Orange Color Electroluminescence from Bis(2-styryl-8-quinolinolato)zinc(II)

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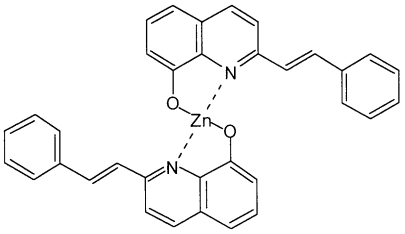
An orange-light-emitting zinc complex ($Znsq_2$) having 2-styryl-8-quinolinolato ligands was synthesized and used as an emitter material in organic electroluminescent (EL) devices. The device structure of glass substrate / indium-tin oxide / tetraphenyldiamine derivative / $Znsq_2$ / Mg:Ag was employed. The EL device exhibited orange light originating from $Znsq_2$ with a maximum luminance of 2000 cd/m^2 at 11 volt.

Organic electroluminescent (EL) devices usually consist of a multilayer structure with a hole-transporting layer and an electron-transporting layer to confine injected carriers as well as generated excitons in the organic layers.[1] One of the electron-transporting materials is green-light-emitting tris(8-quinolinolato)Al(III) (Alq_3) complex which was introduced by Tang and VanSlyke in 1987.[1] Later, other types of light-emitting metal complex have been developped for EL applications.[2-5] Tang et al. also demonstrated a color tuning method by doping Alq_3 layer with organic dyes with different emission colors.[6] The color tuning mechanisms involve energy transfer from the host to the dopant; therefore, the overlap between emission spectrum of the host and the absorption spectrum of the guest dopant should be large enough so that the excited energy can be completly transfered to the guest molecule. This suggests that Alq_3 may not be a good host material for red-emitting dopants having the main absorption peak at around 600 nm because of the poor overlap between the emission of Alq_3, peaking at 520 nm, and the absorption of the dopants. In such cases, the emission of the host material can not be completely quenched by the dopants, which causes the poor color purity of the light emitted from the device. Therefore, orange-light-emitting host materials with emission at around 600 nm are reqired to develop efficient red-emitting EL devices with high color purity.

In this study, we designed an orange-light-emitting metal complex by extending the π-conjugation of 8-quinolinol structure, and synthesized a zinc complex having 2-styryl-8-quinolinolato as ligands, bis(2-styryl-8-quinolinolato)Zn(II) ($Znsq_2$). The EL properties of this complex is reported here.



$Znsq_2$

2-Styryl-8-quinolinolato was received from Chemipro Kasei Kaisha, Ltd. and used without further purification. $Znsq_2$ was synthesized from zinc chloride and 2-styryl-8-quinolinol. To an ethanol solution of zinc chloride, a tetrahydrofurane solution of 2-styryl-8-quinolinol was slowly added. Then, the pH value of the solution was brought to about 7 by the addition of an aqueous solution of sodium hydroxide. Precipitated $Znsq_2$ was collected by filtration and dried in a vacuum oven, and it was finally purified by the train sublimation method (yield 39%). [Elemental analysis: H 4.28 (4.34), C 72.99 (73.20), N 5.05 (5.02), ( ) Calcd]

$Znsq_2$ was evaluated as an emitter layer in a bilayer-type device having a hole transport layer inserted between the anode and the emitter $Znsq_2$ layer. The device structure is a glass substrate / indium-tin oxide (ITO) / *N,N'*-diphenyl-*N,N'*-(3-methyl phenyl)-1,1'-biphenyl-4,4'-diamine (TPD) (400 Å) / $Znsq_2$ (600 Å) / Mg:Ag (10:1). The organic layers were successively deposited onto an ITO-coated glass substrate at 1.0 x 10^{-5} Torr. The Mg:Ag top electrode was finally codeposited at 7.0 x 10^{-6} Torr. The emitting area was 0.5x0.5 cm^2. ITO-coated glasses, having a sheet resistance of 15 Ω/square, were purchased from Asahi Glass Co., Ltd. Luminance was measured with a Topcon BM-8 luminance meter at room temperature and ionization potential was measured by atmosphere ultraviolet photoelectron analysis using a Riken Keiki AC-1 under ambient atmosphere.

From the bilayer device, orange light peaking at 600 nm was observed when operated in a continuous dc mode with Mg:Ag negative. The EL spectrum in Figure 1 (a) is identical with the photoluminescence (PL) spectrum of the vacuum deposited film of $Znsq_2$, Figure 1 (b), indicating that electron-hole recombination occurs in the $Znsq_2$ layer. Compared with the EL spectrum of Alq_3, the EL spectrum of $Znsq_2$ is red shifted.

