Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings 5 (2018) 1673–1678

materialstoday: PROCEEDINGS

www.materialstoday.com/proceedings

PMME-16

Analyzing p-type Conjugated Conducting Poly (diaminonaphthalene) Doped Poly (vinyl alcohol) Bulk Hetrojunction Film for Organic Solar Cells

[a]Rinkesh Bhatt, [a]Ashish Tiwari, [b]D.S.Bisen, [b]A.K.Bajpai*

a. Department of Physics, Global Engineering College, Jabalpur (M.P.), INDIA 482001
b. Department of Chemistry, Bose Memorial Research Lab., Govt. Autonomous Science College, Jabalpur (M.P.), INDIA 482002

Abstract

Bulk Hetrojunction configuration for those electronics devices which require interpenetrating strength with large doner-acepter interfacial area is the matter of concern in microelectronics. At the same time developing p-type conjugated conducting polymers with easy synthesis, high charge carrier mobility, strong absorption properties and suitable energy gap for bulk hetrojunction (BHJ) are also required for sake of efficient applications. BHJ solar cell architecture, where in bulk, phase separation between the two components are required in controlled form are achieved by both accepter and donor materials which enhance the solar cell performance in terms of parameters like power conversion efficiency and fill factor. Poly (diaminonaphthalene) doped Poly (vinyl alcohol) (PDAN doped PVA), a p-type conjugated conducting polymer film, may be the materials for bulk semiconductor hetrostructure. The D.C conductivity at room temperature of PDAN doped PVA film was found to be 2.0408 x 10^{-4} mho m^{-1} which gives the mobility in the range of 0.43 cm^2/Vs. The economic chemical oxidation method was used for synthesizing PDAN doped PVA films. The Arrhenius plot provides the energy band gap of the order of 1.312 eV which is smaller than the limit 1.77 eV for approximately 700 nm range wavelength of solar spectrum for photovoltaic mechanism. The spatial parameter "redundance" calculated from Atomic Force Microscopy (AFM) which provides the fractal morphology of the sample, was found to be -0.18 for PDAN doped PVA film thus suggests for less disordered surface which satisfies the desired criteria for electronics applications.

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

Keywords: Organic Solar Cell; Bulk hetro-junction; p-type conjugated polymer PDAN doped PVA film; Arrhenius plot; Redundance.

* Corresponding author. Tel.: 09425325699; fax: +91761-2621272.
E-mail address: akbmrl@yahoo.co.in

Selection and Peer-review under responsibility of International Conference on Processing of Materials, Minerals and Energy (July 29th – 30th) 2016, Ongole, Andhra Pradesh, India.

1. Introduction:

Harvesting the renewable solar energy by means of organic materials is one of the most important ways to obliged nature for sustainable environmental clean-up. Low cost, easy fabrication and biodegradability enhance the acceptability of electronic devices by using conjugated conducting polymer materials [1-3]. Organic solar cells (OSCs) fulfill the criteria when bulk heterostructure [4-5] and blend film nano-morphology concepts are applied. If blending of donor and accepter materials occurs in a film, then large interfacial interpenetrating bulk hetrostructure network is achieved which enhances quantum efficiency of charge separation because the effective field so developed between two different polymer semiconductors causes dissociation of excitons into electron-hole pairs. Several donor-acceptor interfaces within Bulk-hetrojunction (BHJ) result in fast exciton diffusion and charge separation [6-7].

Low band gap polymers as active material in solar cell mechanism follows a criterion that HOMO-LUMO energy gap should match the solar radiation for maximum absorption and for that those p-type conjugated polymers which have band gap energy less than 1.77 eV for mean solar radiation may be desired. Furthermore, for the bulk hetrojunction the selected materials are defined by work function which provides knowledge about electron and hole transportations between the band gap of HOMO-LUMO energy levels in bulk hetrojunction [8]. It is also important that the difference between energies between HOMO-HOMO donor/accepter and LUMO-LUMO donor/accepter levels of the two semiconductor levels is remains small therefore the mechanism of polymer solar cell will be satisfied. On the other hand, the 'responsivity' of the PSC depends on the movement of dissociated electrons and holes towards respective electrodes. Faster the movement and collection of charge carriers more the photon to electron conversion works.

Due to Peierls instability or distortion, the conjugated polymer shows unusual charge mechanism and the charge carriers are transferred by the nonlinear topological defects in the chain. Non-degenerate energy levels of conjugated polymers produce the optical properties [9] and therefore used in OSCs. Poly (diaminonaphthalene) (PDAN) is ideal p-type conjugated polymer with easily synthesis, low energy band gap and broad absorption band width, matched with charge mobility due to bulk hetro-structure and visible region spectra of sunlight. Non-degenerate ground-state levels causes the charge mechanism required for the optimum photo-conduction in OSC and PDAN doped PVA will provide one of the active material for the bulk hetrojunction.

Film morphology also affects the quantum efficiency of the OSCs. Roughness parameters resulting in many voids create resistance and decrease the charge mobility. Controlled growth bulk hetrostructure will prevent trapping of charges through disordered interpenetrating interfaces network. Roughness morphology of PDAN doped PVA film via Atomic Force Microscope (AFM) results highly desirable controlled structure for OSCs. When fullerene (C_{71}) derivative also doped inside the PVA film, the nano-structured voids generated on the surface of PDAN doped PVA film are filled by the fullerene derivatives forming a nano width channels between n-type and p-type organic material which is necessary condition for the diffusion length of excitons in organic electronic materials.

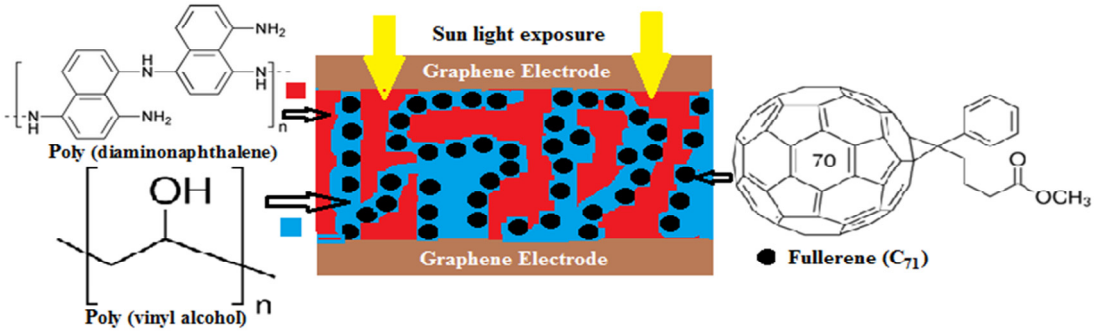

Fig. 1: Modelling of bulk hetero-junction Organic solar cells

The concept of planer hetero-junction OSC was first experimentally introduced by Tang et al. with power conversion efficiency of around 1% [10]. The limitation of delay of charge carrier mobility towards their respective electrodes was rectified by introducing bulk hetero-junction which involves multiple channels for charge carriers,