

Electroluminescence Characteristics of New PQ

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Abstract: — A new monomer bearing dialkyl groups, 3,3-dinonanoylbenzidine, when copolymerized with diacetyl monomers gave six new alternating conjugated copolymers, poly(2,2-arylene-4,4-bis(4-alkylquinolines))s, which are soluble in organic solvents. The thermal, electrochemical, photo physical, and electroluminescent properties of the new polyquinolines varied with the arylene linkage, including p-phenylene, 4,4-biphenylene, stilbene, 5,5-bithienylene, bis (thienyl) vinylene, and 3,7-phenothiazinylene. The new conjugated polymers combined high glass transition temperature (110-254 °C) with quasireversible electrochemical reduction from which 2.72-3.00 eV electron affinities were estimated. The optical band gap varied from 2.19 to 2.86 eV whereas the photoluminescence emission maximum varied from blue-green (477 nm) to deep red (646 nm). Some of the new polymers with alternating donor acceptor architecture showed strong intermolecular charge transfer. Electroluminescence of moderate brightness (up to 209 cd/m²) was achieved with blue-green, green, yellow, orange, and deep red colors depending on the arylene linkage of the copolymer. The new polyquinolines were also demonstrated as useful electron transport materials for the enhancement of polymer light-emitting diodes.

Keywords: - PQ, p-phenylene, 4, 4-biphenylene...

I. INTRODUCTION

This paper reports a new synthetic route to organic solvent-soluble conjugated polyquinolines incorporating bis(4-alkylquinoline) units through a new A-A monomer, 3,3-dinonanoylbenzidine. A series of six new alternating conjugated copolymers, poly(2,2-arylene-4,4-bis(4-alkylquinoline))s, whose structures are shown in Chart 1, exemplify the new synthetic methodology. Diverse n-type conjugated polymers that are soluble in organic solvents can thus be obtained by variation of the arylene linkage which facilitates the tuning of the electronic and optical properties. The arylene linkages shown in the polymers of Chart 1 include p-phenylene, 4,4-biphenylene, stilbene, 5,5-bithienylene, bis(thienyl)-vinylene, and 3,7-phenothiazinylene, and they allowed the variation of the electron affinity in the 2.7-3.0 eV range, the glass transition in the 110-254 °C range, and the electroluminescence color from blue-green, green, yellow, and orange to deep red.

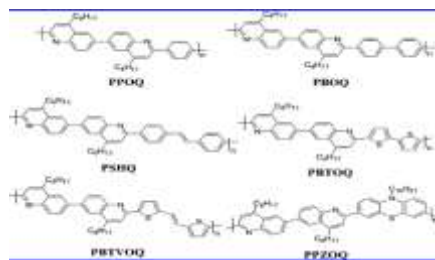


Chart 1- structure of new PQ

II. RESULT AND DISCUSSION

Electroluminescence and Electron Transport Properties We investigated the intrinsic electroluminescence (EL) of the new polyquinolines by using poly-(ethylenedioxythiophene)/poly(styrenesulfonic acid) (PEDOT) thin film on indium tin oxide (ITO) as the anode, poly(N-vinylcarbazole) (PVK) as the hole transport layer, the spin-coated polyquinoline as the emissive layer, and aluminum as the cathode: ITO/PEDOT/PVK/

polyquinoline/Al. The film thicknesses of the emissive polyquinolines were ~75 nm. Representative EL spectra of four of the polymers are shown in Figure 1a. Emission maxima (λ_{maxEL}) varied from 513 to 656 nm, indicating that we can effectively tune the emission color from blue-green to red by varying the arylene linkage. The EL maxima for PPOQ, PBOQ, and PSHQ are between 513 and 580 nm. The EL spectra for these polymers are considerably red-shifted 36-87 nm, relative to the PL spectra. The 551-656 nm EL maxima of PBTOQ, PBTVOQ, and PPZOQ are more consistent with the PL maxima. The voltage-current and voltage-luminance curves for all six polyquinoline OLEDs are shown in Figure 2. The turn-on voltage (electric field) of the diodes was 8.5-12 V (~1.2 - 106 V/cm). PPZOQ, which has the smallest barrier to hole injection (IP) 5.17 eV, has the lowest turn-on voltage. The generally high turn-on voltages of these diodes are because of the large film thicknesses and the large barriers for charge injection.

