Fabrication of large-size plastic film dye-sensitized solar cells by binder-free nanocrystalline TiO_2 paste coating

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Introduction

In the field of soft energy industries, usefulness of flexible solar cells is most expected as a power to charge handy electronic devices and displays. We have developed a method to fabricate flexible plastic-based dye-sensitized solar cells (DSSCs) based on the low-temperature TiO_2 coating technology using a binder-free TiO_2 paste.[1] This method leads to significant cost reduction in manufacture by roll-to-roll continuous production. With a miniature photocell (8 x 8mm), energy conversion efficiency reaches 4-5% with use of volatile electrolytes containing I^-/I_3^-. For practical use, however, electric power should be amplified by realizing a large size film-type photocell with serial DC connection. Electrolyte composition should also be converted to non-volatile alternatives such as ionic liquids. In this respect, we have fabricated a prototype of large plastic film DSSC.

Experimental results and discussion

Binder-free TiO_2 paste for doctor-blade coating was prepared by mixing nanocrystalline TiO_2 particles with acidic TiO_2 sol in aqueous *tert*-butanol (see our paper in this proceedings) and coated on ITO-PET film substrate (188 μm, 15-16 ohm/square) followed by heat treatment at 150℃ for 5 min. A 10~15 μm-thick layer was formed, which was dye-sensitized with a Ru complex (N719) to supply a plastic photoanode. Counterelectrode was a plastic film with surface coated with a platinized metal layer. Both electrodes were assembled into a thin sandwich type film (thickness, ~400μm) by insertion of a porous separator film and electrolyte layer consisting of propylene carbonate-based or molten salt (alkyl-imidazolium salt)-based compositions of high boiling points. Various sizes of film DSSCs were tested ranging from name-card size to A4 size.

Increasing the electrode size decreases fill factor (*FF*) of the photocell. This influence was particularly large at the distance between current-generating area and current-correcting terminal that exceed 2 cm (corresponding to IR drop of 0.2V at 10 mA current). A name-card size full plastic photocell (32 cm^2, 2.5 g, thickness 400 μm) was fabricated by using propylene carbonate-based electrolyte (Peccell, PECE-02) and gave 60-70 mA under exposure to 1/4 sun. A miniature photocell that used the same electrolyte composition yielded efficiency of 3% (1 sun) and 4.2% (1/4 sun), as shown in Fig. 1. An example measured for long time stability of the photocell in room-temperature preservation was exhibited in Fig. 2. This result is regarded as a minimum stability of the cell without equipment of a gas barrier layer to block invasion of water and leak of I_2. Our molten salt-based photocells gave low efficiency < 2%, due to high viscosity of electrolyte and low open-circuit photovoltage (~0.6V).

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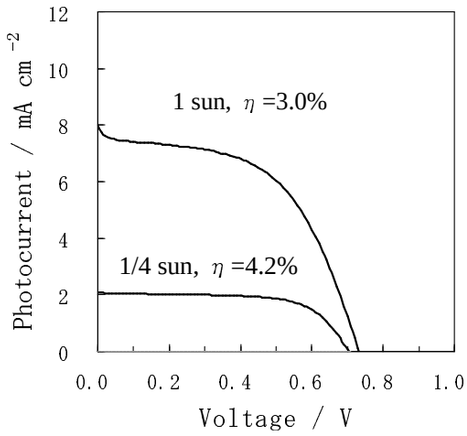

Figure 1 Photocurrent-voltage characteristics of the dye-sensitized ITO-PET film electrode with use of a quasi-nonvolatile electrolyte composition (PECE-02).

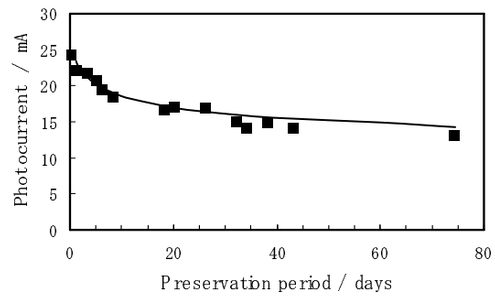

Figure 2 Stability of photocurrent as a function of preservation period measured for a plastic DSSC.

Figure 3 A name-card size full-plastic DSSC.

1. Y. Kijitori, T. N. Murakami, N. Kawashima, and T. Miyasaka, 205th ACS meeting, abstract #629, San Antonio, 2004.