VOPcPhO:P3HT composite micro-structures with nano-porous surface morphology

Mohamad Izzat Azmera, Zubair Ahmadb,*, Khaliah Sulaimana,*, Farid Touatib, Tahani M. Bawazeerde, Mohammad S. Alsoufi*

aLow Dimensional Materials Research Centre (LDMRC), Department of Physics, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
bDepartment of Electrical Engineering, College of Engineering, Qatar University, P. O. Box 2713, Doha, Qatar
cDepartment of Chemistry, Faculty of Applied Science, Umm Al-Qura University, Makkah, Saudi Arabia
dMechanical Engineering Department, College of Engineering and Islamic Architecture, Umm Al-Qura University, Makkah, Saudi Arabia

ARTICLE INFO

Article history:
Received 24 October 2016
Received in revised form 7 December 2016
Accepted 13 December 2016
Available online 14 December 2016

Keywords:
VOPcPhO, P3HT, FESEM, AFM, Electro-spraying, Humidity sensor

ABSTRACT

In this paper, composite micro-structures of Vanadyl 2,9,16,23-tetrahydroxy-20H,31H-phthalocyanine (VOPcPhO) and Poly (3-hexylthiophene-2,5-diyl) (P3HT) complex with nano-porous surface morphology have been developed by electro-spraying technique. The structural and morphological characteristics of the VOPcPhO:P3HT composite films have been studied by field emission scanning electron microscopy (FESEM) and atomic force microscopy (AFM). The multidimensional VOPcPhO:P3HT micro-structures formed by electro-spraying with nano-porous surface morphology are very promising for the humidity sensors due to the pore sizes in the range of micro to nano-meters scale. The performance of the VOPcPhO:P3HT electro-sprayed sensor is superior in terms of sensitivity, hysteresis and response/recovery times as compared to the spin-coated one. The electro-sprayed humidity sensor exhibits ~3 times and 0.19 times lower hysteresis in capacitive and resistive mode, respectively, as compared to the spin-coated humidity sensor.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Nowadays, researchers in the field of sensors are focusing on formulating right materials with aim to overtake the conventionally used inorganic sensing devices. Particularly, improvement in sensitivity and response time has been aimed, while maintaining the simplicity and low processing cost and eco-benign characteristics [1–3]. Due to the rapid development in the organic thin film deposition technologies, all these promising characteristics along with physical flexibility could be owned by organic based sensors [2,4–6]. Among the commonly reported film deposition techniques, electro-spraying has been well established with its pervasive applications, particularly in nanocomposite technology [7]. Many studies have also been devoted to the applications of electro-spin and structural alteration of polymer composite for humidity sensing [8–11]. Their findings have demonstrated significant improvements in term of sensing response, sensitivity, and hysteresis gap for the fabricated sensors that can be correlated with the emergence of highly porous nano-structures on the surface of the composite films. Whereas, the electro-sprayed structures possess high porosity and large surface to volume ratio, which enhanced absorption of the sensing layer, thus contribute towards better performance of the sensing devices. For instance, humidity sensors based on electro-sprayed polymer electrolyte composite, polyethylene oxide and polyaniline, has been prepared by Li et al. [8]. They have found that the presence of the nano-fibers effectively enhanced resistive sensitivity of the device.

In this research work, we herein report on a comparative study of VOPcPhO:P3HT composite layer for humidity sensing applications prepared by electro-spraying and spin-coating film deposition techniques. The aim of this work is to enhance the humidity sensing properties of the composite by optimizing the morphological structure of the active composite films. The combination of VOPcPhO and P3HT composite has been reported for the first time in the application of photo-sensor by Ahmad et al. [12]. They described that the rapid response time of the sensor has been observed due to the doping of VOPcPhO in the matrix of P3HT, where the π-electron bonding system of the phthalocyanine has contributed towards excellent sensitivity of the composite...