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Optimization of Photovoltaic Performance of Electrospun PVdF-HFP Nanofiber Membrane Based Dye Sensitized Solar Cells with Membrane Thickness

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Electrospinning is a versatile and efficient method to fabricate polymeric nanofibers with attractive properties such as the large surface area to volume ratio, better pore interconnectivity, and superior mechanical performances, which can be extended to applications in Dye Sensitized Solar Cells (DSSCs). Hence, to overcome the problem of poor long-term stability of conventional liquid electrolyte based DSSCs, the use of electrospun polymer nanofiber membrane-based gel electrolytes is a possible option. The DSSCs with polymer nanofiber-based gel electrolyte, made by trapping a solution electrolyte within a three-dimensional matrix made of polymer nanofibers exhibit almost liquid-like ionic conductivities while offering better mechanical and chemical stability than conventional liquid electrolyte based DSSCs. In electrospinning, there are various processing parameters, which significantly affect the characteristics of fiber membrane. In this work. a systematic study was performed to analyze the influence of membrane thickness on the photovoltaic performance of the DSSCs, which was assumed to be proportional to electrospinning time. Poly (vinylidene fluoride-co-hexafluoropropylene) (PVdF-HFP) nanofiber membrane was fabricated using the electrospinning method and in order to vary the membrane thickness of the nanofiber mat, electrospinning time was varied. Scanning Electron Microscopic images have shown that the PVdF-HFP membrane consists of porous, thin nanofibers with an average fiber diameter of 80-100 nm. The host polymer membrane was soaked in the solution electrolyte made with iodine (I_2), potassium iodide (KI), and tetrapropyl ammonium iodide (Pr_4NI) dissolved in ethylene carbonate (EC) and propylene carbonate (PC) co-solvent. The short circuit current density (J_{sc}) and light-to-electricity conversion efficiency (η) have shown almost similar variation with the duration of electrospinning. Both parameters have gradually increased to a maximum value and then has decreased with electrospinning time. Maximum efficiency (η) of 5.96% was observed for the DSSC fabricated with optimized nanofiber membrane, corresponding to 4 minutes of electrospinning time. The open circuit voltage (V_{oc}), short circuit current density (J_{sc}) and fill factor were recorded as 693.4 mV, 14.6 mA cm^{-2}, and 58.86% respectively at an incident light intensity of 1000 W m^{-2} with a 1.5 AM filter whereas the conventional liquid electrolyte cell showed an efficiency (η) of 6.56%.

***Keywords*:** Dye sensitized solar cells; PVdF-HFP co-polymer; Nanofiber gel polymer electrolyte; Electrospinning