



Novel pbi-Br blue light-emitting phosphors for OLED

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Abstract :

The new blue emitting organic phosphor 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole (pbi-Br) has been synthesized by Suzuki Coupling reaction at 130 °C for the application in organic light-emitting diodes (OLEDs). The Optical, structural and thermal properties of the 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole (pbi-Br), has been studied. The UV-vis absorption spectra could provide a good deal of information on the electronic structures of the polymeric compound. The photo physical properties were studied by UV-vis absorption and photoluminescence. The organic phosphor (pbi-Br) shows three absorption peaks at 262, 301 and 337nm in Acetic Acid solution and exhibit blue photoluminescence in solid-state crystalline powder. The synthesized pbi-Br organic phosphor demonstrates emission in blue region at 390 & 409 nm in powder when excited at 347nm. It is proposed that the synthesized phosphor may be efficiently used as the emitter materials in Organic Light-Emitting Diodes OLEDs. It is promising candidates for potential applications in organic light-emitting diodes OLEDs, light-emitting electrochemical cells and solid-state organic lighting applications.

Keyword:-Synthesis, pbi-Br, Photoluminescence, FTIR.

INTRODUCTION :

In the past two decades, organic light emitting diodes (OLEDs) have received great attention for their application in flat panel display (FPD) and solid state lighting (SSL) as they offer several advantages for self-emitting displays, a wide viewing angle (almost 180°), a thin panel (<2 mm), light weight, a fast response time (microseconds and less), high contrast, flexible display, bright emission and surface emitting [1–9]. Compared with other components in OLEDs, e.g., electrodes, electron/hole transports, hosts, light emitting materials are considered to be the core of OLEDs [10], because their photophysical properties have a direct impact on the performance of OLEDs. Since influential and pioneering work made by Forrest et al. [11], heavy transition metal complexes have been attracting increasing attention due to their harvesting both singlet and triplet excitons for phosphorescence emission to present internal quantum efficiency of 100% in OLED [12–15], which are superior to fluorescent emitters, for which only singlet excitons can be harvested, giving an upper efficiency limit of 25%. Many blue light-emitting dyes have been studied to achieve blue light emissions with host and dopant materials as the emitter, but there is still a clear need for further improvements in terms of stability, efficiency, and color purity [16–19]. Latest studies reveal blue OLEDs with phosphorescent emitters to exhibit comparatively high device efficiency [20–22]. It is important to note that deep-blue or even pure-blue emission has not yet been observed from the phosphorescent emitters containing OLED devices to the moment. Besides, the

lifetime of phosphorescent blue OLEDs is still far too short to be adopted commercially [23]. Therefore, blue fluorescent material is still of prime importance for application in full-color flat-panel displays.

The present work deals with synthesis and structural & photo physical characterization of blue-light-emitting pbi-Br phosphor.

2. EXPERIMENTAL :

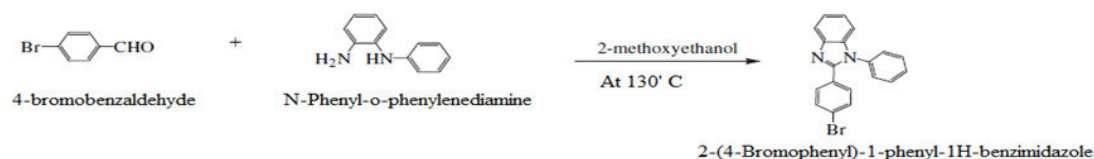
All reagents and solvents were used as received without further purification. All reactions were performed under argon atmosphere. pbi-Br Phosphor was synthesized conveniently by Suzuki Coupling reaction. Bruker Fourier transform infra-red (FTIR) spectrometer was used to confirm the packing arrangements, chain conformational properties of pbi-Br chromophores over the range 4000–600/cm by averaging 64 scans at a maximum resolution of 04/cm. The optical absorption spectrum of phosphor in Acetic Acid was obtained on PerkinElmer Lambda 35 spectrophotometer. The photoluminescence (PL) spectrum was obtained by a SHIMADZU RF 5301 spectrofluorometer.

