

Blue organic light emitting diode based on lithium tetra-(8-hydroxy-quinolinato) boron complex

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Blue electro-luminescent materials are essential for the development of full colour display. The synthesis and characterization of blue emitter lithium tetra-(8-hydroxy-quinolinato) boron complex for organic light emitting diode (OLED) applications have been reported. The boron complex was synthesized by the reaction of lithium borohydride with 8-hydroxyquinoline at room temperature and shows absorption cut-off wavelength at 410 nm and bright blue photoluminescence (PL) with a peak wavelength at 485 nm. The electro-luminescence (EL) and *I-V* characteristics of bilayer OLED are also reported. The results show that boron complexes have a great potential for the blue emitters for OLED applications.

[**Keywords:** OLED, LiBq₄, Photo-luminescence, Electro-luminescence, Boron complex]

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1 Introduction

Since the pioneering work of Tang and VanSlyke¹ in electro-luminescence (EL) devices using organic molecular materials, the research activity on organic light emitting diodes (OLEDs) has been booming and progressed considerable in recent years²⁻⁴. OLED of this category is of great interest because of their potential applications in making low cost display products. Research at present is focused on the development of new efficient luminescent materials and ingenious device fabrication techniques^{5,6}. Metal-chelate complexes are very efficient luminescent materials and often used in fabrication of OLEDs. Alq₃ exhibits high performance as an electron transport material, an efficient emitting material and an excellent host material in the doped organic systems. Analogues materials, such as bis (8-hydroxyquinolinato) zinc (Znq₂) and bis (8-hydroxyquinolinato) beryllium (Beq₂), also exhibit high performance⁷. Alq₃ is a green emitter with peak wavelength around 530 nm. Blue electro-luminescent emitters are very important for the development of

full-colour displays based either on the colour changing medium technology or the RGB filtered white emission^{8,9}. Therefore, there is a lot of interest in the development of emitter materials in the blue region similar to that of Alq₃. A study on various blue light emitting materials is also reported¹⁰. A large number of complexes based on 8-hydroxyquinoline have been studied for their electro-luminescence (EL) properties^{11,12}.

In the present work, the synthesis and characterization of highly fluorescent vacuum evaporable lithium tetra-(8-hydroxy-quinolinato) boron complex (LiBq₄) for the OLED applications have been reported. Evaporated LiBq₄ complex film shows good photo-luminescence in the blue region and optimum OLED device gave a strong blue electro-luminescence.

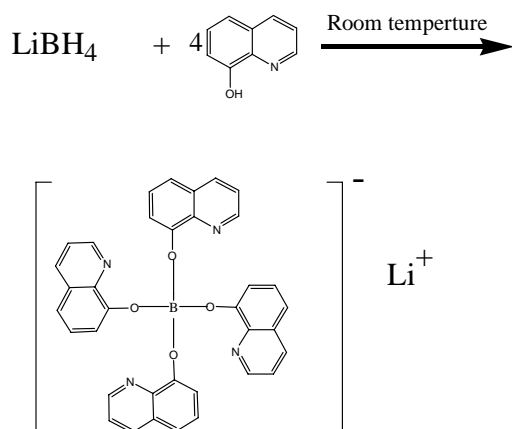
2 Experimental Details

2.1 Synthesis of LiBq₄ complex

LiBq₄ complex was prepared by the reaction of 8-hydroxyquinoline (8 mmol) and lithium borohydride (2 mmol) in ethanol at room temperature. The reaction proceeds as shown in the equation below. The reaction mixture was stirred for two hours in a

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nitrogen atmosphere to obtain a white precipitate. The precipitate was filtered, purified with a micro-soxhlet extractor using diethyl ether as the solvent for 24 hours, and dried under vacuum to yield a white powder. The powder was further purified by vacuum sublimation¹³.



2.2 Fabrication of the OLED device

A schematic representation of the device is shown in Fig. 1. The device has been fabricated by first coating a hole transport layer (30 nm) of TPD [N, N'-diphenyl-N, N'-bis (3-methylphenyl) (1,1'-biphenyl) 4,4'-diamine] on patterned indium-tin oxide (ITO) substrates having a sheet resistance of 20 ohm/square at a vacuum of 10^{-5} Torr followed by the vacuum deposition of LiBq₄ complex film onto which a thin layer of aluminium (150 nm) was thermally evaporated. Voltage in the range of 6-9 V was applied between these two electrodes using an Aplab power supply to get bright blue light emission.

