

PACS numbers: 81.20.ka, 81.70.Pg, 85.60.Jb

## SYNTHESIS AND ELECTROLUMINESCENCE CHARACTERIZATION OF CADMIUM COMPLEX

**Rahulkumar<sup>1</sup>, K. Singh<sup>1</sup>, R. Srivastava<sup>2</sup>, M.N. Kamlasanan<sup>2</sup>**

<sup>1</sup> Thapar University, 147004, Patiala, India  
E-mail: [kusingh@thapar.edu](mailto:kusingh@thapar.edu)

<sup>2</sup> National Physical Laboratory  
110012, New Delhi, India

*We have synthesized and characterized a new electroluminescence material, Cadmium [(2-(2-hydroxyphenyl)benzoxazole)(8-hydroxyquinoline)] Cd(HPB)q. The absorption spectra of this material show maxima at 378 nm. It may be attributed due to  $\pi-\pi^*$  transition. The photoluminescence showed peak at 520 nm. TGA data of the material shows stability up to 370 °C. Organic light emitting diode have been fabricated with this material and the fundamental structures of the device is ITO/ $\alpha$ -NPD/Cd(HPB)q/BCP/Alq<sub>3</sub>/LiF/Al exhibited a luminescence peak at 550 nm. The maximum luminescence of the device was 295 cd/m<sup>2</sup> with current density of 6687 A/m<sup>2</sup> at 20 V. The maximum current efficiency of OLED was 1.01 cd/A at 17 V and power efficiency was 1.01 lm/w at 17 V.*

**Keywords:** LUMINESCENCE, THERMAL STABILITY, CADMIUM COMPLEX CD(HPB)Q, FTIR.

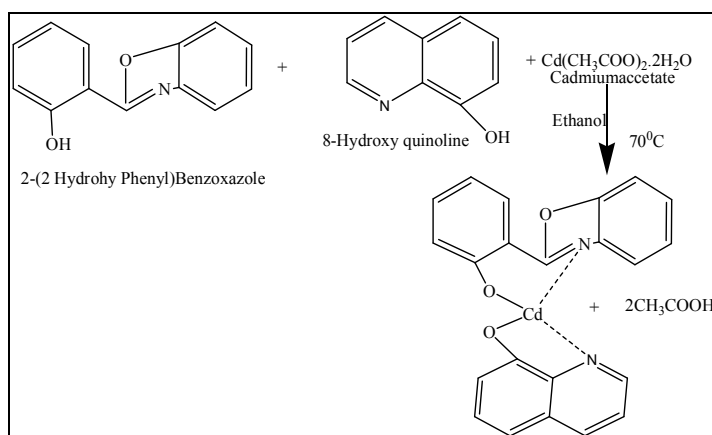
(Received 04 February 2011)

### 1. INTRODUCTION

Luminescent organic/organometallic compounds have been attracting much attention in recent years because of their potential application in flat panel displays based on organic light emitting diodes (OLEDs). These materials have been shown to be useful in OLEDs because of their relatively high stability and efficiency [1, 2]. Among these materials, cadmium complexes have been especially important because of the simplicity in synthesis procedures and wide spectral response. Extensive research work is going on in various laboratories to synthesize new cadmium complexes containing new ligands to produce a number of novel luminescent cadmium complexes [3-5], as emitters and electron transporters in OLED research [5-10]. The coordination numbers of cadmium complexes are variable, making it possible to synthesize new emitter materials with varying optoelectronic properties. In this study, a new material cadmium[(2-(2-hydroxyphenyl)benzoxazole)(8-hydroxyquinoline)] Cd(HPB)q has been synthesized and its optical and photoluminescence (PL) properties have been studied in detail. Organic light emitting device was fabricated using Cd(HPB)q as emitting layer to study its electroluminescence (EL) properties and the results obtained are reported here.

