ساخت و مشخصه یابی دیود نورگسیل پلیمری از مشتقات سنتز شده Chromeno[3,4-b]quinoline

زهرا عابدی[1]، عزالدین مهاجرانی[1]، زهرا رشیدی[2]، محسن کوهکن[1]ونی، ابراهیم صفریان[1]

[1] پژوهشکده لیزر و پلاسما، دانشگاه شهید بهشتی، تهران، ایران

[2]دانشکده شیمی، دانشگاه شیراز، شیراز، ایران

چکیده - *در این مقاله، دیود نورگسیل تک لایه پلیمری که در آن مشتقات مختلف Chromeno[3,4-b]quinoline به عنوان میهمان در PVK و PBD آلائیده شده اند، گزارش شده است. انتقال انرژی از محیط میزبان، PVK با PBD، به مشتقات Chromeno[3,4-b]quinoline مطالعه شد. همچنین مشخصات اپتیکی و الکتریکی مواد و دیودها در راستای بهبود عملکرد قطعه، مورد بحث و بررسی قرار گرفت.*

کلید واژه- دیود نورگسیل، آلائیده، تک لایه، ***Chromeno[3,4-b]quinoline*** .

Characterization of PLED From Synthesized Derivatives of Chromeno[3,4-b]quinoline

Zahra Abedi[1], Ezeddin Mohajerani[1], Zahra Rashidi[2], Mohsen Kouhkan[1], Ebrahim Safarian[1]

[1]Laser and Plasma Research Institute, Shahid Beheshti University, Tehran, Iran

[2]Department of Chemistry, Shiraz University, Shiraz, Iran

Correspondence to: Ezeddin Mohajerani, e-mohajerani@sbu.ac.ir, +982129904003

Abstract- Single-layer polymer light-emitting diodes that employ different derivatives of Chromeno[3,4-b]quinoline as a guest doped in poly(vinylcarbazole)(PVK) with 2- tert-butylphenyl-5-biphenyl-1,3,4-oxadiazol (PBD) is reported. Energy transfer from the polymer blends, PVK with PBD(host), to Chromeno [3,4-b] quinoline derivatives(guest) is studied. In addition, the optical and electrical characteristics of materials and devices are investigated for optimization of device performance.

Keywords: Light-emitting diodes, Dope, single-active-layer, Chromeno[3,4-b]quinoline

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1 Introduction

Since organic light-emitting diodes (OLEDs) and polymer light-emitting diodes (PLEDs) have drawn great interest due to their unique characteristics such as high brightness, light weight, thin structure, and wide colour range, much effort has been made to improve the performance of the device [1-2]. For small-molecule-based light-emitting diodes (SMOLEDs), multilayer configuration is applied to achieve a balanced charge-carrier injection and enhanced luminescence efficiency [3]. However, the complex multilayer SMOLEDs have some fabrication disadvantages as high vacuum sequential multilayer deposition, device size limitation, complexity and high cost. Since the polymer thin films are typically coated using solution based techniques (spin casting, screen printing or inkjet printing), an alternative method to integrate the functions of different materials into a thin film is to mix all electron-transport, hole-transport, and emissive materials together in a single solvent and then spin-coat the mixture in a single step, resulting in lower cost fabrication with the advantage of large area manufacturability [4].

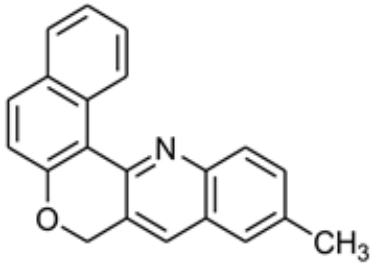
The use of dopant emitters in the host-guest systems is an effective approach to improve the electroluminescence (EL) efficiency and to achieve various emission colours by choosing appropriate fluorescent dyes as the dopant. In this instance as well, dye-doped polymers are good with more flexibility in material design and are ideally fitted for the fabrication of single-layer devices.

In this article, we report the luminescent properties of Chromeno [3,4-b] quinoline derivatives and investigate the excitation energy transfer from polymer blends, PVK with PBD(host), to Chromeno [3,4-b] quinoline derivatives(guest). Low molecular weight electron-transport material PBD is mixed with PVK to improve the electron injection and transfer.

