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Photovoltaic Properties of Dye-Sensitized Solar Cells Fabricated with Polythiophene-Based Solid Electrolytes

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Dye-sensitized solar cell (DSSC) constructed using dye molecules, nanocrystalline metal oxides and organic liquid electrolytes have attractive features of high energy conversion efficiency and low production cost. Solar power conversion efficiencies of DSSCs using liquid electrolyte have reached 10%. However, it has not applied commercial because of its practical problems like the sealing of the cell. Recently, the replacement liquid electrolytes to solid-state electrolytes using hole conducting polymers have been able to solve the problems. Therefore, hole conducting polymer has been the point of issue to improve power conversion efficiencies of DSSCs. Especially, the alkyl substituted thiophene copolymers are attractive materials as polymer electrolytes as well as conducting polymers because of their solubility, processability, environmental stability, and excellent conductivity. Moreover, the introduction of carboxyl group in thiophene copolymers makes the polymers adsorbed onto TiO_2 nanoparticles surface in DSSC device.

In this study, we synthesized the poly[(3-hexylthiophene)-co-(3-thiophene acetic acid)] (Copolymer 1 and 2) containing both the hexyl and carboxyl groups for a hole conducting polymer on the DSSC. In order to increase the interface absorption onto nanoporous TiO_2 layer such as working electrode in the DSSC, two kinds of thiophene monomers substituted the hexyl and the carboxyl group was used. In order to investigate the adsorption effects on the introduction of carboxyl group, poly(3-hexylthiophene) (P3HT) without carboxyl group was synthesized in the same conditions. The photovoltaic effects of the DSSC devices using the synthesized copolymers or P3HT were investigated by Solar simulator AM 1.5. According to I-V curves of DSSC device using P3HT, Copolymer 1 or Copolymer 2 in Figure 1, the solar power conversion efficiency of P3HT, Copolymer 1 and Copolymer 2 were measured at 2.63 %, 2.72 % and 2.78 %, the open-circuit voltage (V_{oc}) were 0.55, 0.56 and 0.54 V, and the short-circuit current (J_{sc}) were 10.62, 10.01 and 10.74 mA/cm^2, respectively.

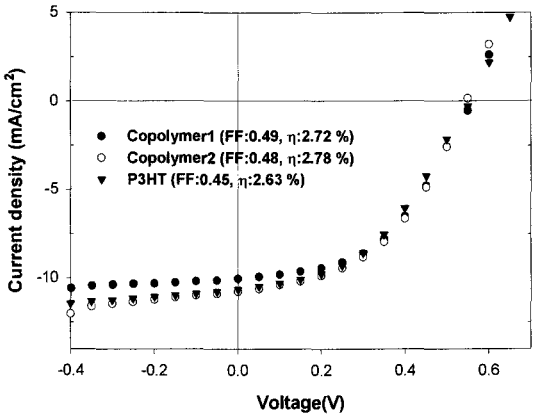

Figure 1. The I-V curves of DSSC devices using P3HT, Copolymer 1 or Copolymer 2 as a hole conducting material in illumination at AM 1.5.