$) as an initial material. Then, we fabricated the red organic EL device with a dye (DCJTB) doped and inserted Znq2 between emission layer and cathode for increasing EL efficiency. The hole transporting layer is a N,N'-diphenyl-N,N'-bis-(3-methylphenyl)-1,1'-diphenyl-4,4-diamine (TPD), and the host material of emission layer is Znq2. And the electrical and luminance characteristics of the device were measured. We found that the EL device with Znq2 inserting layer results in the increasing luminance efficiency.

*Keywords* : Organic EL device (OELD), Bis(8-oxyquinolino) Zinc II (Znq2), Red emitting layer, DCJTB (4-dicyanomethylene-6-c-julolidinostyryl-2-tert-butyl-4H-pyran), Dye dopant.

## 1. INTRODUCTION

Organic electroluminescent (EL) device is the self-radiative display luminated by electrical excitation of fluorescent organic compounds. Organic EL displays have excellent advantages such as low driving voltage, high recognition by the self-radiation, and ultra thin- and light-type. Recently, the problems of liquid crystal display (LCD), which has been attracted great interests as a flat panel display, is narrow viewing angle, late response time, and low luminous efficiency, etc. Because organic EL display is able to solve these problems, it is attractive as a new generation display candidate. Since C. W. Tang and S. A. VanSlyke reported the results for high efficiency and high brightness of organic EL devices, many studies have been made for recent decade. However, there are many problems to be solved for practical applications, and among them the luminescent efficiencies of red, green, and blue which is required to realize for full-color display are 3, 6, and 1 [lm/W], respectively. The luminescent efficiency level of green and blue color reaches the relatively satisfied value. But, that of red in the case of monomer luminous materials is about 1.5 [lm/W] and in polymer materials is 1.8 [lr These results in red color are very poor valu practical uses. In 1987, Tang and VanSlyke used or 8-hydroxyquionoline aluminium ($Alq_3$) which lumi the light in green region of 520 nm, and the va colors in the broad ranges from green to red color able to obtain by the doping of organic dye[1,2].

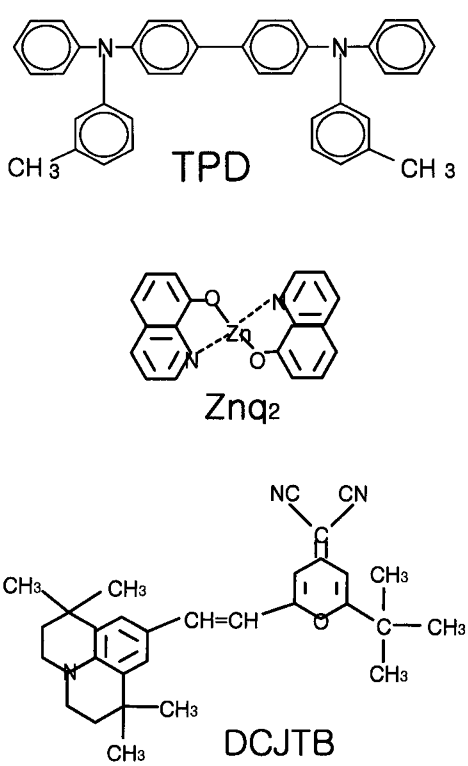
The 8-hydroxyquinoline Zinc ($Znq_2$) is attra luminous material in which has been reported luminance of 16,200 [cd/m$^2$] at the applied voltage V[3]. Because the band gap of red emission lay generally narrow for the red color device, a red emi assist (EA) dopant is added in the green emi material. Particularly, DCM family such as a D( shows the highest luminance and superior operat stability among the various red dopants, and appro nearly to the NTSC requirements[4].

In this paper, we fabricated the organic EL devices o color using Znq2 as a host material and DCJTB as dopant. The luminance and electrical characteristics as EL spectra, EL efficiency, I-V curve and V-L were investigated.

