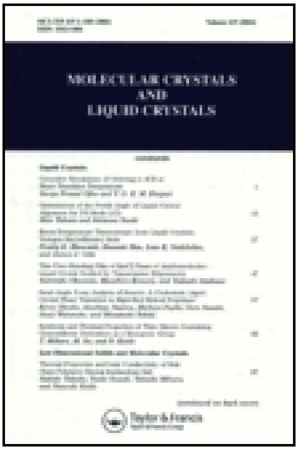

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Electroluminescence of Poly(N-Vinylcarbazole) and its Blends with Poly(4,4′-dialkyl-2,2′-bithiophene)

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Electroluminescence of Poly(N-Vinylcarbazole) and its Blends with Poly(4,4′-dialkyl-2,2′-bithiophene)

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Polymer light-emitting diodes (LEDs) have been fabricated from poly(N-vinylcarbazole) (PVK) or from blends of PVK and poly(4,4 ′-dialkyl-2,2 ′-bithiophene) (PDABT). Since PDABT and PVK are soluble in common organic solvents, thin polymer layers needed for the construction of diodes can be prepared by casting from appropriate solutions using the spin-coating technique. No subsequent processing or heat treatment is required. The active part of the diode consists of one polymer layer which is sandwiched between two electrodes, an indium tin oxide (ITO) transparent electrode and an Ca/Al electrode. In order to achieve bipolarity in the single polymer emitter layer, PVK was molecularly mixed with electron transport additives, such as PDABT. This approach enabled us to improve the efficiencies of the prepared LEDs. The light emission appears at ca 7 V with the maximum of the band at 530 nm.

Keywords: light-emitting diodes; poly(N-vinylcarbazole); poly(4; 4′-dialkyl-2; 2′-bithiophene); polymer blends

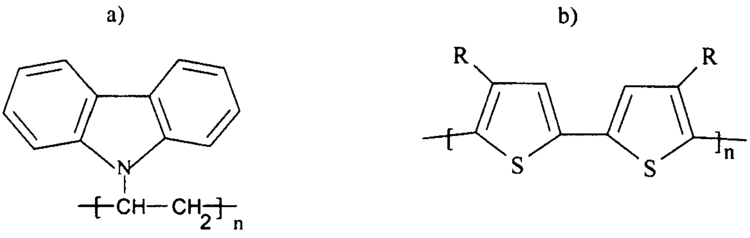
INTRODUCTION

Over the past few years organic electroluminescent devices based on organic fluorescent materials have been a subject of many publications because of their high luminescence, low drive voltage, a variety of emission colors and also their possible applications as large area light-emitting displays.

Although, a significant progress in the synthesis of electroluminescent organic materials has been observed in the recent years, the number of soluble polyconjugated systems which exhibit high luminescence efficiency is still limited. Typically used polymers are substituted poly(p-phenylene vinylene), such as in the cases of, for example, poly(p-phenylphenylene vinylene) [1], poly(2-methoxy,5-(2'-ethyl-hexyloxy)-p-phenylene vinylene)[2], poly(2,5-bis (cholestanoxy)-1,4-phenylenevinylene)[3] or alkyl substituted polythiophenes[4]. In search for new materials for polymer light-emitting diodes (LED-s) polymer blends have been investigated as the emitting layers [5],[6]. Such blends are usually composed of a soluble conjugated polymer in a matrix of hole-transporting polymer. In this paper the properties of the material obtained by mixing poly(4,4'-dialkyl-2,2'-bithiophene) (PDABT) with poly(N-vinyl-carbazole) (PVK) are reported. PVK is not only the hole-transmitting host matrix but also it exhibits a light-violet colored electroluminescence (EL) (two broad EL bands at 428 and 618 nm).

EXPERIMENTAL

PVK (Fig. 1a) was purchased from Aldrich Co. Inc. and used as received. PDABTs (Fig. 1b) were synthesized according to the previously described procedure[7]. The blends of PDABT and PVK were prepared from tetrahydrofuran solutions with the PDABT/PVK weight ratio varying from 1:16 to 5:3.



PVK PDABT

FIGURE 1 Structure of poly(N-vinylcarbazole) and poly(4,4'-dialkyl-2,2'-bithiophene). R = $C_{10}H_{21}$ in a typical experiment.

Thin films of ca 100 nm of both polymers or their blends were deposited onto an ITO coated glass substrate by spin coating technique. Then, 10 nm thick Ca and 100 nm thick Al layers were deposited consecutively onto the polymer layer (Fig. 2). The active area of each device was 0.1 cm^2. Electrical measurements employed a Keithley 236 source - measure unit. Electroluminescence spectra were measured using ORIEL MULTISPEC II spectrometer with fiber optics (ORIEL MS125™).