## 2. SYTHESIS OF CADMIUM [(2-(2-HYDROXYPHENYL) BENZOAZOLE) (8- HYDOXYQUINOLINE)] CD(HPB)q

A solution of 2-(2-hydroxyphenyl) benzoxazole (HPB) 0.211 g (1 m mol) (Merck, India) was dissolved in 20 ml of absolute ethanol (s.d. Fine Chem Limited India) in a 100 ml three neck flask and stirred with a magnetic stirrer for one hour at a constant temperature of 70 °C under nitrogen atmosphere. The solution was stirred for 1 h, after which Cadmium acetate dihydrate 0.267 g (1 m mol) in water (3 ml) and 8-hydroxyquinoline (q) (0.145 g) in absolute ethanol (10 ml) were added drop wise while the stirring continued. After the addition was completed, the reaction was further carried out for 3 h. The yellow precipitates were collected by filtration, purified by re-crystallization from acetone and ethanol and dried overnight. The schematic diagram of synthesis is shown in Fig. 1.

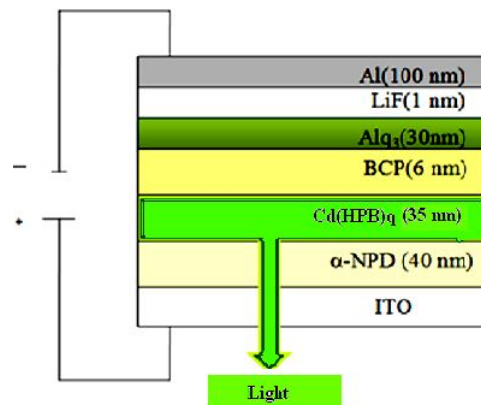


*Fig. 1 – Synthesis of Cd(HPB)q*

## 3. PROCESSING OF OLED DEVICE

The OLED device was fabricated in a configuration ITO/ $\alpha$ -NPD (40 nm)/Cd(HPB)q (35 nm)/BCP (6 nm)/Alq<sub>3</sub> (30 nm)/LiF (1 nm)/Al (100 nm) as shown in schematic diagram of OLED Device in Fig. 2. Indium-tin oxide (ITO) coated glass substrates with sheet resistance of 20 Ohm/m were patterned using photolithography and cleaned using trichloroethylene, acetone, isopropyl alcohol and deionised water sequentially for 20 min using an ultrasonic bath and dried in flowing nitrogen. Prior to film deposition, the ITO substrates were treated with oxygen plasma for 5 min. On the substrate, the hole transport layer and the emitting layers were deposited sequentially under a high vacuum ( $1 \times 10^{-5}$  torr) at a deposition rate of 0.2-0.5 Å/sec and LiF at 0.1-0.2 Å/sec. Thickness of the deposited layers were controlled by a quartz crystal monitor. The cathode was deposited on the top of the structure through a shadow mask. A 40 nm N,N diphenyl-N'N'-bis (1-naphthyl)-1,1'-biphenyl-4,4'-diamine( $\alpha$ -NPD) (Sigma Aldrich) was used as hole transport layer.

Cd(HPB)q was used as the emitting layer and aluminium tris-8-hydroxyquinoline(Alq<sub>3</sub>) (Sigma Aldrich) was used as electron transport layer. The electron injection was facilitated using a 1 nm thin LiF (Merck, Germany) layer followed by a thick layer of Aluminium. The size of each pixel was  $5 \times 3$  mm<sup>2</sup>.



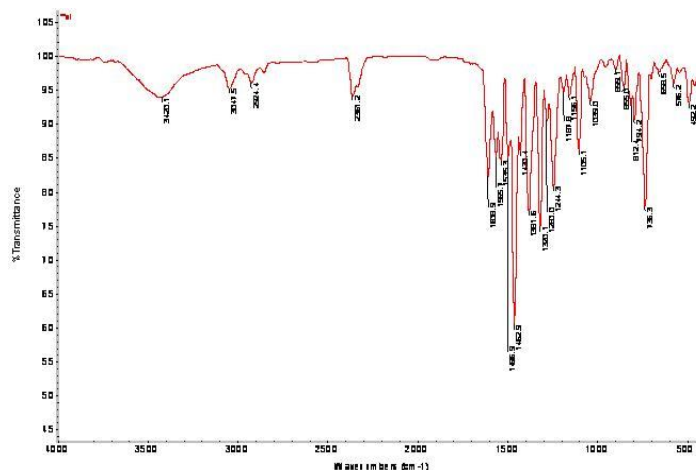
*Fig. 2 – Device structure of OLED using Cd(HPB)q as an emitter*

The luminance-current-voltage (I-V-L) characteristics were measured using a luminance meter (LMT 1009) and a Keithley 2400 programmable voltage-current digital source meter.

