



The effects of the PEDOT:PSS acidity on the performance and stability of P3HT:PCBM-based OSCs

Burak Y. Kadem¹ · Mohammed Al-Hashimi² · Ali S. Hasan³ · Raheem G. Kadhim¹ · Yaqub Rahaq⁴ · Aseel K. Hassan⁴Received: 3 July 2018 / Accepted: 14 September 2018
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Abstract

The optical transmittance, electrical conductivity and morphology of PEDOT:PSS treated with ammonium hydroxide (NH₄OH) have been investigated. Transmittance spectra of spun PEDOT:PSS layers were enhanced slightly as a result NH₄OH treatment while surface of the films has exhibited variation in the roughness and an increase in the electrical conductivity. Improvement in the physical properties of PEDOT:PSS is shown to be the key factor in enhancing the power conversion efficiency (PCE) with values as high as 4% associated with high fill factor (FF) of 57%, open circuit voltage (V_{OC}) of 0.64 V and larger short circuit current density (J_{SC}) of 11 mA cm⁻². Stability test of the devices has been carried out over a period of 2 months, when a device incorporating PEDOT:PSS with pH~4 as the hole transport layer has shown an improved stability with a degradation in PCE in about 43% whereas J_{SC} has decreased in about 20% compared to a device incorporating pristine PEDOT:PSS with PCE decreased in about 66% and J_{SC} in about 50% over the stated period of test. These effects have been ascribed to the increased acidity of the hole transport layer.

1 Introduction

Organic solar cells based on conjugated polymers have demonstrated significant improvements in the device performance over the last decade [1, 2]. In order to achieve organic solar cells with high efficiencies, a thin conductive layer of polymer mixture named poly(3,4-ethylenedioxythiophene):polystyrene sulfonic acid (PEDOT:PSS) is typically used and employed as the anode and buffer layer [3, 4]. PEDOT:PSS is a conductive polymer, which is made up of two substances, PEDOT and PSS. The PEDOT is a polymer of the 3,4-thylenedioxythiophene (PEDOT), which is insoluble in water. The solubility of the PEDOT increased via combining it with the soluble polystyrene sulfonic acid (PSS). As a result, the PEDOT:PSS becomes easier to use

as a solution-processed layer [5]. A stable anode interface is one of the basic requirements for organic optoelectronic devices operation. Indium doped tin oxide (ITO) is widely used for such devices due to its high conductivity and high optical transparency; although, the work function of ITO is low. In order to overcome this undesirable property, ITO surface is usually coated with a buffer layer such as PEDOT:PSS, which can support charge transfer more efficiently [5]. PEDOT:PSS is supposed to be beneficial for device performance by decreasing the surface roughness of the ITO transparent electrode; it also has higher work function relative to ITO which improves the selectivity of the anode and enhances the electron blocking properties [6]. The acidity of the PEDOT:PSS layer may also result in the etching of the ITO surface during the spin coating process, and hydrolysis of the deposited PEDOT:PSS by moisture absorption can also etch ITO and cause indium incorporation into the polymer [7]. The control of PEDOT:PSS properties has been thoroughly investigated via varying different processing of film deposition parameters such as addition of surfactants and organic solvents [8–10] or through thermal annealing [11, 12]. Charge carrier concentration in 5 wt% dimethyl sulfoxide (DMSO) doped PEDOT:PSS films has been shown to increase by controlling the pH level of the polymer using sodium hydroxide (NaOH) [13]. The applied technique has enabled optimisation of the thermoelectric

✉ Burak Y. Kadem
drburakkadem@gmail.com

¹ Physics Department, College of Science, University of Babylon, Hillah, Iraq

² Department of Mathematics, Missan University, Amarah, Iraq

³ Department of Engineering of Polymer and Petrochemical Industries, University of Babylon, Hillah, Iraq

⁴ Material and Engineering Research Institute, Sheffield Hallam University, Sheffield, UK