



## Optical Study of Blue Light Emitting Cl<sub>2</sub>-Br-DPQ Organic Phosphor for OLED's

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### Abstract:

A new-deep blue light emitting organic phosphor namely, Cl<sub>2</sub>-Br-DPQ has been synthesized for single-layer, solution-processable, and blue organic light-emitting diodes (OLEDs). Their absorption and photoluminescence systematically studied. The UV-vis absorption spectra could provide a good deal of information on the electronic structures of the polymeric compound. UV-Vis measurements of Cl<sub>2</sub>-Br-DPQ in different polar solvents show three absorption bands in range of 250-400 nm related to π-π\* and n-π\* transitions. Cl<sub>2</sub>-Br-DPQ in different solvents emits light in the range 421-441 nm with the Commission Internationale de l'Eclairage (CIE) coordinates that are positioned in the blue region of the chromaticity diagram.

These results show that the synthesized Cl<sub>2</sub>-Br-DPQ can be used in applications such as opto-electronic OLED devices, displays and solid state lighting technology.

**Keywords:** Cl<sub>2</sub>-Br-DPQ, OLED's, display device.

### 1. Introduction

There is an enormous demand for advanced visual displays in the Information Age. Portable wireless communication devices need sophisticated low-power, color flat-screen displays. Flat screen displays for computers and televisions are in high demand. There is, therefore, a great interest in the developing OLED technology to produce low power, high-definition, and flat-screen visual displays [1-7]. Since the first commercialization of organic light-emitting diodes

(OLEDs) in 1997 by the pioneering company in Japan [8]. For OLED devices to become competitive in the market place, OLED having higher life span are desirable. In recent years, white phosphorescent OLEDs (PHOLEDs) have received a great deal of attention owing to their potential use in high performance and brightness displays, solid state lighting, and back lighting for Liquid Crystal Displays [9]. White emission can be achieved by mixing three primary colors (red, green, and blue) [10-13]. Red and green emitters have enough whereas blue emitters show degradation with operating time. However, the blue PHOLEDs have a critical problem of short lifetime [14] because of lack of stable high triplet energy host and charge transport materials which can confine triplet excitons and prolong the lifetime of the blue PHOLEDs. Color purity and stability of blue color remains a challenge. Several low molecular blue emitting materials such as distyrylalkenes, metal chelates, anthracene derivatives, spirofluorenes, pyrazoloquinolines, siloles, etc. were used for fabricating blue OLEDs [15-16]. The blue emitter is doped into a wide-band-gap electron-transport host. Small

concentration reduces the concentration quenching in the blue emitter and also improves the electron injection and transport in the host matrix [17-20].

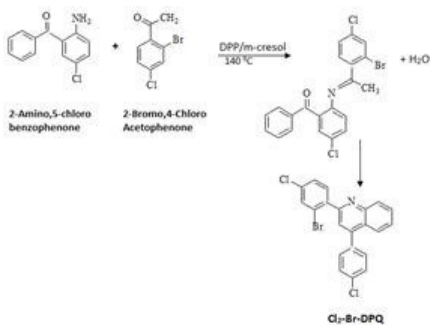
Therefore, there is a need to develop stable and efficient blue-emitting materials. In this investigation, we have synthesized new blue light emitting Cl<sub>2</sub>-Br-DPQ.

### 2. Experimental

#### 2.1. Synthesis of 2-(2-Bromo, 4-Chloro phenyl) 4-chlorophenyl quinoline (Cl<sub>2</sub>-Br-DPQ)

The Cl<sub>2</sub>-Br-DPQ were synthesized conveniently according to Scheme-I from the condensation of 2-Amino, 5-Chloro Benzophenone and 2-Bromo 4-Chloro Acetophenone using the acid-catalyzed Friedlander reaction [21-23].

2-Amino, 5-Chloro Benzophenone (1 gm) and 2-Bromo 4-Chloro Acetophenone (1 gm) were added along with 1 gm of diphenyl phosphate and 3 ml of m-cresol in a glass reactor fitted with mechanical stirrer. Heat the reaction mixture at 90°C for 1 h and then for 4 h at 140°C. After cooling, methylene chloride (100 ml) and 10% NaOH (100 ml) were added to reaction mixture. The organic layer was separated and collects this layer on watch glass to evaporate remaining dichloromethane, then washed with distilled water (50 ml × 5 times) and Hexane (20 ml × 5 times) to obtain crystalline solid of Cl<sub>2</sub>-Br-DPQ. Relative molar mass of Cl<sub>2</sub>-Br-DPQ = 429.13 gm.



