Polymer 118 (2017) 40–48

Contents lists available at ScienceDirect

Polymer

journal homepage: www.elsevier.com/locate/polymer

Optoelectrochromic characterization and smart windows application of bi-functional amid substituted thienyl pyrrole derivative

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ARTICLE INFO

Article history:
Received 27 February 2017
Received in revised form
23 April 2017
Accepted 24 April 2017
Available online 26 April 2017

Keywords:
Conducting polymers
EQCM
Electrochemistry
Electrochromic device

ABSTRACT

Because of some disadvantages of polythiophenes and polypyrroles, alternatively thienylpyrrole monomers which include these two heterocycles in its structure have been synthesized for overcome optical, electrical and stability problems. However, the desired properties can only be achieved by the copolymerization of thienylpyrroles with EDOT. The optical, electrical properties and stability of the thienylpyrrole compounds have reached unique levels when using amide substituent derivatives synthesized by our group for the first time. In this work, terephthalamide was used to synthesize double-sided, symmetric amide substituted thienyl pyrrole. By doing so, we obtained a superstructure that provides three dimensional electrical conductivity and has much better optical, electrical properties and stability. Besides investigation of its optical and electrical properties, deposition of the polymer film on the electrode during electropolymerization and the ion mobility in the redox process were determined by EQCM. An electrochromic device has been constructed with this new type polymer to demonstrate the utility of its use in practical applications. As a result, it has been shown that the new type amide substituted thienyl pyrrole derivatives have promising usage for all practical applications of conductive polymers due to their unique properties such as high optical contrast, high stability and fast response time.

1. Introduction

Due to the unique optical and electrical properties, researchers were very interested in the design and synthesis of the novel conjugated polymers. Conjugated polymers (CPs) possess a one-dimensional π-extended backbone, which endows them outstanding optic and electronic properties and a wide range of applications [1–4]. Among conjugated polymers, due to the low oxidation potential and facile chemical and electrochemical polymerization, Poly(2,5-dithienylpyrrole) derivatives (PSNS) are one of the most potential polythiophenes derivatives. The monomer 2,5-di(2-thienyl) pyrroles (SNS) compose of thiophene and pyrrole rings interconnected by their α-positions which allow further improvement of the properties [5]. In literature, 2,5-di-(2-thienyl)-1H-pyrrole (SNS) derivatives [6] have very useful properties for optoelectronic applications and there are lots of SNS derivatives, having substituted alkyl derivatives [7], phenyl derivatives [8–12] and [13], ferrocene [14–17], pyrene [18], bipyrrole [19]. However, except our group's studies [20–24], there is no study related to hydrazide substituted SNS derivatives in the literature. The recent studies have shown that using hydrazide instead of amine is not only increase product yield but also improve optical and electrical properties of the corresponding polymer [12].

Meanwhile, electrochemical quartz crystal microbalance (EQCM) technique is a precise in-situ piezoelectric tool which is capable of controlling mass changes in nano-gram range (10^{-8} to 10^{-9} g) [25] [26], [27]. It is particularly useful in predicting the polymerization efficiency, as well as the solvent and ion exchange between the polymer and the solution upon redox cycling. The change in resonance frequency of this device, which uses the piezoelectric properties of quartz crystals to measure bound mass (up to nanograms) on the surface of the electrode, depends on the change in mass according to the Sauerbrey equation [28].

Because of three main purposes, EQCM is extensively used to study the properties of CPs such as PPY [29–33], PEDOT [34–36] and PANI [37]. First of all this technique can be used to follow up deposition of the CPs on the working area surface. Secondly, EQCM

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http://dx.doi.org/10.1016/j.polymer.2017.04.060
0032-3861/