#### 4. CHARACTERIZATION

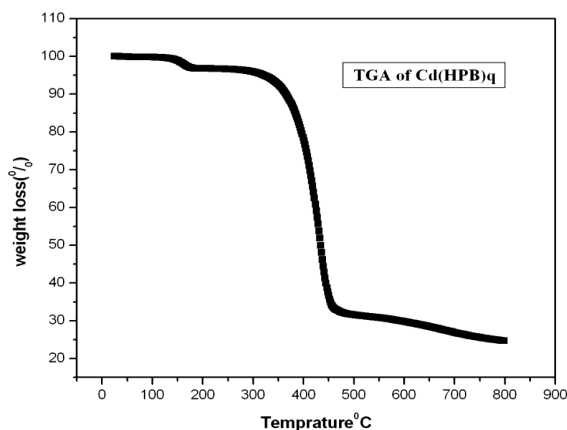
##### 4.1 Thermal and structural characterization of Cd(HPB)q

The infrared absorption spectrum of the material in KBr pellets has been studied using a Nicolet 5700 spectrometer. The Thermo gravimetric Analysis (TGA) has been done by using SDTA851Metter-Toledo-star system in the temperature range 0-800 °C. In Fig. 3 shows the FTIR spectrum of the material carried out of sample, prepared by pellets containing Cd(HPB)q powder (0.1 weight %) dispersed in KBr powder. The FTIR spectra were recorded on Nicolet 5700 in the region  $4000\text{ cm}^{-1}$  to  $400\text{ cm}^{-1}$ . The main peak of Cadmium 2-(2-hydroxyphenyl) benzoxazole Cd(HPB)q shown in the in the FTIR spectrum are shown in Fig. 3.



*Fig. 3 – FTIR spectra of Cd(HPB)q*

Each peak in the graph corresponds to a functional group present in the molecule. In case of Cd(HPB)q the main characteristic bands are observed at  $1614\text{ cm}^{-1}$ ,  $1600\text{ cm}^{-1}$ ,  $1570\text{ cm}^{-1}$ ,  $1495\text{ cm}^{-1}$  for the aromatic phenyl ring,  $1321\text{ cm}^{-1}$ ,  $1279\text{ cm}^{-1}$  for C-N-C, and at  $1106\text{ cm}^{-1}$  for C-O bond stretching while the band between  $760 - 735$  represent the C-H out of plane bending vibration for the four adjacent hydrogen atoms along with the band at  $576\text{ cm}^{-1}$ ,  $493\text{ cm}^{-1}$  and  $462\text{ cm}^{-1}$  represent Cd-O and Cd-N bond stretching, respectively.



**Fig. 4** – Thermo gravimetric analysis of Cd(HPB)q

TGA of synthesized Cd(HPB)q was carried out in temperature range 0–800 °C as shown in Fig. 4. The TGA plot shows a some weight loss around temperature 150 °C which due to some volatile impurities or moisture present in material but no weight loss in Cd(HPB)q. At temperature around 370 °C the material degrade completely. Hence the material is stable upto 370 °C

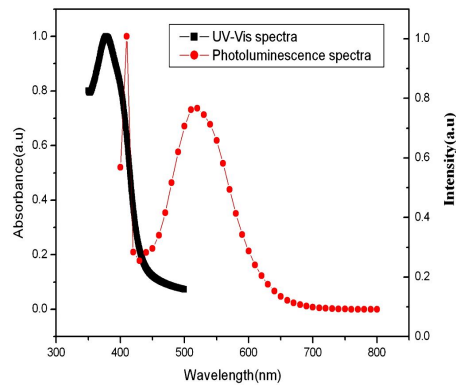
#### 4.2 Optical analysis of Cd(HPB)q

UV-visible absorption spectra were recorded on a Shimadzu UV-2401 spectrophotometer. The excitation and emission spectra of a material were recorded with a Fluorolog Spectrofluorometer (Horiba Jobin YVON Fluolog Model FL 3-11) at room temperature.

