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FUTURE PROSPECTS OF ORGANIC AND HYBRID SOLAR CELLS FOR NEXT GENERATION PHOTOVOLTAICS

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SUMMARY: Next-generation solar cells based on new concepts and/or novel materials are currently attracting wide interests. In this study, several types of next generation organic photovoltaics, such as panchromatic dye-sensitized solar cells (DSSCs), surface complex solar cells, and energy-storable dye-sensitized solar cell (ES-DSSC), have been investigated. Additionally, we developed the various tandem solar cells showing a high overall power conversion efficiency (η) over 17%.

Keywords: organic photovoltaics, dye-sensitized solar cell, hybrid solar cell, electrochemical solar cell

PANCHROMATIC DYE-SENSITIZED SOLAR CELL

Among the emerging solar cells, dye-sensitized solar cells (DSSCs) have received much attention as the low-cost solar cells. However, the energy conversion efficiency should be improved for the practical use. In order to improve the energy conversion efficiency, the extension of absorption range of the sensitizers to near-infrared regions is an important issue. In our study, panchromatic photoelectric conversion up to around 1000 nm has been accomplished by the use of new sensitizers DX1, 2, and 3 (Fig. 1).

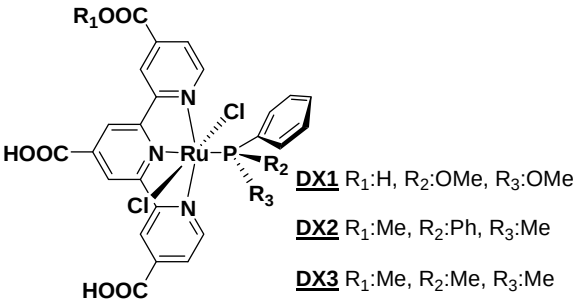

Fig. 1. Structures of DX1, DX2, and DX3.

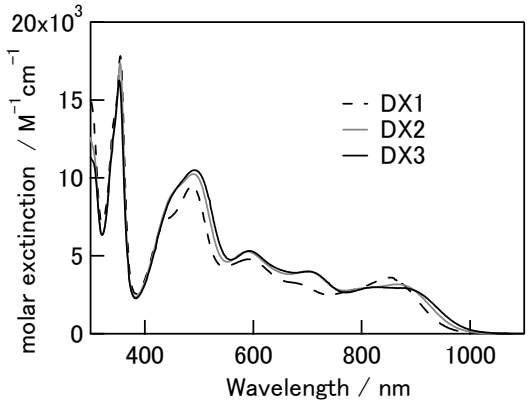

Fig. 2. Absorption spectra of DX1, DX2, and DX3.

The DXs exhibits near-infrared absorption of spin-forbidden transition (Fig. 2) and can decrease the spin exchange energy loss through inter-system crossing from the singlet excited states to the triplet excited states (Fig. 3).

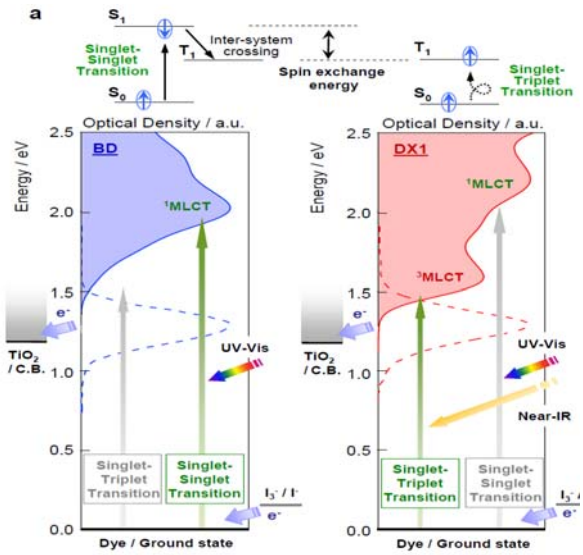

Fig. 3. Absorption process and electron transfer of DSSC using BD and DX1.