Scheme 1: Synthesis of Cl<sub>2</sub>-Br-DPQ

**3.Result and Discussion**

**3.1. Photophysical properties**

**(a) UV-Vis absorption**

The electronic transitions in compounds can be determined by ultraviolet-visible spectroscopy [24-25]. The optical UV-Vis absorption was measured in different solvents (in molar concentration about 10<sup>-4</sup>) by using SHIMADZU-1800 Spectrophotometer at room temperature. The absorption spectra are of Cl<sub>2</sub>-Br-DPQ as shows in Fig.1.

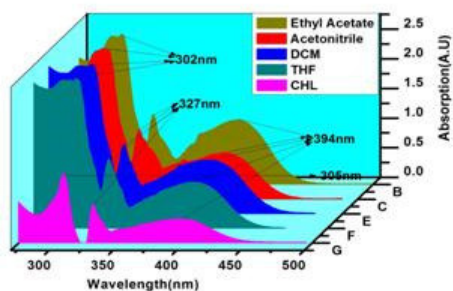


Fig.1. Absorption spectra of in 10<sup>-4</sup> mol different solvents

The spectra contain three notable peaks. The shapes of absorption spectra of compound in different solvents are similar. The UV-VIS absorption spectra could provide a good deal of information on the electronic structures of the polymeric compound. The maximum absorption peaks region is 302nm-305nm. the second shoulder obtained at 327nm. The three transitions π→π\*, n→σ\*, n→π\* are responsible for absorption in the region 200-800 nm, whereas σ→σ\* require much higher energy [26-27]. The lowest-energy absorption bands located at 394 nm can be due to the n-π\* transition assigned to the intermolecular charge transfer (ICT). The numbers of shoulders of absorption spectra's are due to the different bond vibration. The intensity of absorptions peak approximately reduces to zero at 450 nm.

Optical band gap of Cl<sub>2</sub>-Br-DPQ in different solvents were calculated from the absorption spectra by using the procedure described by Morita et al., [28] shown in Fig. 2.

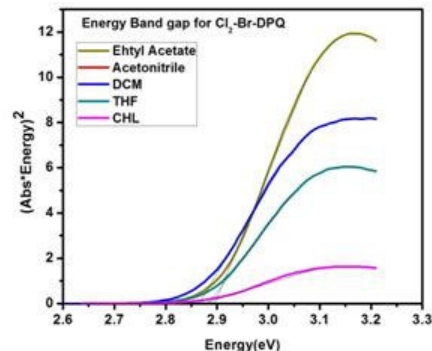


Fig.2. Determination of band gap E<sub>g</sub> for Cl<sub>2</sub>-Br-DPQ in different solvents at absorption 394nm. The calculated energy band gap for Cl<sub>2</sub>-Br-DPQ found to be in the range of 2.86-2.88eV in different solvents. The energy band gap for different peak value has been mentioned in Table 1.

**(b)Photoluminescence spectra**

Fig.3. shows excitation spectra for Cl<sub>2</sub>-Br-DPQ. When Cl<sub>2</sub>-Br-DPQ in different solvents excited at 327nm and at 346nm it shows same emission wavelength.

The PL spectra Cl<sub>2</sub>-Br-DPQ in different solvent (Fig.4) displayed blue phosphorescence. When Cl<sub>2</sub>-Br-DPQ in different solvents excited at 327nm, it gives blue emission in the range 421 nm-441nm. When pure DPQ is excited at 383 nm, it emits intense blue light of wavelength 436 nm. Due to the presence of electron-withdrawing bromo and chloro substituent groups in 2-4 diphenyl quinoline, it shows red shift in emission wavelength of Cl<sub>2</sub>-Br-DPQ.

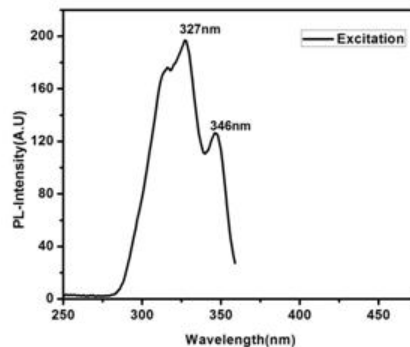


Fig.3. Excitation spectra for Cl<sub>2</sub>-Br-DPQ

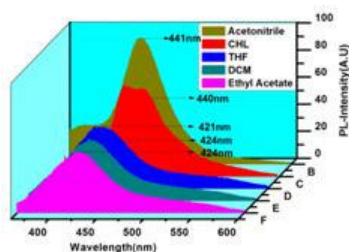


Fig.4: Excitation spectra of Cl<sub>2</sub>-Br-DPQ in powder form

The solvent-polarity independence of absorption and emission spectra indicated that the molecule was almost nonpolar and its dipole moments and conformation remained unchanged on electronic transition. These favorable nonpolar properties of Cl<sub>2</sub>-Br-DPQ would facilitate stability of blue-light emitting and improvement of device efficiencies.