The UV-Vis absorption and photoluminescence spectrum were obtained in a solution of toluene and are shown in Fig. 5. The maximum of the UV-Vis absorption peaks of Cd(HPB)q was observed at 378 nm, which is due to the  $\pi$ - $\pi^*$  transition of aromatic ring. The peak of the PL spectrum of Cd(HPB)q was observed at 520 nm.

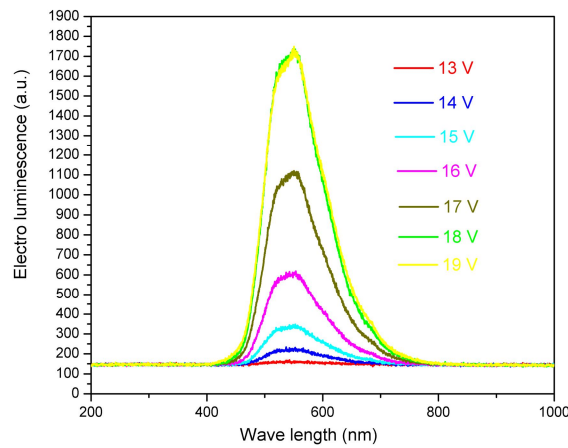
#### 4.3 Electroluminescent analysis

The electroluminescent (EL) spectrum was recorded on a high-resolution spectrometer (Ocean Optics, HR-2000CG UV-NIR). The luminance–current–voltage (I-V-L) characteristics were measured using a luminance meter (LMT 1009) and a Keithley 2400 programmable voltage-current digital source meter.

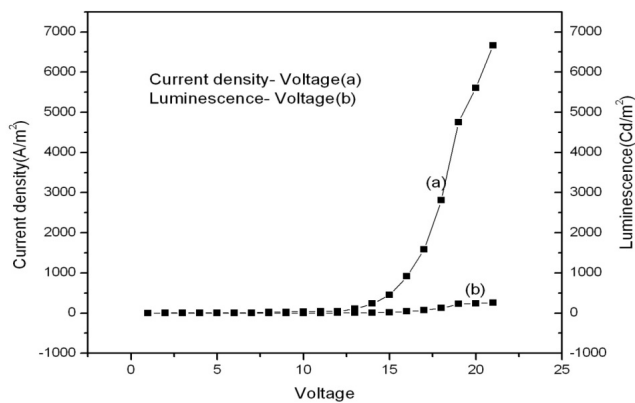


**Fig. 5** – UV-Visible and Photoluminescence spectra of Cd(HPB)*q*

The EL spectra were recorded at various applied voltages as shown in Fig. 6. The EL intensity of the device increases with increase in voltage from 12 V to 21 V, and the peak position remain unchanged at 550 nm.