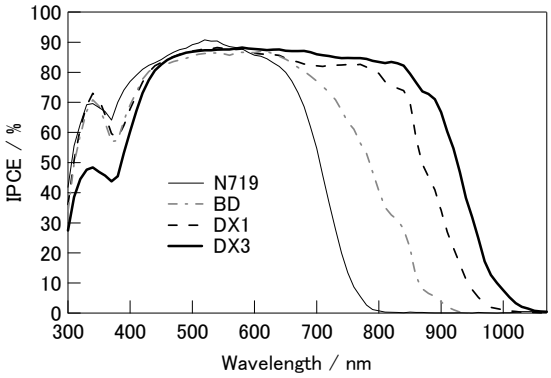

Fig. 4. IPCE spectra of DSSCs with N719, BD, DX1, and DX3.

The DSSC using the new dye DX exhibited an IPCE spectrum, which rises from the vicinity of 1,050nm, and was capable of increasing the spectral sensitivity wavelength by more than 100nm compared with BD and N719 (Fig. 4).

The panchromatic DSSC with DXs are useful for a series-connected tandem solar cell. We prepared the various tandem solar cells, including the stable perovskite solar cell, showing a high overall power conversion efficiency (η) of about 17%.

ELECTROCHEMICAL SOLAR CELL USING SURFACE COMPLEX

We have developed organic photovoltaics based on the surface complexes formed of TiO_2 with dicyanomethylene compounds (TCNX). The surface complexes exhibit broad absorption bands in the visible to near-infrared region due to interfacial charge-transfer transitions from the surface bound TCNX to the conduction band of TiO_2. In the solar cell, charge separation occurs directly by the charge-transfer transitions. It was found that the spectral sensitivity of the solar cell can be controlled by adjusting the π-conjugation length of TCNX. Ionization potential measurements revealed that the effects arise from the increase of the HOMO energy

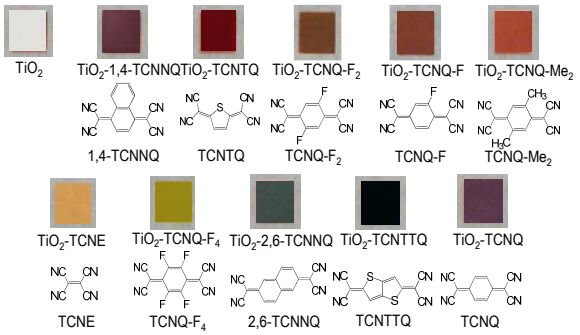

Fig. 5. Various surface complex of TCNXs and TiO_2.

of the surface bound TCNX with extension of the π-conjugation system and the resultant red-shift of the charge transfer absorption band. In order to increase the energy conversion efficiency, effects of coadsorbents on TiO_2 and cations in the electrolyte were investigated.

ENERGY-STORABLE DYE-SENSITIZED SOLAR CELL

Since the mechanisms of DSSC include electrochemical reaction, it can be hybridized with an electrochemical storage battery. We have reported a three-electrode solar rechargeable battery, namely "energy-storable dye-sensitized solar cell (ES-DSSC)", composed of the photoanode, the counter electrode and the charge-storage electrode. The ES-DSSC not only generates output power, but also stores the electricity by itself. The partial shadowing effect on the output voltage were studied on series-connected cells. The output voltage of the two DSSCs connected in series significantly decreased not only when both cells were shadowed, but also when either one of the cells was shadowed. These results indicate that the ES-DSSCs can stabilize output power under various photoirradiation conditions. Additionally, design panels of the ES-DSSC is constructed as shown in the Fig. 6.

Fig. 6. Colorful Design Panels of Energy-Storable Dye-sensitized Solar Cells with a Built-in Storage Battery.

References

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