**Color Co-ordinate**

The CIE chromaticity diagram is as shown in given fig.5. The color of the synthesized Cl<sub>2</sub>-Br-DPQ phosphor phosphorescence is calculated from the emission spectrum using the

chromaticity coordinate calculation method [29]. The Chromaticity coordinates of Cl<sub>2</sub>-Br-DPQ in different solvents are in the blue region. CIE Co-ordinates with full width at half maximum (FWHM) value are in different solvents are mentioned in Table 1.

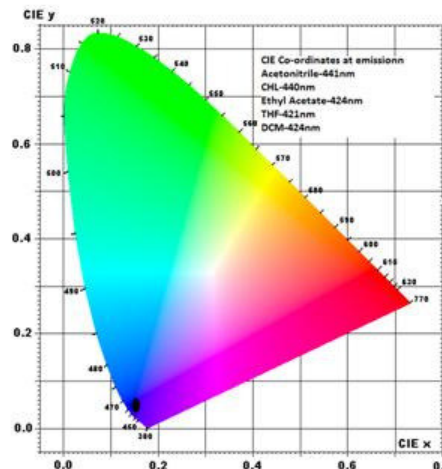


Fig.5: CIE 1931 (x,y) diagram displaying emission color coordinates of Cl<sub>2</sub>-Br-DPQ

The Stokes shift was observed between the absorption and emission spectra maxima. The Stokes shifts (cm<sup>-1</sup>) were determined by Eq. (2).

$$(V_{Abs} - V_{Em}) = (1/\lambda_{Abs} - 1/\lambda_{Em}) \times 10^7 \text{ cm}^{-1} \dots\dots\dots(2)$$

The molecules show Stokes shifts are high with values as tabulated as follows (Table 1) ensuring that there is no re-absorption of the emitted radiation. The derivatives have high Stokes' shifts, which is applicable for good light emission [30].

**Table 1. UV-Vis and Photoluminescence parameters for Cl<sub>2</sub>-Br-DPQ**

Solvent	$\lambda_{Abs}^a$ (nm)	$E_g^b$ (eV)	$f^c$	O.D <sup>d</sup>	$T^e$	CIE Co- ordinate	FWHM <sup>f</sup> (nm)	Stoke's shift (cm <sup>-1</sup> )
THF	302	3.76	0.708	2.52	5.803	X=0.1566, Y=0.0463	73	9360
	327	3.45	0.056	1.17	2.695			
	394	2.88	0.168	0.78	1.796			
Chloroform	305	3.72	0.126	1.17	2.695	X=0.1520, Y=0.0493	62	10056
	327	3.46	0.037	0.66	1.519			
	394	2.88	0.095	0.40	0.921			
Di chloro methane	302	3.82	0.501	2.52	5.803	X=0.1560, Y=0.0471	72	9533
	327	3.51	0.051	1.17	2.695			
	394	2.86	0.229	0.9	2.072			
Ethyl ace tate	302	3.82	0.481	2.53	5.827	X=0.1559, Y=0.0498	74	9533
	327	3.51	0.036	1.19	2.741			
	394	2.89	0.212	1.09	2.510			
Ace tonitrile	302	3.80	0.549	2.54	5.849	X=0.1526, Y=0.0399	54	10443
	327	3.5	0.061	1.17	2.695			
	394	2.84	0.193	0.77	1.773			

<sup>a</sup> maximum Absorption Wavelength  
<sup>b</sup> Energy band gap (Using UV)  
<sup>c</sup> Oscillator strength

<sup>d</sup> optical density = A/L (Length of cuvette)  
<sup>e</sup> optical depth = A ln 10  
<sup>f</sup> Full width half maxima (Using PL)

**4. Conclusion**

The Cl<sub>2</sub>-Br-DPQ has been synthesized in nearly quantitative yield by Friedlander condensation of and characterized by photophysical properties. In conclusion, The Cl<sub>2</sub>-Br-DPQ, organic compound is a blue light emitting chromophore in solid powder form. The synthesized Cl<sub>2</sub>-Br-DPQ in different solvents when excited at 351 nm show blue emission in the range 421nm-441nm with ideal CIE coordinates (CIEy ≤ 0.1). Using UV-Vis absorption and photoluminescence (PL) spectroscopy, basic photo physical characteristics such as the absorption maxima (a<sub>bs</sub>), optical band gaps (E<sub>g</sub><sup>opt</sup>), maximum intensity, optical density, optical depth and CIE co-ordinates of the molecules are determined. This describe result indicate that the new synthesized Cl<sub>2</sub>-Br-DPQ is very promising for applications in flexible organic devices and to be cheaper and more saving energy efficient than the technologies currently available.

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