Novel soluble europium complex for light-emitting material

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Organic electroluminescent devices (OELDs) have become one of the most important subjects because of their potential application as large-area flat-panel displays since Tang and Van Slyke first reported bright organic EL at low voltage [1, 2]. There are advantages in fabricating electroluminescent devices using rare earth complexes. Theoretically, the upper limit of inner quantum efficiency can reach 100%, which is four times higher than that of other fluorescent materials. The sharp emission bands of rare earth ions are very suitable for full-color display [3, 4].

Recently, to realize an applicable sharp red emission from organic light emission devices (LEDs) some LEDs have been fabricated by using europium (Eu) complexes as an emissive layer, however there are some problems with organic LEDs containing Eu complexes. The Eu complexes reported so far exhibit poor carrier-transporting ability and film formability, are not volatile enough, and are easily decomposed during vacuum vapor deposition. Therefore, in general, conventional rare earth complexes, such as Eu (TTA)$_3$(TTA = 2-thenoyltrifloroacetonato) and Eu (TTA)$_3$ phen(phen = 1,10-phenanthroline) showed quite high photoluminescence efficiency when they were incorporated into LEDs [5]. Kido and co-workers reported the fabrication of an EL device with Eu complexes as the dopant by spin coating from a solution containing a transporting polymer [6, 7]. However, in the case, the solubility of these Eu complexes was low. On the other hand, doping the Eu complexes in a polymer film with good carrier-transporting ability and solubility can improve the carrier-transporting ability and enhance the film formability. Therefore, a novel soluble europium complex (Eu(C8DBM)$_3$phen) was designed and synthesized to improve the efficiency of red light organic EL device in this paper. The structure of Eu(C8DBM)$_3$phen is shown in Fig. 1. Eu(C8DBM)$_3$phen could be completely dissolved in common solvents, such as chloroform and acetone, thus, it could be homogeneously dispersed in poly(N-vinylcarbazole) (PVK).

The device structure is shown in Fig. 2. 5 wt% Eu(C8DBM)$_3$phen doped in poly(N-vinylcarbazole) (PVK) was used as light emissive center and spun-cast on N,N′-diphenyl-N,N′-bis(3-methylphenyl),-

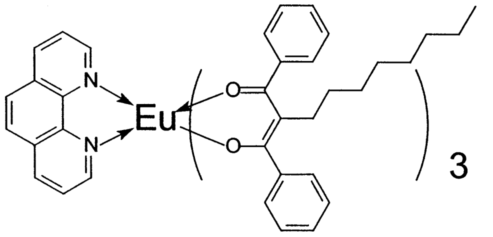

Figure 1 Molecular structure of Eu(C8DBM)$_3$phen.

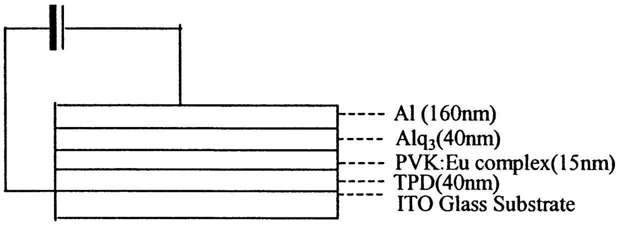

Figure 2 Configuration of EL device (LED).

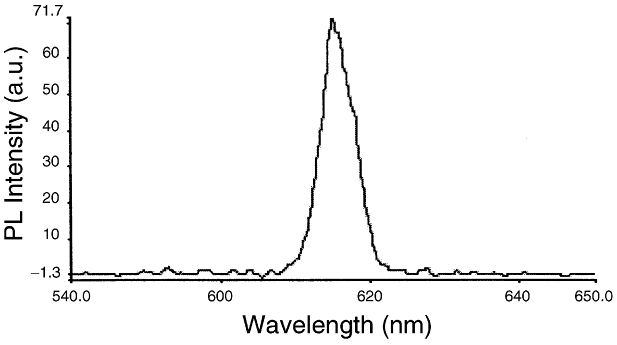

Figure 3 PL spectrum of Eu(C8DBM)$_3$phen.