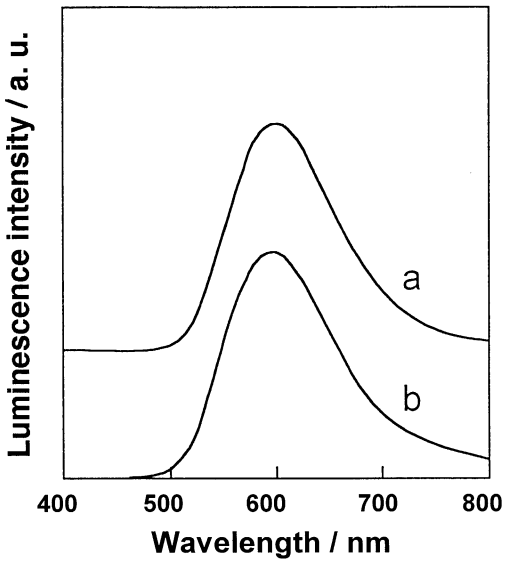


Figure 1. (a) EL spectrum of an ITO/TPD(400Å)/$Znsq_2$ (600 Å)/Mg:Ag device, and (b) PL spectrum of a vacuum deposited film of $Znsq_2$ (λem=436 nm). Spectra are offset for clarity.

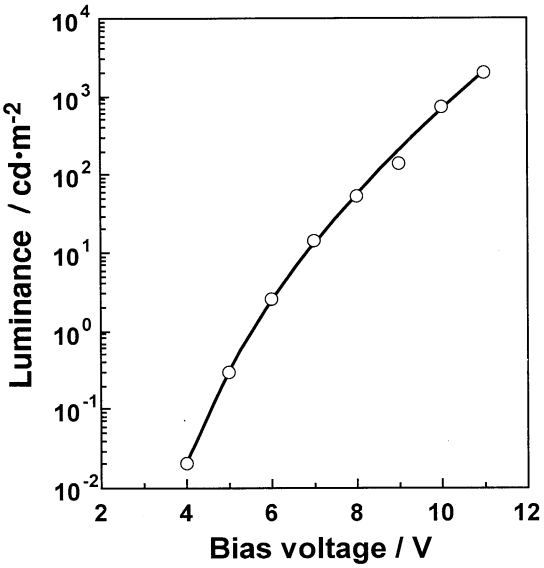


Figure 2. Luminance-voltage characteristics of an ITO/TPD (400 Å)/$Znsq_2$(600 Å)/Mg:Ag device.

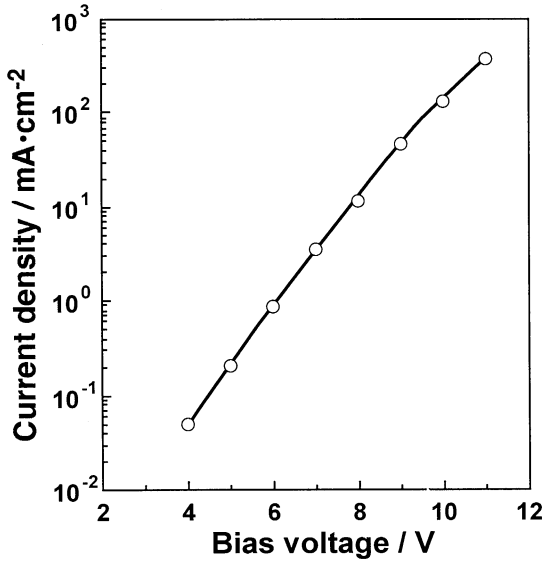


Figure 3. Current density-voltage characteristics of an ITO/TPD(400 Å)/$Znsq_2$(600 Å)/Mg:Ag device.

This is due to the extended π-conjugation of the ligands, which causes narrower energy gap between the HOMO and the LUMO of $Znsq_2$ compared with that of Alq_3.

The luminance (L)-voltage (V) curve for the ITO / TPD / $Znsq_2$ / Mg:Ag device is displayed in Figure 2. Luminance increases with increasing injection current as well as bias voltage. The maximum luminance of the device is 2000 cd/m^2 at 11 V. The external quentum efficiency of the device is calculated to be 0.22% at this drive voltage.

The current (I)-voltage (V) curve of the device is plotted in Figure 3. High current densities such as 360 mA/cm^2 at 11 V are observed, which may indicate that $Znsq_2$ has high electron affinity. From the ionization potential of the complex (5.45 eV) and the optical energy gap (2.35 eV), the pseudo electron affinity (Ea) value of $Znsq_2$ is estimated to be 3.1 eV, which is slightly larger than to that of Alq_3 (3.0 eV).

In conclusion, we have demonstrated that $Znsq_2$ is an electron-transporting orange light emitter. By extending the π-conjugation of 8-quinolinol, the emission peak can be red shifted. Doping of $Znsq_2$ with red-emitting dye to obtain red electroluminescence will be carried out and the results will be reported elsewhere.

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