Advanced Organic LED Materials for the Excellent Organic LED Displays

Toshio Enokida
FC Development Center, Toyo Ink Mfg.Co.,Ltd., Wadai 27, Tsukuba, Ibaraki 300-4247, Japan
Phone: 81-298-64-4501, E-mail: toshio.enokida@toyoink.co.jp

Tae-Sun Gwon
Dept. of Multimedia, Univ. of Kyungwoon, 55 Induk-ri, Sangdong-myun, Kumi, Kyungbuk 730-852, Korea
Phone: 82-18-343-7950, E-mail: tsgwon@hanmail.net

Abstract

In this paper, we explain the materials of the advanced organic light emitting diode(OLED) for the excellent OLED displays. We have been designed the various kinds of organic materials like as the hole-injecting materials (HIMs), the hole transporting materials(HTMs), the light emitting materials(LEMs), and the electron injecting materials(EIMs). As the results, we found the excellent materials and their combinations for the OLED displays.

1. Introduction

Research on the OLEDs has attracted considerable attention since Tang and VanSlyke first reported OLED's which had a high luminance and low voltage[1]. Many researchers have been developed the organic materials for the OLED displays. We believe the importance of the combination with the each materials used in the organic layers. One goal in the research on the OLED is to develop the full-color displays. For obtaining the higher driving efficiencies, it is important to develop the light-emitting materials for each of these three colors. In addition, the development of the carrier injecting materials, such as hole and electron, is also very important for the excellent OLEDs. OLED displays with extremely high luminance and high efficiency have been demonstrated from ten years ago. Therefore, OLED's are expected to find applications in full-color and very thin display. We hope the success of the development with the OLED displays as the flat panel displays of several kinds of mobile-instruments in near future.

In this paper, we would like to explain with our OLED materials and the results of the OLED performances for the excellent OLED displays. And, we hope to suggest the excellent material for the advanced OLED displays.

2. Organic LED Materials

2.1 Hole Injecting Materials(HIMs)

When HIMs are designed,it is necessary to consider the following factors:

1) hole-injecting ability from ITO electrode;
2) hole-transport ability to hole-transport layer(HTL) or light-emitting layer(LEL);
3) thermal stability.

We designed to several kinds of copper phthalocyanine(CuPc) as the thermal stable HIMs. Emitting life of the OLEDs, used CuPc as the HIM, is longer than other ones used the usual aromatic amine derivatives. However, the color purity is not so well, for the full color displays. We developed the new HIM instead of the CuPc. The new HIM shows the excellent OLED performances. Figure 1 shows the comparison of the OLED efficiencies used newly developed HIM and CuPc as the HIMs.

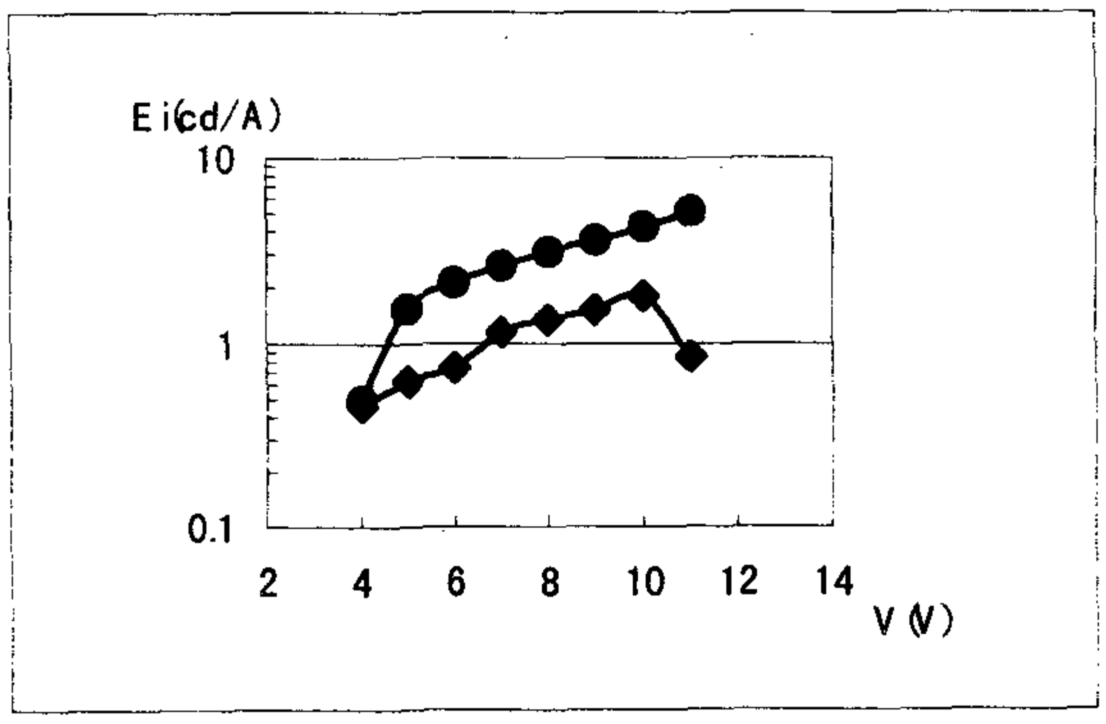
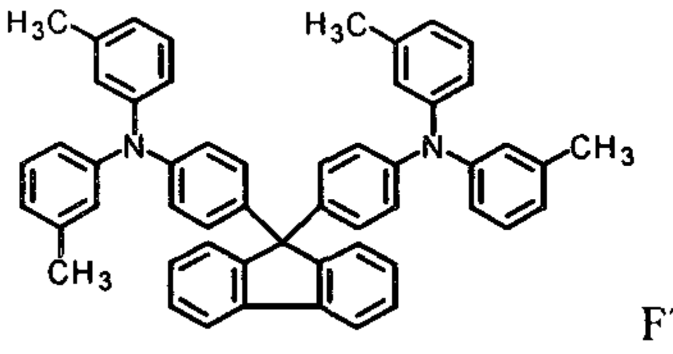