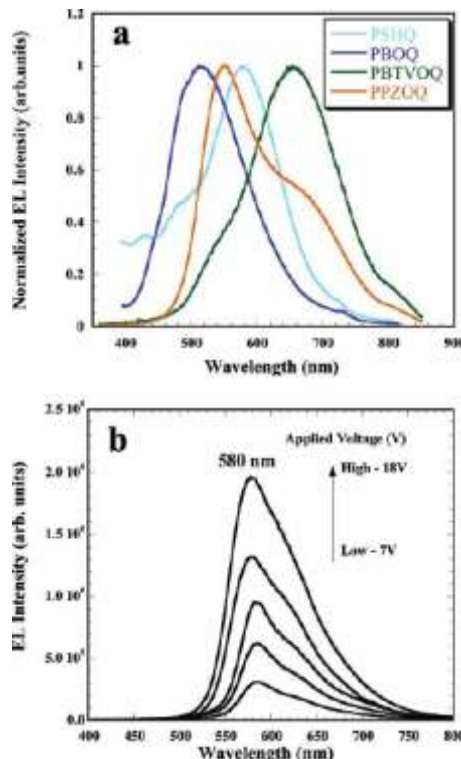


Figure 1. Electroluminescence (EL) spectra of selected polyquinolines in ITO/PEDOT/PVK/polyquinoline/Al diodes (a) and for a ITO/PEDOT/MEH-PPV/PPOQ/Al diode (b).

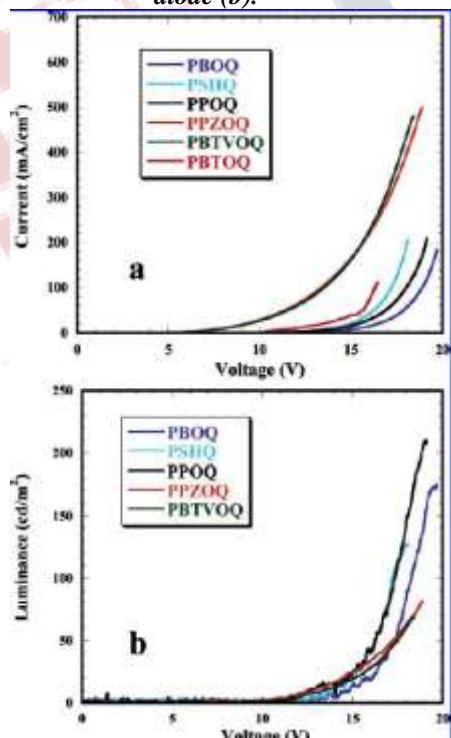


Figure 2. Current density-voltage characteristics (a) and luminance-voltage characteristics (b) for ITO/PEDOT/PVK/polyquinoline/Al diodes.

III. CONCLUSIONS

We have devised a new synthetic route to soluble n-type conjugated polyquinolines. Synthesis of the key o-amino keto-functionalized monomer, 3,3-dinonanoylbenzidine (5), was achieved by reacting alkylmagnesiumbromide with the appropriate carboxylic acid. The new polymers derived from this monomer contained bis(4-alkylquinoline) in the main chain, facilitating solubility in organic solvents. The polymers had glass transitions of 110-254 °C and decomposed at above 400 °C, proving them to be thermally robust materials suitable for application in organic electronic devices. By varying the arylene linkage in poly(2,2-arylene-6,6-bis(4-alkylquinoline)s from p-phenylene to bis(thienyl)vinylene, the optical band gap, redox properties, and electroluminescence color could be tuned over a wide range. The electron affinity or LUMO energy level of the polymers was in the range 2.72-3.00 eV, and blue-green, green, yellow, orange, and red electroluminescence colors were achieved with moderate brightness and efficiency. Enhanced electroluminescence efficiency and brightness were obtained from bilayer OLEDs based on MEH-PPV as the emitter and the new polyquinolines as the electron transport layer. The bis(4-alkylquinoline) platform demonstrated here allows the ready synthesis of diverse new soluble polyquinolines; it thus opens the door to further exploration of this n-type building block in new materials for organic electronics. New polymer structures incorporating more exotic arylene linkages may allow the optimization of the materials for improved performance in optoelectronic devices. Furthermore, optimization of the reaction conditions should lead to higher molecular weight polymers and could likely increase device performance.

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