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Alkyl-end phenanthroimidazole modification of benzotriazole based conjugated polymers for optoelectronic applications

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ABSTRACT

Three different alkyl-end phenantroimidazole modified benzotriazole based conjugated polymers were synthesized. Optical and electronic properties of the conjugated polymers were investigated. Optical/ electronic band gaps of polymers were found as 2.62/ 3.02, 2.22/ 2.39, and 1.89/ 2.01 eV for P1, P2, and P3, respectively. Polymers revealed multichromic properties and fast switching times with reasonable contrasts for P1 (1950 nm, 49% transmittance, 0.2 s) and P2 (1500 nm, 61%, 0.4 s). Strong interaction between phenantroimidazole and conjugated polymer backbone inhibited the photoluminescence of phenanthroimidazole except in thin film for P3. However, electroluminescence did not show emission for phenanthroimidazole unit. P1 incorporated electroluminescent device exhibited superior performance. The highest luminance efficiency for P1 based device was 3.01 cd/A at 9.5 V at a luminance value of 1665 cd/m^2.

1. Introduction

Conjugated polymers have been widely used since their semiconducting properties had been discovered [1] by Alan J. Heeger, Alan G. MacDiarmid and Hideki Shirakawa in 1977. From that time, interest in scientific community has continuously increased. Conjugated polymers have been used various for applications in electrochromics [2,3], organic light emitting diodes (OLEDs) [4–7], photovoltaic devices [8], thin film transistors [9], electrochemical transistors [10], and most recently is bio-applications as biosensors [11], in-vitro diagnostics [12], drug delivery [13]. Electrochromism is simply defined as the reversible color change upon applied potential. This color change generally was observed between one transmissive and one colored state. However there are countless examples of multichromic materials used in various application as displays [14] and as sensors for temperature and pH [15]. Thus introducing new multichromic materials is eventually important for further investigation.

With the discovery of TADF materials, research interest towards OLEDs were vitalized. 2-Component [16–18] or 3-component [19,20] combinations of high performance red, green, yellow and blue colored emitters have been used to produce white OLEDs. In this regard, phenanthroimidazole based molecules, typically emit deep blue or sky blue, were generally preferred for their excellent thermal stability, and compatible optical and electronic properties [21–24]. Combining electron withdrawing and donating units, phenanthroimidazole based molecules did not change the blue colored emission significantly to any other primary color [25]. Strong fluorescence ability of phenanthroimidazole based molecules makes them a good candidate for OLEDs. Generally high fluorescence quantum yields result in high EQE for OLEDs.

On the other hand, when multi component OLED device is aimed, one should consider the energy/charge transfer. Inter/intramolecular transfers may ruin or enhance the properties under investigation. For example, primary colors (red, green, blue) or two complementary colors (blue and yellow) can be used to produce white color OLEDs. However, prevalent and unavoidable energy transfer overwhelmingly dominates the emission of the lower band gap component [26]. There are yet countable examples in which energy transfer could not be observed in solution [27] or both in solution and in thin film form [28].

In this study benzotriazole based conjugated polymers were synthesized where their alkyl-ends were modified with blue emitting phenanthroimidazole. In this way, two different components were attached to each other via an alkyl spacer. Synthesized polymers were anticipated as being capable of dual emission. Effect of imidazole ring attached via alkyl-spacer to the conjugated polymer backbone was investigated in terms of optical and electronic properties.

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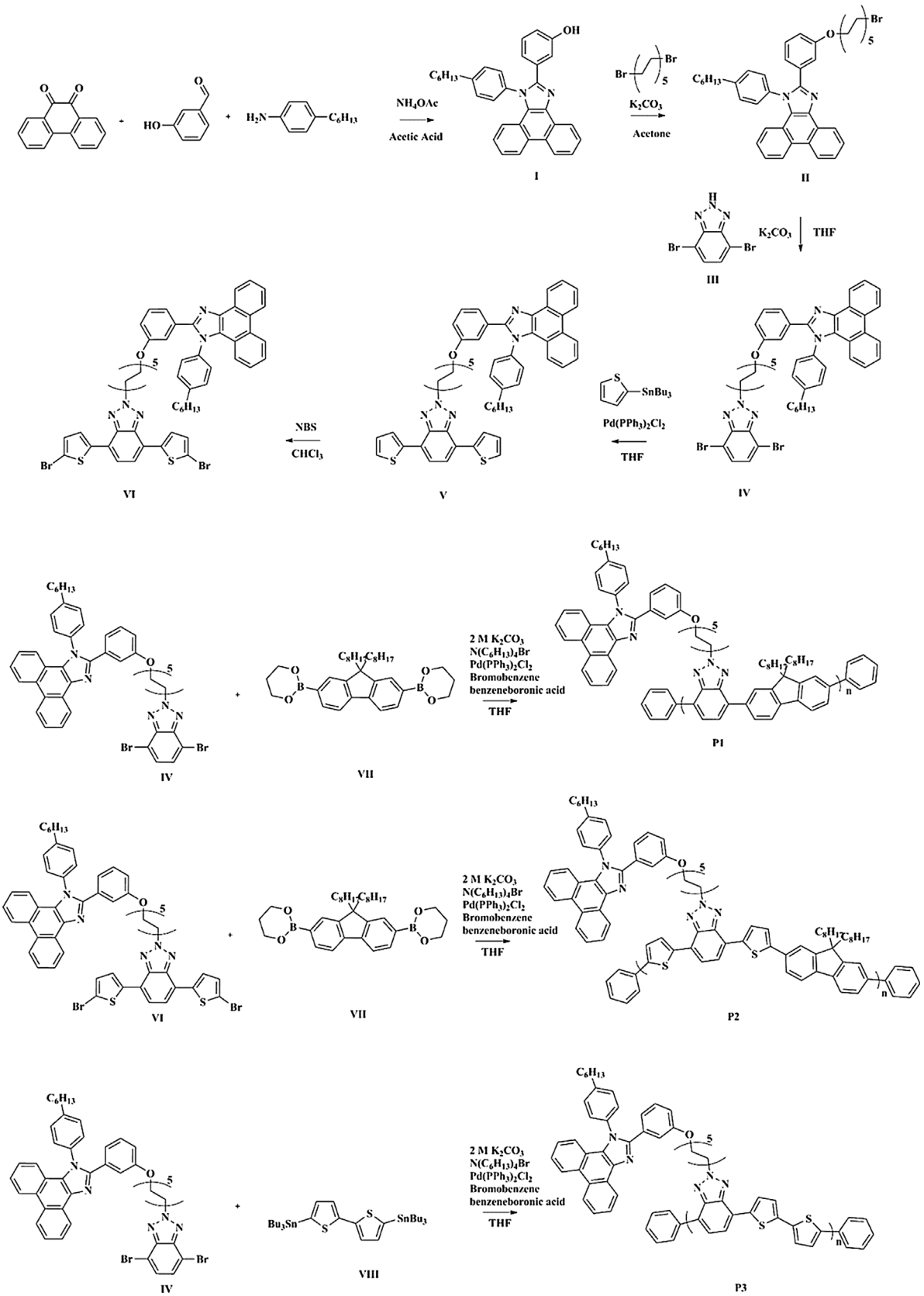

Scheme 1. Synthetic pathway of P1, P2 and P3.