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Disulfide-linked symmetric *N*-alkyl carbazole derivative as a new electroactive monomer for electrochromic applications

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ABSTRACT

In this study, we reported a novel and an unusual method for the preparation of the disulfide-linked symmetrical carbazole derivative and investigated the electrical and optical properties of crosslinked conductive polymer obtained as a result of its electropolymerization. The disulfide-linked *N*-alkyl substituted carbazole monomers are comparatively polymerized in different solvents. It has been found that the conductive polymer obtained in Boron trifluoride diethyl etherate (BFEE) has the high optical contrast and stability compared to other *N*-alkyl substituted carbazoles in literature.

1. Introduction

Disulfide compounds display interesting behaviours both in biology and chemistry [1]. Disulfides have been produced from related thiol and interconversion reaction between thiol and they exploit high stability which makes their oxydated derivatives easily synthesizable due [2]. There is a great interest in synthesizing disulfide compound which can be used for the preparation a new types self-assembled monolayers and monolayer-protected clusters [3,4].

Polycarbazoles and their derivatives are still active research area due to their good electron donating and light emitting properties [5–10]. They are used as light emitting diodes in OLED technology either as dopands or host materials because of conjugation properties [11,12]. In addition to that, these kinds of compounds are also used as organic photoconductors, charge carrier transport materials, organic dyes for solar energy cells [13,14] and drug delivery material [15]. It is well known that carbazoles are active against cancer, cardiovascular disorders [16,17].

Electrochromic materials can have different colors at different applied potential. During the chemical redox processes, they change their colors accordingly. One of the most important application areas of these materials, which attracted great attention for academia and industry, are smart windows [18,19]. Smart windows technology has already advanced, but one of the typical and deadly obstacles of these technologies is low optical contrast [20]. For this reason, electrochromic material used in smart window needs to be totaly transparent in the one oxidation state and it should exhibit high optical contrast between different redox states [21–25]. Usage of the polycarbazole derivatives in electrochromic application has limited, because of theirs poor film forming properties and having low optical contrast. Recently, conductive polymers with high optical contrast and good film quality can be obtained by polymerizing two or more carbazole-containing electroactive monomers [26–29]. This high quality polycabazole films has been obtained by providing conductivity in three dimensions due to cross-links [25,30,31].

In this study, we report a novel and an anusual method for the preparation of the symmetrical carbazole linked disulfide electroactive monomer. Conducting polymer film obtained by electrochemical polymerization of this bifunctional carbazole monomer has showed the high optical contrast (62.5%) among the polycarbazole derivatives in literature. Furthermore it has showed good optical transparency in its neutral state. Due to the high optical contrast value and good tranparency property, this material is an excellent electrochromic material for smart window applications.

2. Experimental

2.1. Materials

All reactions were carried out under an argon atmosphere using Schlenk techniques connected vacuum line. 6-(9H-Carbazol-9-yl) hexane-1-thiol [31] and 3,6-bis(4'-methylphenylsulfoxyloxy) phthalonitrile [32] were synthesized following the literature procedures. All solvents were fresly purified by standard procedures before use [33] ^{1}H

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