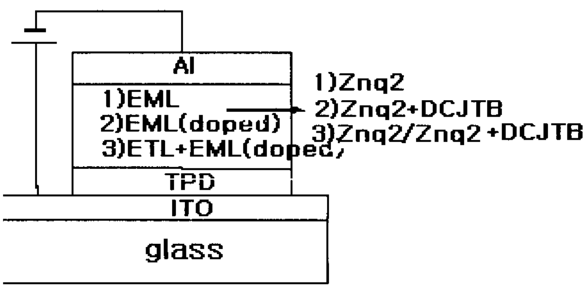
## 2. EXPERIMENTAL

### . Materials

Figure 1 shows the chemical structures of N, N'-›henyl-N, N'-bis-(3-methylphenyl)-1, 1'-diphenyl-4, liamine (TPD), Bis(8-oxyquinolino) Zinc II (Znq2), d DCJTB (4-dicyanomethylene-6-cp-j ulolidinostyryl-:ert-butyl-4H-pyran). The TPD was used as a hole nsporting layer, and purchased from TCI Co. LTD, ›an. The Znq2 as a host material of emission layer was ›pared successfully from zinc chloride as a starting ıterial. The DCJTB (Kodak Co.) as a red dopant was used for red emitting devices.




ʒ. 1. The chemical structure of organic materials (a) N, -diphenyl-N, N'-bis-(3-methylphenyl)-1, 1'-diphe nyl-l-diamine (TPD), (b) Bis(8-oxyquinolino) Zinc II nq2), and (c) DCJTB.




ʒ. 2. The configuration of organic EL device.

### 2.2 Preparation of EL devices

ITO-coated glass sheets with a sheet resistance of : Ω/□ were used as a positive electrode, and were rins‹ by ultrasonic cleaner within acetone and alcohol. Tl organic EL cell was deposited by the convention vacuum evaporator in a chamber at a pressure of 1( Torr. The growth rate of aluminum used as a catho‹ layer was 4-10 Å/sec under the same vacuu conditions of EL deposition, and its thickness was 2( nm. The active emission area of EL device provided 1› $cm^2$, and most of electrical measurements was perform‹ by the dc voltage condition at room temperature.

The brief configuration of organic EL device in th study is shown in fig. 2. The multi-layer devices f bricated in this paper for the comparison of luminan‹ properties are specified by three kinds of the followiı structures: Al(200 nm) /Znq2(60 nm)/TPD(60 nm)/IT‹ Al(200 nm)/Znq2+ DCJTB 2%(60 nm)/TPD(60 nm)IT and Al(200 nm) /Znq2(30 nm)/Znq2+DCJTB 2%(: nm)/TPD(60 nm) /ITO inserting Znq2 layer as ; electron transporting layer.

## 3. RESULTS AND DISCUSSION

### 3.1 Variation for DCJTB dopant

Figure 3 shows the photoluminescent (PL) spectru of Znq2 as an emitting material. The absorption pe; wavelength of 400 nm and the emission peak of ar ouı 535 nm were measured from the PL spectrum. Also tı PL spectrum of DCJTB is expressed in fig. 4. The F

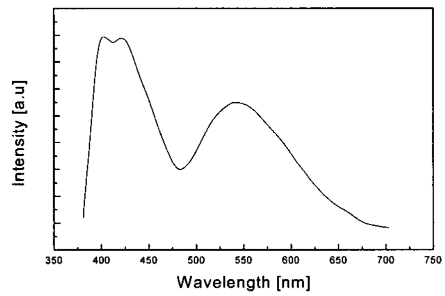



Fig. 3. PL spectrum of Znq2.

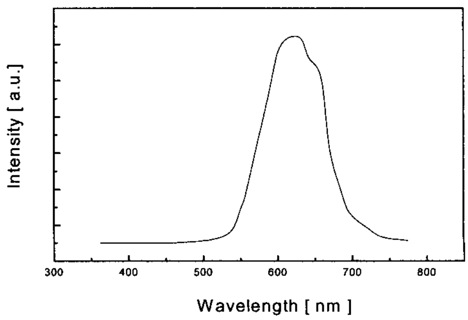



Fig. 4. PL spectrum of DCJTB.