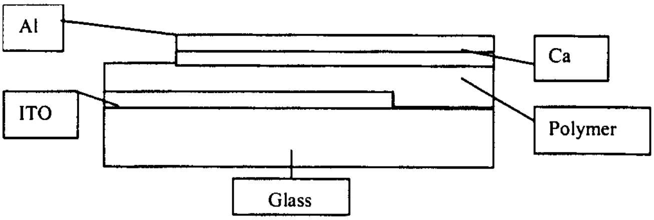


FIGURE 2 LED's structure

The samples for UV-Vis absorption spectroscopy and for photoluminescence were obtained by spin-coating the polymer blend/tetrahydrofuran solution onto the quartz substrate.

RESULTS AND DISCUSSION

Optical absorption spectra of PDABT and PVK thin films are shown in Fig. 3a. The onset of π–π* transition of PDABT is at about 480 nm at room temperature, while the onset of the absorption in PVK in at approximately 355 nm. The photoemission spectra are shown in Fig. 3b.

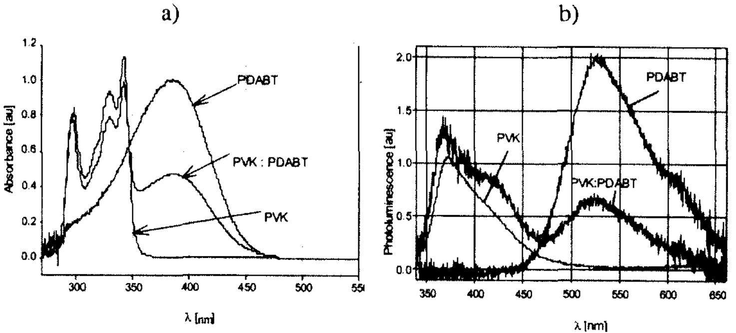


FIGURE 3 Absorption and emission spectra of PVK, PDABT and their blends.

The light emission (with the maximum of the band around 530 nm) was observed from the EL diodes when a forward-bias ITO of positive polarity was applied (Fig.4).

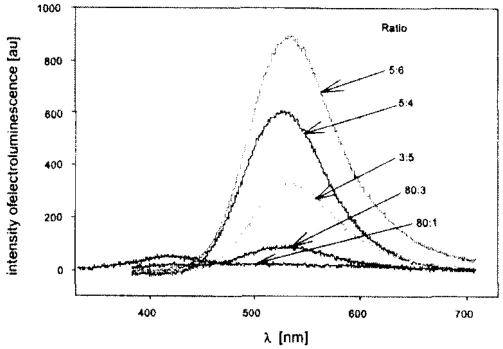


FIGURE 4 Electroluminescence spectra of PVK/PDABT blends.

The I(V) characteristics (Fig. 5) of Al/Ca/polymer blend/ITO device are similar to those of the Al/Ca/PVK/ITO[8].

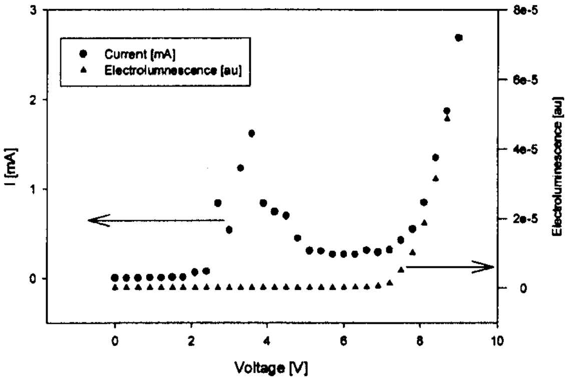


FIGURE 5 Dependence of current on applied voltage and emission intensity on applied voltage for PVK/PDABT (1:1) blend LEDs.

The highest emission intensities were obtained for the PDABT/PVK ratio of 1:1 (wt.) (Fig. 6). The quantum efficiency of polymer blends was greater than that of the pure PVK by approximately a factor of three and greater than that of the pure PDABT by more than five times.

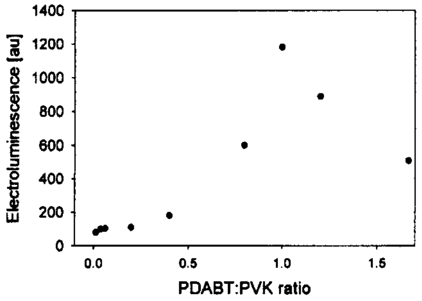


FIGURE 6 Dependence of EL efficiency on the PDABT/PVK weight ratio.

PVK is a well-known hole-transporting material with the negligible electron mobility. The EL efficiency in PVK is, therefore, limited by the electron current. Thus, the sensitization of the EL by adding PDABT may improve the electron injection and the transport in the blend films.

Acknowledgments

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