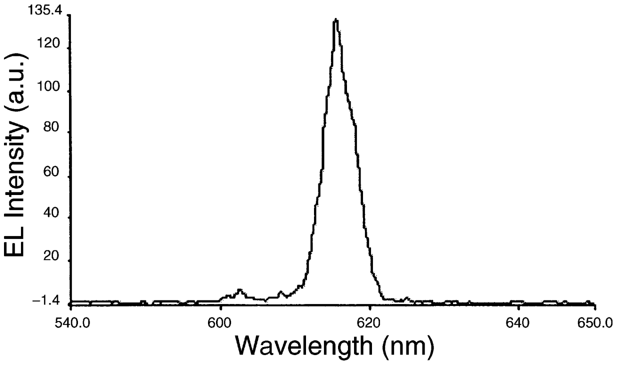

Figure 4 EL spectrum of the LED.

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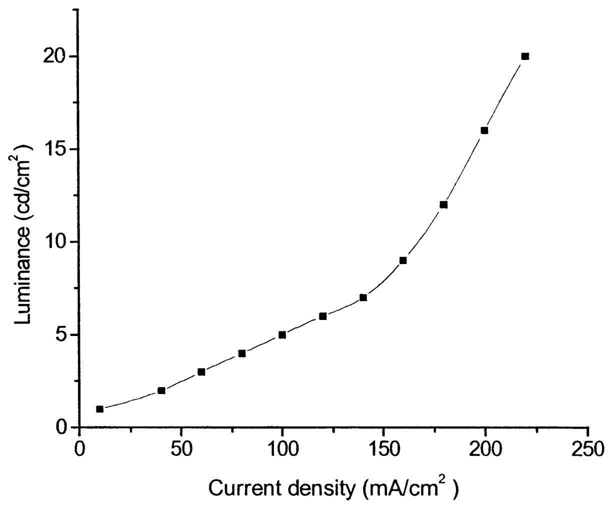

Figure 5 Luminance-current density characteristic of the LED.

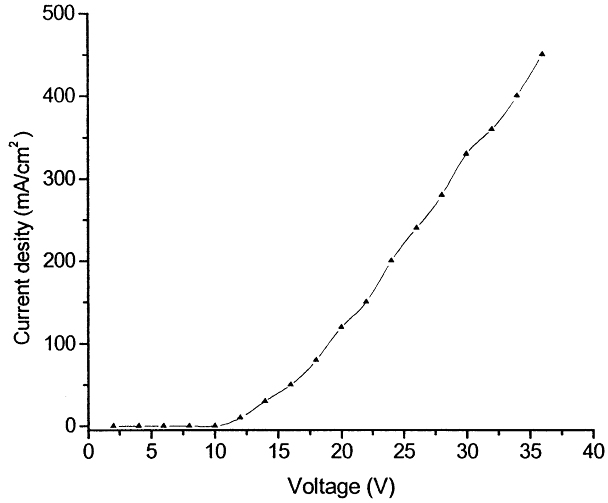

Figure 6 Current density-voltage characteristics of the LED.

1,1′biphenyl-4,4′-diamine (TPD) TPD and tris-8-hydroxyquinolinato (Alq$_3$) were utilized as the hole-transporting layer and electron-transporting layer and fabricated by conventional vacuum vapor deposition in a 5.0×10^{-4} Pa vacuum. Indium-tin-oxide (ITO) was coated on glass substrate. Al was deposited on top by vacuum evaporation at a pressure below 7.0×10^{-4} Pa. The structure of EL device was ITO/TPD/PVK:Eu(C8DBM)$_3$phen/Alq$_3$/Al. The EL and plotoluminescence (PL) spectra were measured with a SPEX FL-2T2 spectrophotometer. The luminance was measured with a calibrated St-900 luminance meter.

The PL spectrum of Eu(C8DBM)$_3$phen and EL spectrum of the device are shown in Figs 3 and 4, respectively. The peak of PL spectrum was sharp and strong at 615 nm. It was found that a bright red electroluminescence was obtained with a sharp half line width (10 nm) at about 615 nm. The EL spectrum was almost similar to the PL spectrum, which indicated that the EL emission originated from Eu complex. The luminescent intensity of EL was higher than that of PL because the PVK could transfer energy to europium ion and had good carrier-transporting ability [8].

The luminance-current density and voltage-current density characteristic of the device are shown in Figs 5 and 6, respectively. The forward bias current could be obtained when the ITO electrode was passively bias and the Al electrode negatively. The current increased when the forward bias voltage increased, and the reverse current remained small when the ITO electrode was negatively biased and the Al electrode positively. The luminance increased with increasing the forward bias voltage. Luminance started at 12 V and the maximum luminance of 20 cd·m^{-2} was achieved at 220 mA/cm^2 of current density.

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