Area 4: Organic and Dye-sensitized Solar Cells

IMPROVED CONVERSION EFFICIENCY OF 10% FOR SOLID-STATE DYE SENSITIZED SOLAR CELLS USING P-TYPE CUI

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Solid-state dye-sensitized solar cells (SDSCs) with inorganic p-type semiconductors as hole transfer materials (HTMs) have been actively researched for practical usage. We have previously developed SDSCs with p-type CuI as an HTM, because CuI has various advantageous characteristics such as higher stability and higher conductivity than organic HTMs and hence gives high efficient photovoltaics, and eventually achieved a conversion efficiency (η) of 6% using D149 red dye [1]. For further higher η, we have developed a novel donor-accepter type double porphyrin to widen the sensitivity range and enhance the short-circuit current density (Jsc) in the present study. In addition, we have improved the open-circuit voltage (Voc) by a post treatment using inorganic iodide after the dye adsorption.

We have designed a novel molecular structure and synthesized the dye composed of donor-accepter type double porphyrin (DIPDAB2), which has higher absorption coefficient than conventional double porphyrins (DTBC) [2] in the long wavelength range from 700nm to 800nm, as displayed in Fig. 1.

The incident photon-to-current conversion efficiency (IPCE) of the SDSC using DIPDAB2 was higher than that of DTBC. To achieve further higher Jsc by filling the dip between the Soret band and Q band in the absorption spectrum of DIPDAB2, we have combined DIPDAB2 with other organic dyes: indoline-type D131 and D358. The IPCE spectrum covered a notably wider wavelength range than that for the D149 DSC, as shown in Fig. 2. As a result, Jsc was improved dramatically.

On another front, we have found that Voc of the SDSCs with CuI was improved by dipping the porous TiO_2 electrodes into inorganic iodide solutions such as LiI, CaI_2, and KI after the dye adsorption. In addition, Voc of the fabricated cells increased after irradiation of light for 10 to 30 min. By these treatments, η of the SDSCs with CuI using the multi-dyes consisting of the novel porphyrin (DIPDAB2) and organic dyes (D131 and D358) reached 10% as depicted in Fig. 3, substantially exceeded the highest value of 7.4% for the conventional SDSCs with CuI using N3 dye [3].

[1] S. Moribe, et al., Appl. Phys. Express **5**, 112302 (2012).[2] Y. Liu et al., Chem. Commun. **47**, 4010-4012 (2011).[3] H. Sakamoto, et al.,Organic Electronics,**13**,514 (2012).

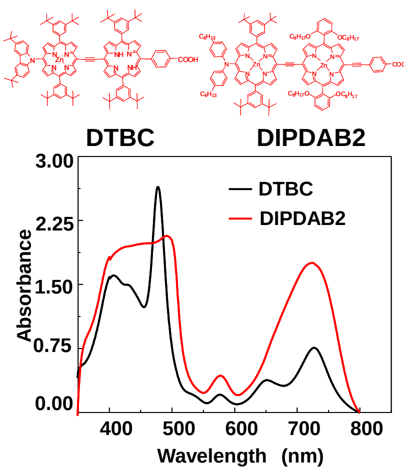

Fig.1 Absorption spectra and molecular structures of DTBC and DIBDAB2 dyes

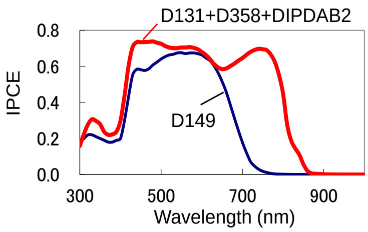

Fig.2 IPCE spectra of the SDSCs with CuI using a single dye (D149) and multi-dyes (D131+D358+DIPDAB2)

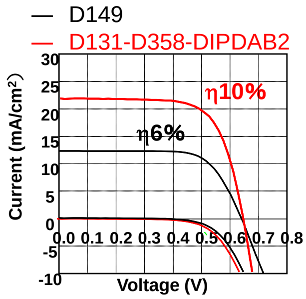

Fig.3 Current-voltage curves of the SDSCs with CuI using a single dye (D149) and multi-dyes (D131+D358+DIPDAB2)