

Effect of the ligand on the properties of emitting materials: Pentacoordinated 8-hydroxyquinoline aluminum complexes

Guang Wang^{a,*}, Yi He^b, Lixiang Wang^c

^a Faculty of Chemistry, Northeast Normal University, Changchun 130024, PR China

^b College of Chemistry, Jilin University, Changchun 130025, PR China

^c The State Key Laboratory of Polymer Physics and Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, PR China

Received 8 June 2006; accepted 25 December 2007

Available online 16 January 2008

Abstract

Two series of pentacoordinated complexes, AlMq₂q' and Alq₂q' (q is 8-hydroxyquinoline, Mq is 2-methyl-8-hydroxyquinoline and q' is phenolato ligand), were synthesized, and assessed as potential emitting materials in thin film (photoluminescence, PL) and electroluminescent (EL) device. EL devices with a configuration of ITO/NPB(50 nm)/Complex(50 nm)/Mg/Ag(10:1) were fabricated. Strong blue and green emission were observed from thin solid film and EL device of AlMq₂q' and Alq₂q', respectively. The results revealed that the PL and EL emission wavelengths of these materials are primarily determined by Mq and q (first ligand), whereas phenolato ligand (second ligand) has little effect on the emission wavelength but remarkable influence on EL efficiency.

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Keywords: Ligand; Pentacoordinated 8-hydroxyquinoline aluminum complex; Photoluminescence; Electroluminescence; OLED

1. Introduction

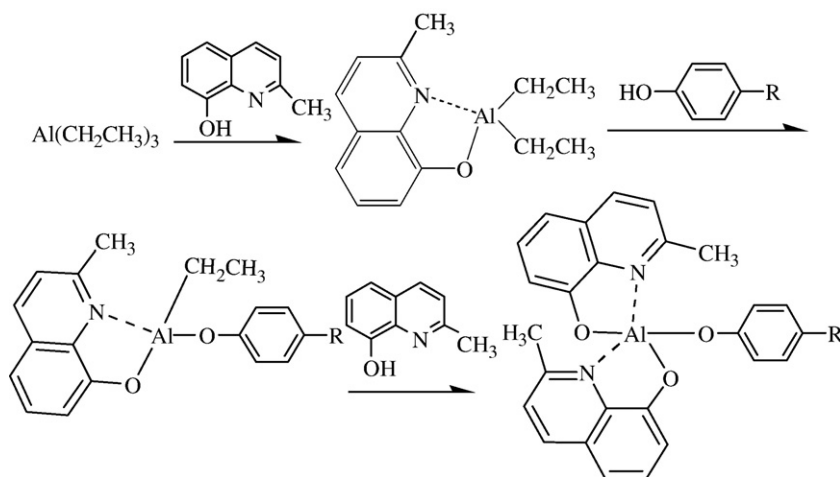
Since the first report of high-efficiency EL work on efficient electroluminescence (EL) from Alq₃-based organic light-emitting diode (OLED) by Tang and Vanslyke [1], considerable progress has been made on OLED using organic–metal complex [2–6]. For further understanding the mechanism of EL and getting high-efficiency OLED, many approach about making multilayer OLED or doping luminescent dye into the organic layer has been tried [7–8]. The material properties of emission color, thermal stability and film-formation can be easily tailored [2–4]. Much progress in modification of 8-hydroxyquinoline complex has been made, for example, pentacoordinated complexes of aluminum [9] and gallium [10], which have the same first ligand (2-methyl-8-quinoline), different second ligand and different central metal ion (Al³⁺ and Ga³⁺), have been studied. Although much work on 8-hydroxyquinoline complex as light-

emitting material has been reported, to the best of our knowledge, there is a lack of systematic studying on correlation between structure and light-emitting performance of pentacoordinated 8-hydroxyquinoline aluminum complex. The effect of first ligand (q or Mq) and second ligand (phenolato) in pentacoordinated 8-hydroxyquinoline aluminum complex on emission and efficiency of OLED using these complexes as emitting materials is not fully understood.

Our group first reported the synthesis and light-emitting performance of pentacoordinated 8-hydroxyquinoline aluminum complexes, Alq₂q' [11], the emitting color of these complexes was dominated by the first ligand (q) and not the second ligand (phenolato ligand, q'). The hole transporting ability of second ligand in complex (Scheme 1) increased gradually from A to D, but the EL efficiency using complex as emitting material in double-layer device descended gradually from A to D. To further enucleate the effect of ligand of pentacoordinated 8-hydroxyquinoline aluminum complex on its property in PL and EL, we designed and synthesized series of pentacoordinated 2-methyl-8-hydroxyquinoline aluminum complex (AlMq₂q')

* Corresponding author. Tel.: +86 431 85099544.