3 Results and Discussion

3.1 UV-VIS absorption spectra

For studying the UV-Vis absorption spectra, the thin films of LiBq₄ were vacuum deposited on cleaned

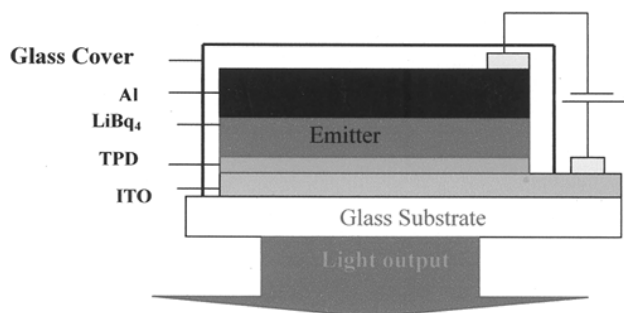


Fig. 1—Schematic diagram of ITO/TPD/LiBq₄/Al device

fused silica substrates. Fig. 2 shows the absorption spectrum of LiBq₄ complex films. The absorption spectra were studied in the range 270-570 nm using a Shimadzu UV-2401 PC spectrophotometer. The absorbance maximum for LiBq₄ is at 280 nm and cut-off is about 410 nm. This agrees very well with the values reported earlier for this material¹².

3.2 Photoluminescence and electro-luminescence spectra

Photoluminescence (PL) spectra of LiBq₄ were studied on thin film of the material vacuum evaporated on fused silica substrates. Fig. 3 shows the photoluminescence (PL) spectra of LiBq₄ complex film illuminated with 350 nm light from a Xe lamp with Cornerstone (Model No. 74100) monochromator and Jarrel Ash scanning monochromator connected with a photomultiplier tube (EMI 9658 B) for recording spectral energy distribution curves. The PL spectrum shows the emission lies in the blue region with peak at 485 nm and peak shoulder at 450 nm. The absorption cut-off and PL peak wavelength are about 60 nm shorter than those of Alq₃. Such large blue shift is originated in the different coordination structures of boron complexes compared to Alq₃. In fact, the boron ligand bonds are generally much more covalent than the corresponding aluminium ligand bonds. As a consequence boron compounds are in