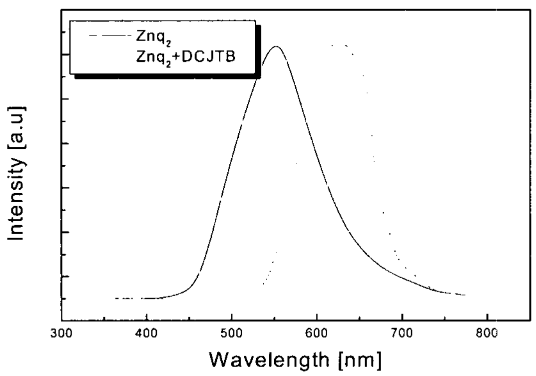
:ak wavelength of DCJTB is positioned at 630 nm as ıown in the figure.

Figure 5 presents the EL spectra of Znq2 emission :vices and the mixed layer of Znq2+DCJTB, adding an nitting dopant of red color such as DCJTB. The :vices with an emission layer of only Znq2 have the EL :ak at 550 nm, similar to the PL peak spectrum of Znq2 535 nm as shown in fig. 3. However, the EL spectrum ifts toward higher wavelength, as the DCJTB dopant is lded in the emitting layer. The EL peak of ıq2+DCJTB appears at 630 nm and, therefore, the :vice shows the luminescent characteristics of red color. 'actically, there is no comparison between the two ses directly, because Znq2 has the main emission of een while the device with DCJTB dopant has the main nission of red color[5].

The luminance in the Standard Visible Sensitivity dicates as a maximum 1, identifying the intensity at the avelength of 555 nm for light sensitivity that human :comes aware generally. Therefore, it cannot be flected exactly the intensity value of EL luminance. ıt fig. 5 shows that the peak amplitude is normalized bitrarily to a value of 1, to certify the shifted peak ıvelength.

### 2 Effect of electron transporting layer

The current density of EL devices as a function of ıplied voltage is shown in fig. 6. The current of EL :vice with DCJTB dopant is more difficult to flow than at of device without dopant as expressed in figure. ıus it means that the DCJTB molecular works as the rrier trap in Znq2[6]. However, as the DCJTB dopant added and an electron transporting layer of Znq2 is serted, the device is similar to the undoped devices. ıe Znq2 operates as an electron transporting layer, and e electrons caused by tunnel effects move into the ıitting layer of Znq2+DCJTB[7].




g. 5. EL characteristics with the variations of emitting yer.

Figure 7 describes the variations of EL spectrum devices with/without an electron transporting layer Znq2. Both devices with DCJTB represent the lumina properties with EL peaks at 630 nm, due to the addit of red DCJTB dopant. The device that inserts an elect transporting layer of individual Znq2 shows a little br peak at nearby 550 nm as EL spectrum of Znq2 in fig It means that a small amount of hole does not recomb in an emitting layer, and moves to the Znq2 layer recombines with electron in there.

Figure 8 shows the luminance properties as a functior applied voltage. As the DCJTB as a red dopant is add the luminance of device is lower than that of device us Znq2 as an emitting layer of green color.

Figure 9 shows the luminance efficiency versus pplied voltage relationships for three types of emiss layer as the following structures: Znq2, Znq2+DCJ (2%), and ZNq2/Znq2+DCJTB (2%). As the organic devices of red color have the Znq2 emission layer mix

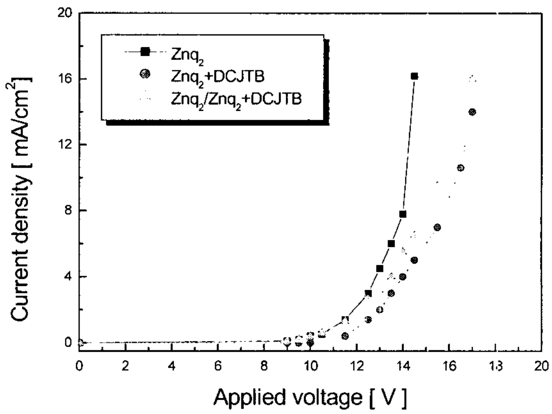



Fig. 6. Current density of EL devices as a function applied voltage.