2.1. 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole(pbi-Br) :

The organic phosphor 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole (pbi-Br) was synthesized conveniently according to Scheme 1 from the condensation of N-Phenyl-ophenylenediamine and 4-bromobenzaldehyde by Suzuki Coupling reaction. N-Phenyl-ophenylenediamine (1 equiv) and 4-bromobenzaldehyde (1 equiv.) were dissolved in 50 ml of 2-methoxyethanol. The mixture was refluxed for 48 hrs. The volatiles were

removed under vacuum and the resulting solid was extracted by dichloromethane. The organic extract was washed with brine solution and dried over anhydrous $MgSO_4$,

and then it was filtered and evaporated to dryness. The pure compound was acquired as a brownish solid with a 60% yield. $[C_{19}H_{13}BrN_2]$



Schem-1: Synthesis route of 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole

3. RESULT AND DISCUSSION :

3.1 FTIR Analysis :

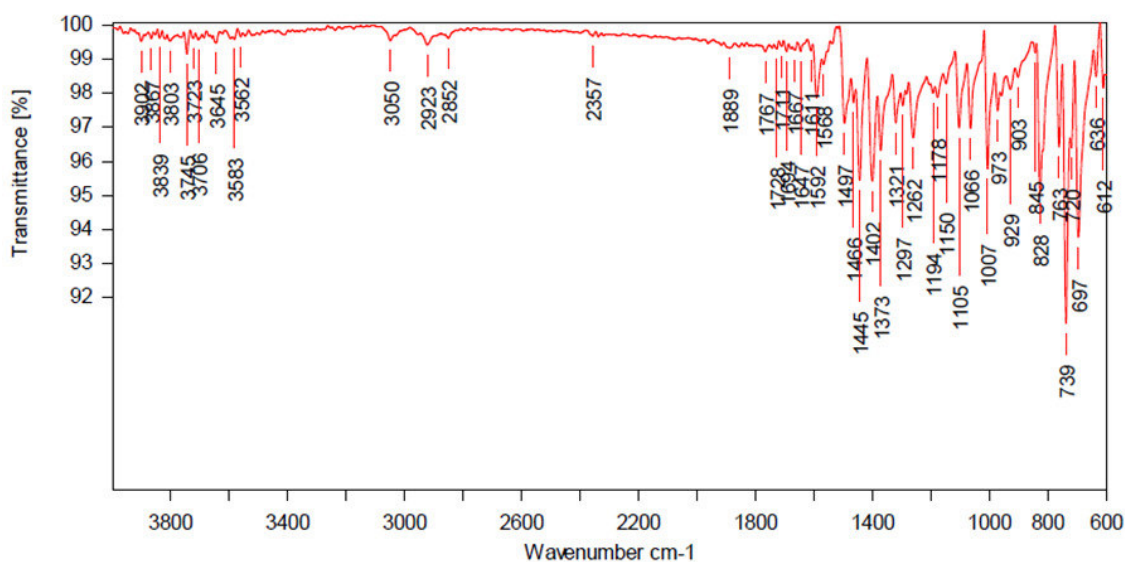


Fig 1 : FTIR graph of 2-(4-Bromophenyl)-1-phenyl-1H-benzimidazole (pbi-Br)

Fourier Transform Infrared Spectroscopy (FT-IR) is an analytical technique used to identify organic materials. The molecular structures of polymeric compound are confirmed by FT-IR spectra. This technique measures the absorption of various infrared light wavelengths by the material of interest. The FTIR spectra of pbi-Br phosphor is as shown in figure 1. The variation in the range $3600 - 3950\ cm^{-1}$ was observed due to single bond stretch free O-H stretching vibrations. The next strong variation was observed in the range $2800 - 3100\ cm^{-1}$. It may due to the effect of single C-H stretching vibrations. There are aromatic C=C stretching bands for the

carbon-carbon bonds in the aromatic ring) at about $1500\ cm^{-1}$.

3.2 Optical Properties :

3.2.1 Photo- physical properties:

The Photoluminescence spectra of pbi-Br is shown in Fig.2. When the powder is excited at $347\ nm$, it emits blue light at the wavelength of $390\ nm$ and $409\ nm$ and is suitable for OLED as shown in Fig. Thus the luminescent properties of the materials become interesting as they have received extensive attention for their potential applications in many aspects such as photonic crystal, optical glasses, and fluorescent or laser systems.