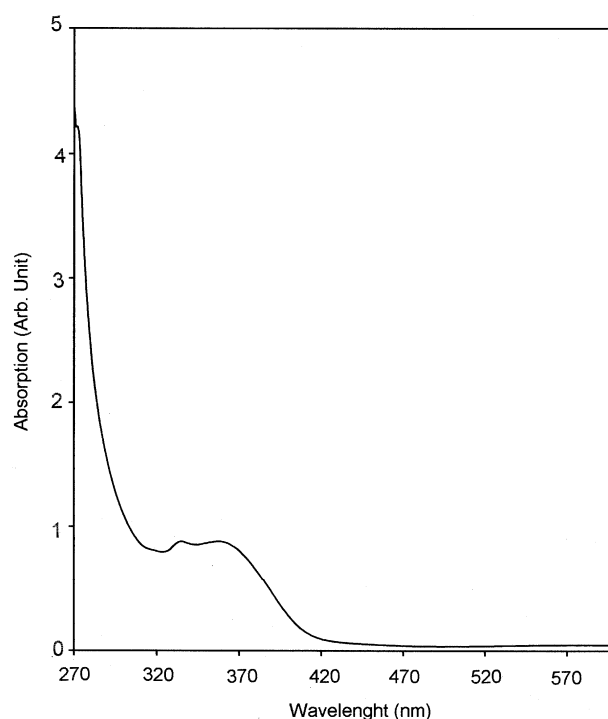


Fig. 2—UV-VIS absorption spectra of LiBq₄ thin film

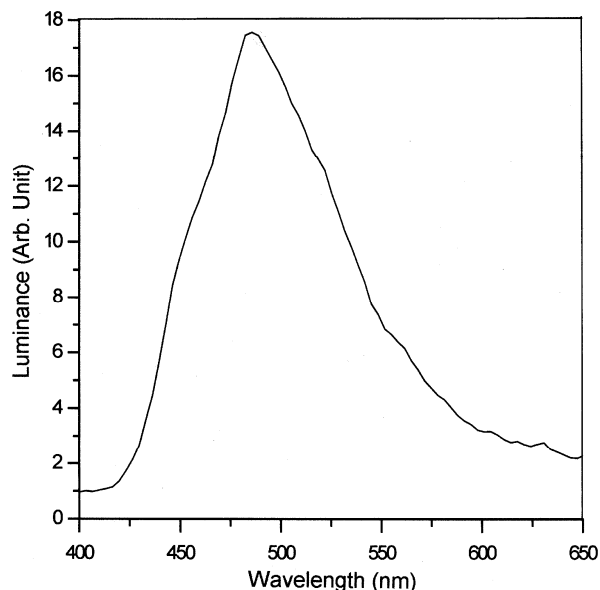


Fig. 3—Photo-luminescence spectra of LiBq₄ complex

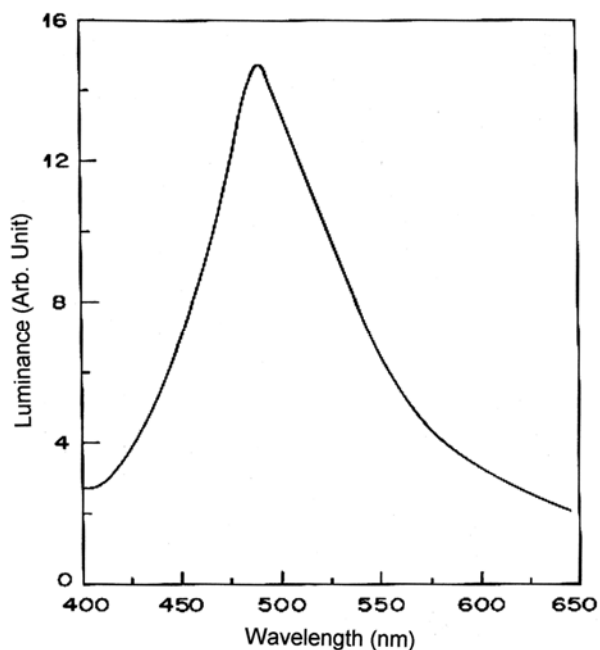


Fig. 4—Electro-luminescence spectra of a bilayer device ITO/TPD/LiBq₄/Al under 9V biased voltage

general much more stable than the corresponding aluminium compounds.

The electro-luminescence (EL) spectra were determined with the same instrument as used in PL measurement by blocking the excitation lamp and scanning the emission from forward biased cells. The EL spectrum is presented in Fig. 4, which shows an

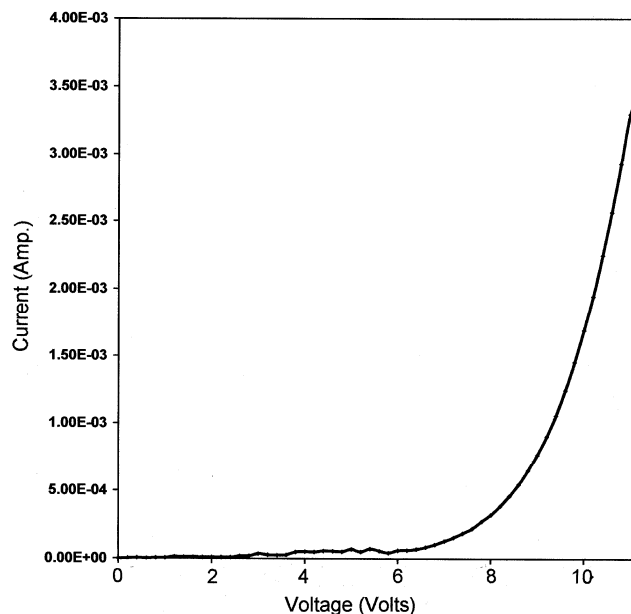


Fig. 5—*I-V* characteristics of a bilayer device ITO/TPD/LiBq₄/Al (Device active area 4 mm²)

emission peak at 485 nm. The fact that the EL and PL emission peaks appear at 485 nm, which shows that the origin of both these peaks is the same due to decay of singlet excitons.

3.3 *I-V* characteristics of the devices

The current-voltage (*I-V*) characteristics of the LiBq₄ complex film, was recorded on devices having the structure ITO/TPD/LiBq₄/Al. This has been fabricated by first coating a hole transport layer of TPD [N, N'-diphenyl-N, N'-bis (3-methylphenyl) (1,1'-biphenyl) 4,4'-diamine] on ITO coated glass substrate followed by vacuum deposition of LiBq₄ complex film over the TPD and a thin layer of thermally evaporated aluminium. A schematic representation of the device is shown in Fig. 1. A Keithley 617 electrometer interfaced with a PC was used to measure the current.

The *I-V* characteristics of the device is given in Fig. 5, which shows that the current rises steeply above 6 V indicating the onset of light emission (threshold voltage). The threshold voltages of the devices based on the LiBq₄ complex are in the range of 6-9 V depending upon the thickness of the organic layer. The optimum thickness of the layer was 50 nm and the thickness of the hole transport layer was 25 nm as measured by quartz crystal thickness monitor. The *I-V* characteristics of the devices show highly non-linear nature with ohmic conduction at

low voltages and trap limited conduction at high voltages. Devices with a 50 nm thick organic layer emitted blue light when a voltage of about 9 V was applied across it.

4 Conclusions

We have synthesized a fluorescent boron complex LiBq₄ and used it as active layer in bilayer OLED device. The boron complex shows electro-luminescence peak at 485 nm with 73 nm full width at half-maximum. The results show that boron complexes have great potential for the blue emitters for OLED applications.

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