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A new way to obtain black electrochromism: appropriately covering whole visible regions by absorption spectra of copolymers composed of EDOT and carbazole derivatives

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Abstract

There is a limited number of studies in the literature on materials showing electrochromic properties between black and transparent. In this study, black-to-transmissive electrochromic materials have been obtained as a result of electrochemical co-polymerization of carbazole derivatives (Cz1 and Cz2) and EDOT. Homopolymers and copolymers synthesizing different monomer feed ratios have been characterized by electrochemical and spectroelectrochemical methods. A new, simple, and fast method of obtaining black electrochromic material has been proposed.

Keywords: conducting polymer, black-electrochromic, copolymerization, electrochemistry, polycarbazole

(Some figures may appear in colour only in the online journal)

1. Introduction

Due to their interesting electrical and optical properties, conductive polymers are potentially of use in many practical applications, such as metals and biosensors [1–4], supercapacitors [5, 6], smart windows [7, 8], etc. One of the most interesting features of conductive polymers is electrochromism, which is defined as reversible color change with applied potential [9–11]. The interest is mainly due to their unique properties, such as thin film processability, high color memory, low potential requirement, and simple device construction [12]. Because of their high coloring efficiency and fine tuning of colors through structural modification, investigations have been most commonly carried out on polythiophene, polypyrrole and polycarbazole derivatives [13, 14]. Carbazoles, which can be easily modified with s-triazines, have been used in the construction of superstructural conducting polymers with high optical contrast and high thermal and electrochemical stability [15, 16]. Unlike cathodically colored poly(3,4-ethylenedioxythiophene) (PEDOT), anodically colored carbazole derivatives are transparent in their neutral state, and are colored blue, green, or turquoise in their oxidizing states [17, 18]. Although many researches have been carried out on different colors of transmissive electrochromic materials such as carbazole, pyrrole and EDOT derivatives, the production of black to transmissive electrochromic materials is still a challenging task. The difficulty is due to the complexity of producing materials capable of absorbing efficiently over the visible spectrum in the colored state and completely bleaching in the same region in the bleached state [19]. Until now, production of black electrochromic polymer by various strategies has been reported by only a few groups [20–24]. The synthesis and characterization of the first black-transparent electrochromic polymer was performed by Reynolds *et al.* They used a donor-acceptor approach to control two-band absorption in the visible spectrum by variation of the relative contribution of the electron-poor and electron-rich moieties in the polymer backbone [25].