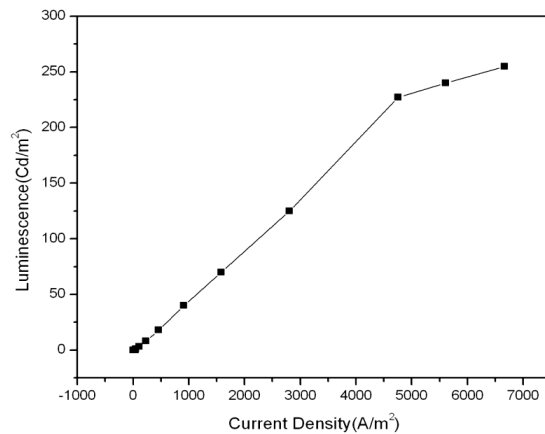


**Fig. 6** – EL Vs Wavelength at different voltages of Cd(HPB)*q*

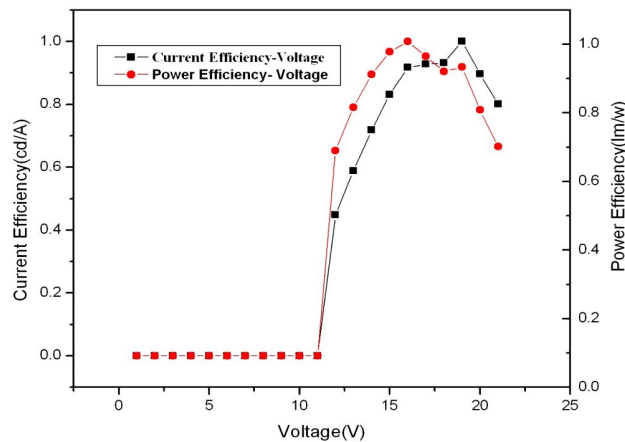


**Fig. 7** – Current density-Voltage-Luminescence curve of Cd(HPB)*q*

The current density- voltage (J-V) and luminiscense versus voltage (b) characteristic of the fabricated device was recorded by applying voltage across the device with ITO as an anode and aluminium as cathode (forward bias) as shown in Fig. 7. From the J-V characteristic it has been seen that the onset of light emission starts at about 11 V (threshold voltage). Above this voltage, the current rises non-linearly due to the space charge effects. Above the threshold voltage the device emits a yellowish green light. Below this voltage the J-V characteristics shows Ohmic current indicating the presence of thermally generated carrier. The current luminiscense versus current density curve is shown in Fig. 8.



**Fig. 8** – Luminiscense-current density curve of Cd(HPB)q



**Fig. 9** – Current Efficiency-Voltage-Power Efficiency curve of Cd(HPB)q

The current efficiency and power efficiency versus voltage curve is shown in Fig. 9. The device shows maximum current efficiency 1.01 cd/A and maximum power efficiency 1.01 lm/W at 17 V.

## 5. CONCLUSION

A new metal complex was successfully synthesized by the reaction of 8-hydroxyquinoline and 2-(2-hydroxyphenyl) benzoxazole with Cadmium acetate. The TGA and FTIR curves show the good thermal stability and proper attachment of cadmium with organic materials, respectively. The thermal stability and electroluminescence properties of Cd(HPB)q suggests a promising yellow emitting material for organic light emitting devices application.

The authors are thankful to the Director of National Physical Laboratory, New Delhi for continuous encouragement. The authors would also like to thank Dr. A.K. Gupta, Dr. S.S. Bawa, Dr. S.K. Dhawan for their suggestions and discussion. The authors also gratefully recognize the financial support from the Department of Information Technology (DIT) India.

## REFERENCES

1. C.W. Tang, S.A. Van Slyke, *Appl. Phys. Lett.* **51**, 913 (1987).
2. C.W. Tang, S.A. Van Slyke, C.H. Chen, *J. Appl. Phys.* **65**, 3610 (1989).
3. Y. Hamada, T. Sano, M. Fujita, T. Fujii, Y. Nishio, K. Shibata, *Jpn. J. Appl. Phys.* **32**, L514 (1993).
4. J. Kido, K. Hongawa, K. Okuyama, K. Nagai, *Appl. Phys. Lett.* **64**, 815 (1994).
5. Y. Hamada, T. Sano, H. Fujii, Y. Nishio, H. Takahashi, K. Shibata, *Jpn. J. Appl. Phys.* **35**, L1339 (1996).
6. S.F. Liu, Q. Wu, H.L. Schmider, H. Aziz, N.X. Hu, Z. Popovic, S. Wang, *J. Am. Chem. Soc.* **122**, 3671 (2000).
7. Q. Wu, J.A. Lavigne, S. Wang, *Inorg. Chem.* **39**, 5248 (2000).
8. Y.K. Jang, D.E. Kim, O.K. Kwon, Y.S. Kwon, *J. Korean Phys. Soc.* **49**, 1057 (2006).
9. N. Donze, P. Pechy, M. Gratzel, M. Schaer, L. Zuppiroli, *Chem. Phys. Lett.* **315**, 405 (1999).
10. A.N. Du, Q. Mei, M. Lu, *Synth. Metals* **149**, 193 (2005).
11. A. Yeha, T.R. Chenb, *Mater. Lett.* **59**, 2911 (2005).
12. Q. Wu, M. Esteghamatian, N.X. Hu, Z.D. Popovic, G. Enright, S.R. Breeze, S. Wang, *Angew. Chem. Int. Ed. Engl.* **38**, 985 (1999).
13. Z.K. Chen, H. Meng, Y.H. Lai, W. Huang, *Macromolecules* **32**, 4351 (1999).
14. S. Tokito, H. Tanaka, K. Noda, A. Okada, Y. Taga, *Appl. Phys. Lett.* **70**, 1929 (1997).