E-mail address: wangg923@nenu.edu.cn (G. Wang).

Scheme 1. The synthetic route for AlMq₂q'.

and investigated performance of PL and EL. AlMq₂q' has similar molecule structure with Alq₂q', the same central metal ion, different first ligand (q or Mq) and second ligand (q'), their molecular structures were depicted in Fig. 1, and the complex H is first reported. As will be shown, the results revealed that the second ligand has little effect on the emitting wavelength, but has remarkable influence on the emitting efficiency of EL device with these complexes as emitting materials, and the first ligand has dominative effect on emission wavelength of PL and EL of pentacoordinated 8-hydroxyquinoline aluminum complexes.

2. Experiment

Elementary analyses were performed on an Elementar Analysensysteme GmbH Varioel. PL and EL spectra were recorded at Perkin-Elmer Ls50B Luminescence Spectrometer. Benzene was refluxed with calcium hydride and distilled. *N,N'*-diphenyl-*N,N'*-di(1-naphthalenyl)-1,1'-biphenyl-4,4'-diamine (NPB) was purchased from Aldrich and used without further purification. The synthesis of complex Alq₂q' was reported in our previous work [11].

The series of complex AlMq₂q' was prepared according to our previously reported synthetic method [11]. The synthetic route is shown in Scheme 1 and details on the general synthesis are given below. The following is a general procedure for the

synthesis. At room temperature, a benzene solution (15 mL) of 2-methyl-8-hydroxyquinoline (1.59 g, 0.01 mol) was added dropwise into the stirring benzene solution (20 mL) of triethylaluminum (1.14 g, 0.01 mol) in a 100 mL three-necked flask under an atmosphere of nitrogen. The solution of 2-methyl-8-hydroxyquinoline was added slowly to the solution of triethylaluminum at such a rate that a gentle reflux of the solvent was maintained (~37 °C). A white precipitate appeared gradually, and the reaction was allowed to continue for 1 h to ensure that diethyl aluminum compound formed. Then a benzene solution (15 mL) of phenolato ligand (0.01 mol) was added dropwise, the precipitate disappeared slowly, and the mixture was continuously stirred for about 2 h. Afterwards, another benzene solution (15 mL) of 2-methyl-8-quinoline (1.59 g, 0.01 mol) was added dropwise, the precipitate appeared again and the reaction solution was continuously stirred for 10 h. The product was collected by filtration and washed with benzene. These metal complexes materials were further purified by train sublimation. The phenolato ligand can be added directly into the reaction solution if it cannot be dissolved in benzene. All obtained complexes are white solid, their element analysis data is as follow. E, found: C 69.58, H 4.93, N, 5.97, Cal: C 69.52, H 4.97, N, 6.01. F, found: C 71.61, H 4.91, N, 6.37, Cal: C 71.56, H 4.85, N, 6.42. G, found: C

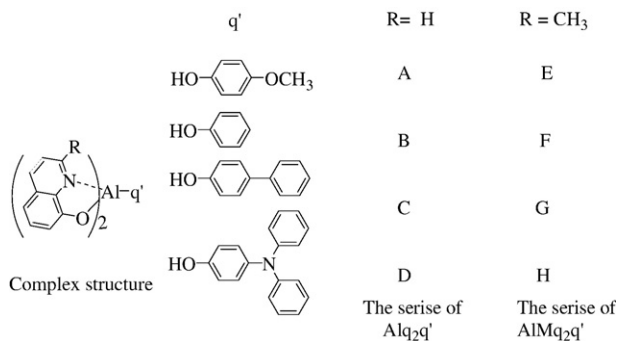
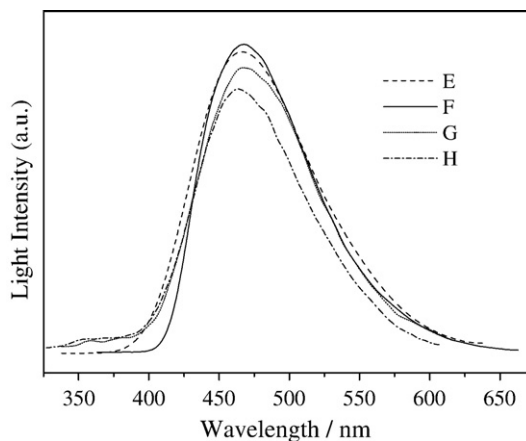


Fig. 1. Molecular structures of pentacoordinated 8-hydroxyquinoline aluminum complexes.

Fig. 2. PL spectrum of AlMq₂q' as solid film.

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