Figure 1 OLED efficiencies used newly developed HIM by Toyo and CuPc as the HIMs.
Device: HIL= Toyo new HIM(circle), CuPc(cube)
ITO/HIL(35nm)/α-NPD(15nm)/Alq3(50nm)/Mg:Ag=10:1

Our HIM shows high efficiency rather than CuPc's one.

2.2 Hole Transporting Materials(HTMs)

In the OLED of the multi-layered type, electrons are injected from cathode into an electron injecting layer(EIL), and holes are injected from HIL when a high electric field is applied to the device. Both carriers recombine close to the interface of the HTL or in the light emitting layer(LEL). Therefore, the HTL plays an important role in transporting holes and blocking electrons.



FTPD-5

Figure 2 Chemical structure of the HTMs presented by Toyo.

We designed the several kinds of materials as the HTMs shown in Figure 2. In this study, we found the excellent HTM like as FTPDs. FTPD-5 shows high glass transition temperature (Tg: 103・) because of the fluorine moiety. The OTPAC used triphenylamine oligomer also presented by Toyo. We can use this OTPAC as the HTM fabricated by the coating and evaporation techniques. TP-$(OCH_3)_3$ also very interesting material for the HTM. This material is a famous one as the LCD. Because of the high hole transporting ability, the OLED used this TP-$(OCH_3)_3$ shows the excellent properties.

2.3 Light-Emitting Materials(LEMs)

Many materials have been developed for recent years. Many LELs are fabricated by the doping technique. However, the doping technique is very difficult and not so stable for the industrial point of view.

Table 1 The OLED characteristics used Toyo's non-doping LEMs.

Color	CIE x	CIE y	Brightness (cd/m2)	Ei (cd/A)
Green	0.32	0.64	135000	23
Blue	0.16	0.27	38000	4.8
Orange	0.55	0.44	24000	7.3
Red	0.65	0.35	2300	0.5

We have been developed the LEMs of the non-doping system. As the result, we can show the excellent performances for OLEDs like as Table 1. Life time of the emitting also enough to use the OLED displays. Especially, the OLED performance used Toyo's green emitting material shows the excellent efficiencies at various applied voltages. The high efficiencies are kept over 100,000(cd/m^2). We have been developed the new LEMs like as blue, orange, red emitting shown in Table 1. More excellent characters are expected from Toyo in near future.