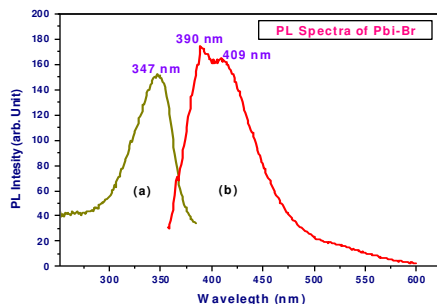


Fig 2 : PL excitation and emission spectra in powder form.

3.2.2 Absorption spectra :

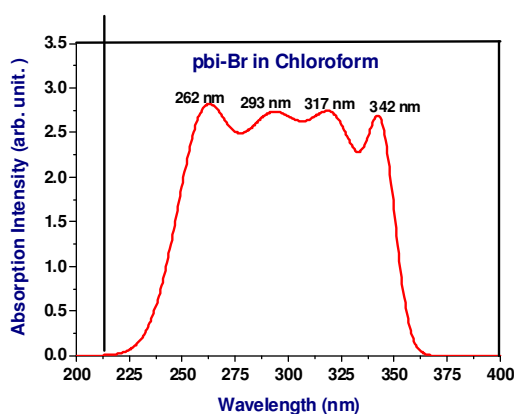


Fig. 3 : UV-Vis spectra of pbi-Br in Chloroform. We have studied the photo physical properties of Pbi-Br. The UV-viz absorption spectra of 10^{-3} M pbi-Br in chloroform and acetic acid at room temperature as shown in fig. 3 & fig. 4 respectively. The emission of colour from different materials is related to the absorption of light at different wavelengths in the region of visible part of spectrum. The UV absorption spectra provide a good deal of information on the basis of electronic structure of the different compounds. The compound Pbi-Br shows broad absorption band in acetic acid ranging from 225 to 375 nm with a λ_{max} at around 320nm and shoulder at 262nm, 301nm and 337 nm.

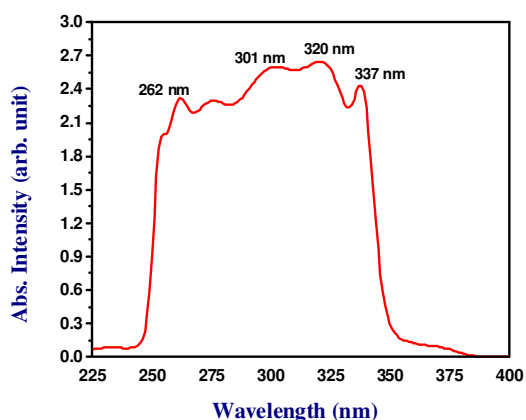


Fig. 4 : UV-Vis spectra of pbi-Br in Acetic acid 337nm respectively . Also in chloroform absorption band ranging from 225 to 375 nm with a λ_{max} at around 342 nm and shoulder at 262nm, 293 nm and 317 nm.

3.2.3 Energy band gap determination:

Morita et al. in 1995 describe the method for the determination of energy band gap. For determining the band gap energy we use figure has the photon energy ($h\nu$) on the X axis and a quantity $(\text{Energy} \times \text{Abs.})^2$ on the Y axis and extrapolating the linear portion of the curve to the X axis yields the energy of the material. Determination of energy band gap for pbi-Br in acetic acid as shown in figure 5.

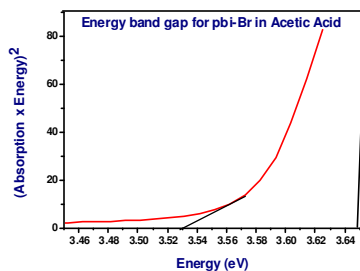


Fig. 5 : Determination of band gap E_g of pbi-Br in acetic acid

Using the procedure described by Morita et al., for energy gap determination, we obtain the energy gap $E_g = 3.53$ eV in acetic acid of 10^{-3} M solution.

4. CONCLUSION :

Blue emitting organic phosphor pbi-Br has been synthesized in nearly quantitative yields by Suzuki coupling reaction of N-Phenyl-phenylenediamine and 4-bromobenzaldehyde. FTIR spectra confirm the formation of the synthesized pbi-Br organic polymer. The UV-vis absorption spectra in acetic acid and chloroform provided information on the electronic structures of the polymeric compound. The synthesized polymeric compounds demonstrate a bright emission in blue region in the wavelength range of 390–450 nm in solid state. Hence this phosphor can be used as a promising blue light material for electroluminescent devices.