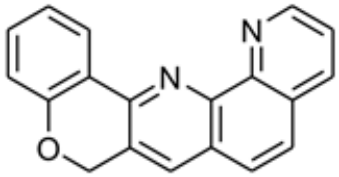
2 Experimental

2.1 Materials

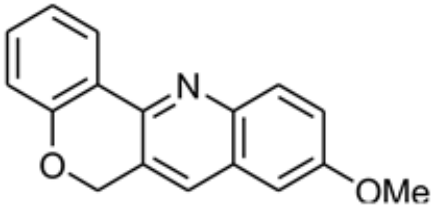
Materials including PEDOT:PSS (poly(3,4-ethylenedi-oxythiophene):poly(styrenesulfo-nate)), PVK and PBD are purchased from Sigma Aldrich and used without any further purification (Fig.1). The derivatives of Chromeno[3,4-b]quinoline were synthesized in the Chemistry Department of Shiraz university and prepared and purified according to the literature procedures [5].



a) 11-Methyl-8H-benzo[5,6]chromeno[4,3-b]quinoline



b) 8H-chromeno[4,3-b][1,10]phenanthroline



c) 6H-chromeno[4,3-b]quinolin-9-yl methyl ether

Figure 1: Chemical Structures of the Chromeno[3,4-b]quinoline derivatives.

2.2 Fabrication and Characterization of PLED

For device fabrication, we used only the single-active-layer configuration with PEDOT:PSS on indium tin oxide (ITO) as the hole-injecting bilayer electrode.

ITO-coated glass substrates were ultrasonically cleaned with detergent, acetone, isopropanol, dichloroethane, ethanol, and deionized water, respectively. Then, the cleaned ITO substrates were dried by blowing nitrogen. PEDOT: PSS layer was spin coated on the clean ITO substrate up to thickness of 70 nm and was baked in oven at 120 $^{\circ}$C for 30 min to remove residual water. In order to prepare light emitting layer (LEL), PVK, dopant Chromeno[3,4-b]quinoline derivatives and PBD were dissolved in dichloromethane. The weight ratios are determined for the various materials PVK:

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Chromeno[3,4-b]quinoline: PBD as 100:5:40, respectively. Different derivatives of Chromeno[3,4-b]quinoline are represented by **a**, **b**, and **c**. Prepared solution was spin coated over the PEDOT:PSS up to thickness of 100 nm and was baked in oven for 30 min at 120 $^{\circ}$C to soften the sharp peaks of layer and to achieve more even surface. Finally, the aluminium cathode was deposited thermally on the top of the structure through a shadow mask. The device structures are shown in Table 1.

Table 1: The device structures; Chromeno [3,4-b] quinoline derivatives (**a**, **b**, and **c**) doped in PVK:PBD

Device	Structure
Device 1	ITO/ PEDOT:PSS (70 nm)/ PVK:PBD (100nm)/ Al (120nm)
Device 2	ITO/ PEDOT:PSS (70 nm)/ PVK:PBD: 5 wt% **a** (100nm)/ Al (120nm)
Device 3	ITO/ PEDOT:PSS (70 nm)/ PVK:PBD: 5 wt% **b** (100nm)/ Al (120nm)
Device 4	ITO/ PEDOT:PSS (70 nm)/ PVK:PBD: 5 wt% **c** (100nm)/ Al (120nm)

3 Results and discussion

The absorption spectra of **a**, **b**, **c**, and PL spectra of PVK:PBD (40 wt %) film are shown in Fig. 2. It can be seen that the maximum PL for PVK:PBD exciplexes in dichloromethane solvent is at 425 nm and has a good overlap with the absorption spectra of **a**, **b**, and **c**. This overlap guarantees the Forster energy transfer from PVK:PBD as a host to **a, b,** and **c** as a guest. Instead of having an efficient Forster energy transfer condition, uniform mixing of the two species is also required since the range of Forster energy transfer is only a few nanometres. This requirement could have been fulfilled by using the spin - coating method.

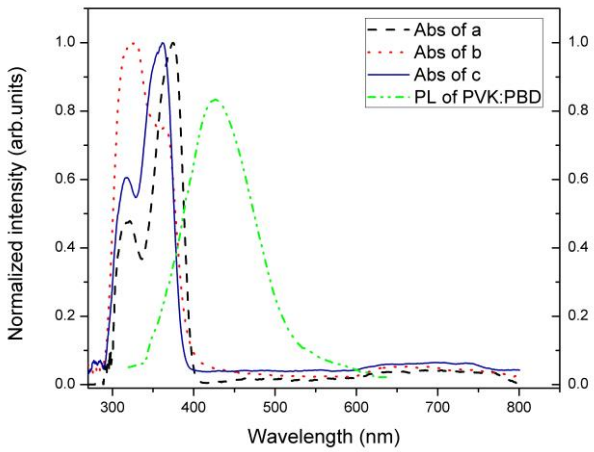


Figure 2: Photoluminescence characteristic of PVK:PBD, and absorbance of a, b, and c.