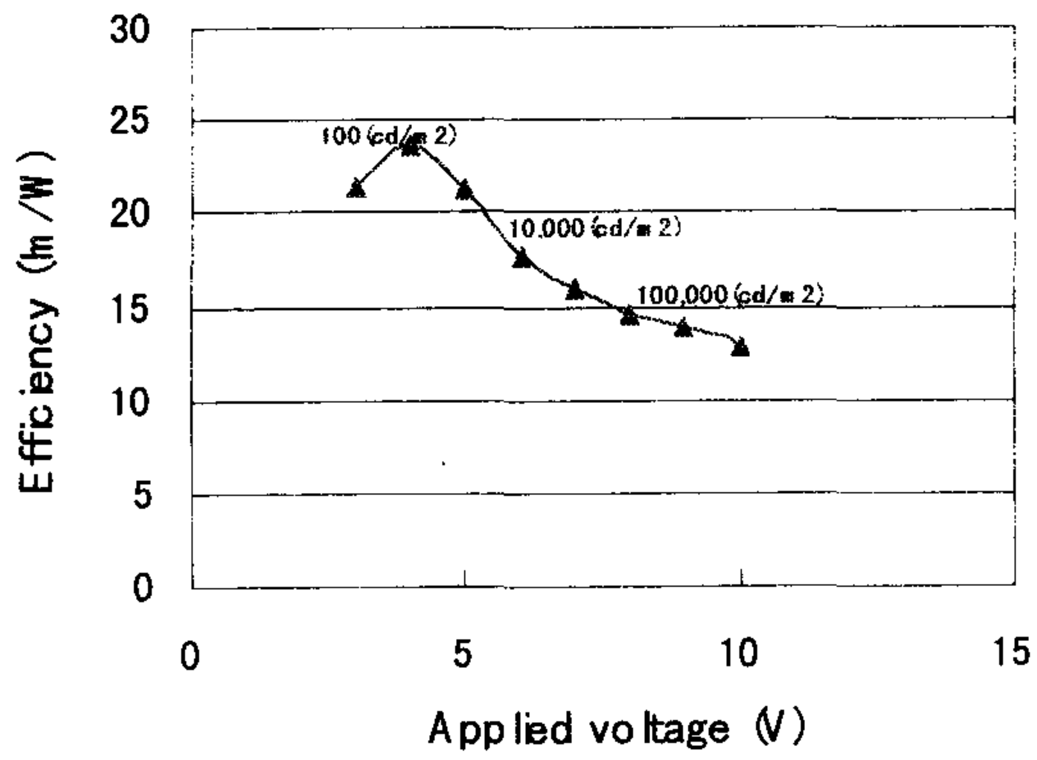


Figure 3 Efficiencies of the OLEDs used Toyo's green emitting material at various applied voltages.

2.4 Electron Injecting Materials(EIMs)

The electron injecting materials also important material for the OLEDs. However, until recent years Alq3 is an only candidate of EIM as the commercial OLEDs. Toyo succeeded the introduntion of the new EIMs to the OLED material market.

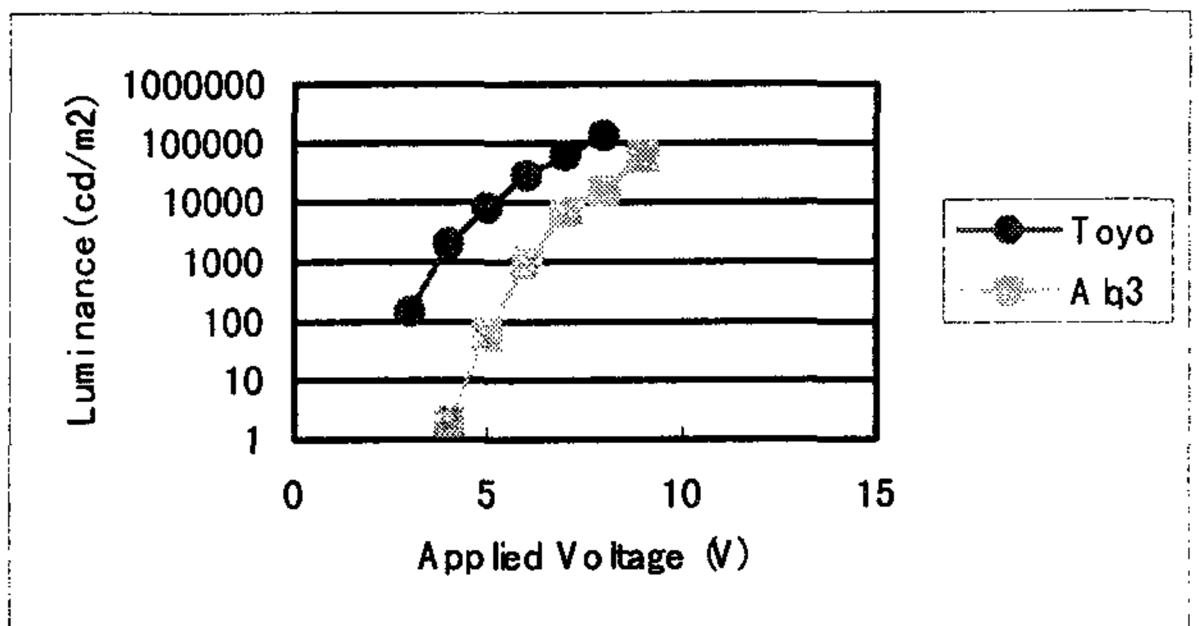


Figure 1 OLED efficiencies used newly developed HIM by Toyo and CuPc as the HIMs.

Device: HIL= Toyo new HIM(circle), CuPc(cube)

3. References

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