REFERENCES :

1. C.W. Tang, S.A. Vanslyke, Appl. Phys. Lett. 51 (1987) 913.
2. M.A. Baldo, M.E. Thompson, S.R. Forrest, Nature 403 (2000) 750.
3. S. Lamansky, P. Djurovich, D. Murphy, F. Abdel-Razzaq, H.E. Lee, C. Adachi, P.E. Burrows, S.R. Forrest, M.E. Thompson, J. Am. Chem. Soc. 123 (2001) 4304.
4. S. Lamansky, P.I. Djurovich, F. Abdel-Razzaq, S. Garon, D.L. Murphy, M.E. Thompson, J. Appl. Phys. 92 (2002) 1570.
5. B.W. D'Andrade, R.J. Holmes, S.R. Forrest, Adv. Mater. 16 (2004) 624.
6. N. Rehmman, C. Ulbricht, A. Köhnen, P. Zacharias, M.C. Gather, D. Hertel, E. Holder, K. Meerholz, U.S. Schubert, Adv. Mater. 20 (2008) 129.
7. H.B. Wu, G.J. Zhou, J.H. Zou, C.L. Ho, W.Y. Wong, W. Yang, J.B. Peng, Y. Cao, Adv. Mater. 21 (2009) 4181.
8. J.H. Zou, H. Wu, C.S. Lam, C.D. Wang, J. Zhu, C.M. Zhong, S.J. Hu, C.L. Ho, G.J. Zhou, H.B. Wu, W.C.H. Choy, J.B. Peng, Y. Cao, W.Y. Wong, Adv. Mater. 23 (2011) 2976.
9. G.J. Zhou, W.Y. Wong, S. Suo, J. Photochem. Photobio. C: Photochem. Rev. 11 (2010) 133.
10. H. Fu, Y.-M. Cheng, P.-T. Chou, Y. Chi, Mater. Today 14 (2011) 472.
11. M.A. Baldo, D.F. O'Brien, Y. You, A. Shoustikov, S. Sibley, M.E. Thompson, S.R. Forrest, Nature 395 (1998) 151.
12. M.A. Baldo, S. Lamansky, P.E. Burrows, M.E. Thompson, S.R. Forrest, Appl. Phys. Lett. 75 (1999) 4.
13. W.Y. Wong, C.L. Ho, Coord. Chem. Rev. 253 (2009) 1709.
14. W.Y. Wong, C.L. Ho, J. Mater. Chem. 19 (2009) 4457.
15. G.J. Zhou, W.Y. Wong, X.L. Yang, Chem. Asian J. 6 (2011) 1706.
16. Gao ZQ, Mi BX, Chen CH, Cheah KW, Cheng YK, Wen WS. Appl Phys Lett 2007;90: 123506-8.
17. H.K. Dahule, S.J. Dhoble, J.-S. Ahn, RamchandraPode, Journal of Physics and Chemistry of Solids 72 (2011) 1524–1528
18. Lee MT, Chen HH, Lian CH, Tsai CH, Chen CH. Stable, Appl Phys Lett 2007;85:3301-3.
19. H. K. Dahule, S. J. Dhoble, Adv. Mat. Lett. 2014, 5(12), 734-741.
20. Su SJ, Gonmori E, Sasabe H, Kido J. Adv Mater 2008;20:4189-94.
21. Chopra N, Lee J, Xue J, So F. IEEE Trans Electron Devices 2010;57:101-7.
22. Jou JH, Wang WB, Hsu MF, Shyue JJ, Chiu CH, Lai IM, et al. ACS Nano 2010; 4: 4054-60.
23. Giebink NC, Forrest SR. Phys Rev B Condense Matter Mater Phys 2008;77:235215.
24. Fuli Zhang, Lian Duan, Juan Qiao, Guifang Dong, Liduo Wang, Yong Qiu, Organic Electronics 13 (2012) 1277–1288.
25. Min-Ji Kim, Chil-Won Lee, Myoung-Seon Gong, Dyes and Pigments 105 (2014) 202-207.