The current–voltage characteristics of the devices 1, 2, 3, and 4 are depicted in Fig. 3. It is obvious there is much variation in I-V curves with different driving voltages. Since all devices are indistinguishable in every aspect, except the dopant complex, we deduce that the device conductivity is related to the nature and position of the substituent on the composite. These structures are aromatic compounds and have conjugated bands. Electron donating chromophore increases the length of this conjugation system. It can be seen that $-OCH_3$ group as an electron donor to main backbone of compound **a** has better contribution to conjugate system compared with other compounds which lack this substituent. Therefore, the dependence of I-V on Chromeno[3,4-b]quinoline derivatives probably emanates from two effects: improved electron injection and improved electron transport as different derivatives were added. When either hole or electron current is dominant, the balance of charge carriers and therefore their recombination is not efficient. Unbalanced carriers injection/transport could displace the recombination zone toward cathode or anode, resulting in luminescence quenching such as devices 3 and 4. Therefore, however the higher current level at a given applied voltage was not obtained from devices 1 and 2, significant EL was seen as a result of the poor electron-injection/transport properties.

Figure 4 shows the EL spectra of the fabricated PLEDs based on PVK:PBD and PVK:PBD:**a** emitting layer. For the emission of PVK:PBD at 502 nm the absorption of **a** displays a red shift. Evidently, the $-OCH_3$ group not only has a considerable influnce on the overall device conductivitiy, but also effects the emission peak.

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In addition, it indicates that the resistivity of organic layers decreased and suppression of electron injection/transport occurred to cause the better carrier balance in the emitting zone.

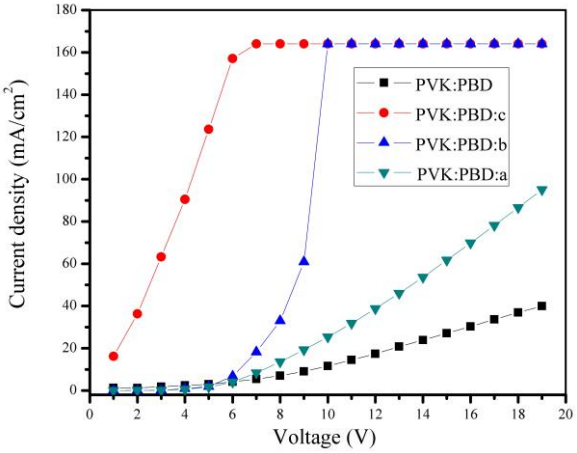


Figure 2: Current density– Voltage characteristic of different derivatives doped in PVK:PBD.

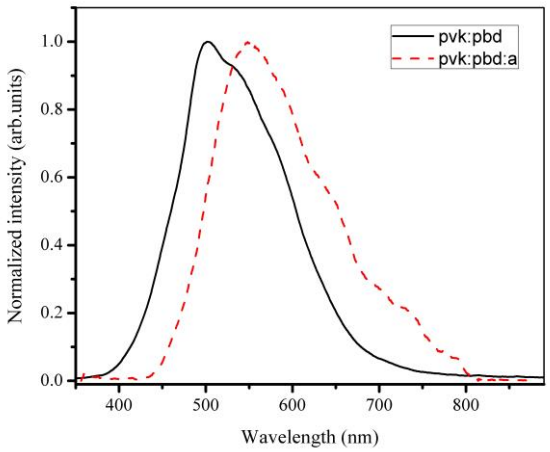


Figure 3: The EL spectra PVK:PBD and PVK:PBD:**a**

4 Conclusion

We have investigated the optical and electrical properties of three derivatives of Chromeno[3,4-b]quinoline as an active dopant in PVK and PBD matrix of PLEDs through solution based technique. Our observations show that the better electron injection/transport ability of Chromeno[3,4-b]quinoline leads to balance or unbalance of carriers injection/transport. This indicates that some of the Chromeno[3,4-b]quinoline derivatives can be promising materials for fabrication of low cost single-layer light-emitting diodes.

Acknowledgements

The authors would like to thank the Vice-President's Office for Research Affairs of Shahid Beheshti University for supporting this work.

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