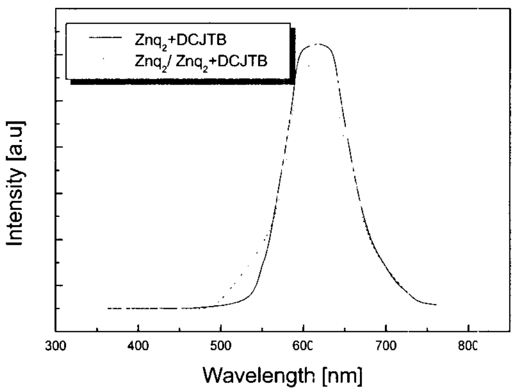
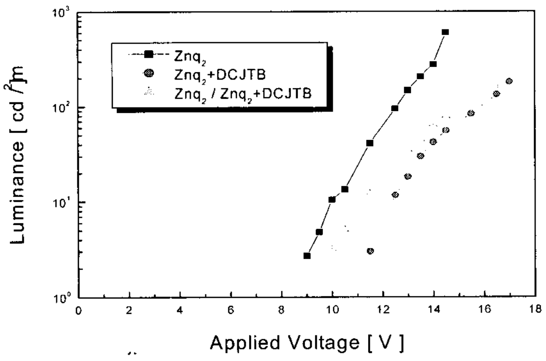
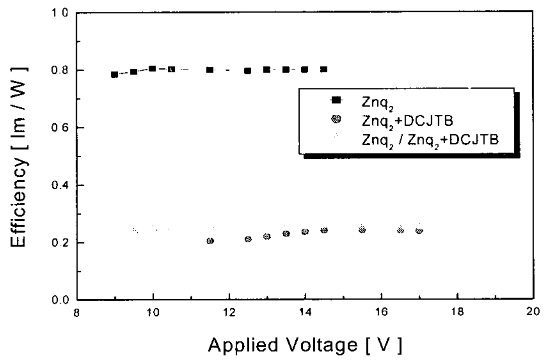



Fig. 7. EL spectrum in devices with an electron tra porting layer.




;. 8. Luminance properties as a function of applied ıtage.




;. 9. Luminance efficiency versus applied voltage ationships for three types of emission: Znq2, q2+DCJTB (2%), and ZNq2/Znq2+DCJTB (2%).

th DCJTB dopant of 2%, the maximum efficiency is '42 lm/W at the applied voltage of 15.5 V. The ıximum efficiency of ZNq2/Znq2+DCJTB structure ıibits 0.262 lm/W at 13.5 V. In order to obtain the :ter red EL devices as shown in fig. 9, the luminance iciency of red color is compensated by the inserting of :ctron transporting layer.

## 4. CONCLUSION

A novel organic EL device of red color was fabricated th the Znq2 doped with DCJTB of 2% as an emitting 'er. The Znq2 as a host material was synthesized :ccessfully from zinc chloride ($ZnCl_2$). The devices th an emission layer of only Znq2 have the main peak 550 nm, while the peak of Znq2+DCJTB appears at 0 nm. Therefore, the device shows the excellent red lor purity and, however, the luminance and efficiency relatively poor. Then, as we fabricated the red organic , device of ZNq2/ Znq2+DCJTB structure having the :ctron transporting layer of Znq2, the luminance is improved and then the EL efficiency is increased. Tl color purity is degraded minutely due to the emission the inserted Znq2 layer. But the device without Zn( layer has also the infinite small peak at nearby 550 nm. would be cut off the holes toward the cathode, if the ho blocking layer was prepared. Then it will be possible th the recombination rates between electrons and holes a increased, and the high color purity is maintaine Therefore, if the choice for proper blocking material searched closely, the efficiency of red emission devic will be improved.

## ACKNOWLEDGMENTS

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