Department of Applied Chemistry and Food Science

Key words Laser Photochemistry, Organic Electronics, Organic EL, Solar Cell, Cyclodextrin, Physical Chemistry, Photochromism

Doctor of Engineering / Professor

Michihiro Hara

Education

Applied Physics and Chemistry, Faculty of Engineering, Fukui University of Technology,
Fukui University of Technology Graduate school of Engineering, Master's Program,
Osaka University Graduate School of Engineering, Department of molecular chemistry(Doctor program)

Professional Background

Educational staff of MEXT/Technical assistant, The Institute of Scientific and Industrial Research (SANKEN), Osaka University, Lecture / Associate Professor, Fukui University of Technology, Professor at Fukui University of Technology

Consultations, Lectures, and Collaborative Research Themes

Lectures and consultations from basic to applied on photochemistry. Time-resolved spectroscopy and dynamic analysis by Laser, and Organic Solar Cell, DSSC, and OLED etc.

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Main research themes and their characteristics

「Improvement of photoionization efficiency of molecules-cyclodextrin complexes by using multi-laser pulse excitation」

Control over the photoreactions of photochromic molecules, such as diarylethene , spiropyran, and azobenzene etc., is required to manipulate photonic devices, photo-driven actuators, and molecular machines containing these molecules. However, photoreaction control under excitation by multiple laser pulses at different wavelengths has not been extensively examined. In Hara lab., the resonant photoionization of the diarylethene incorporated into cyclodextrins (CD) was investigated using one-laser, two-laser, and three-laser irradiation. The ionization quantum yield of diarylethene, which was obtained using one-laser irradiation, was increased by restraint of the cyclization reaction resulting from incorporation of diarylethene into CD. The ionization yield obtained using two-laser irradiation was higher than that measured under one-laser irradiation and this suggested that photoionization of diarylethene proceeded through stepwise excitation by the UV-light and visible-light laser pulses. Increases in ionization yields of diarylethene were achieved under three-laser irradiation because of efficient cycloreversion of diarylethene by the visible-light laser pulse. Increases in photoionization efficiency were related to cyclization quantum yields and the thermal stability of the closed-form of diarylethene. These multiphoton absorption sequences represent a useful method for photo-control of photonic devices and photo-driven actuators.

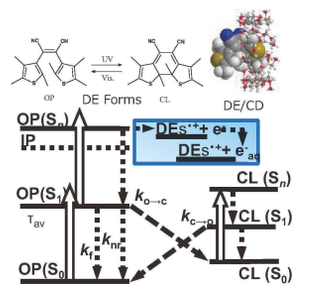

Fig.1 Energy diagram of photoionization of DE/CDs by using 266*532-nm and 355*532-nm irradiation.

「Fabrication of a dye-sensitized solar cell and an organic electroluminescence containing a organic molecular with cyclodextrin」

The fabrication, photovoltaic conversion, and photo-response of dye-sensitized solar cell (DSSC) containing a spiropyran and molecules and cyclodextrins (CD) were investigated for the first time. In fact, we found the adsorption of photomerocyanine form of spiropyran (PMC) and inclusion complexes between the PMC and CD (PMC/CD) to the TiO2 surface. The formation of PMC/CD was confirmed by fluorescence spectroscopy. The incident photon-to-current conversion efficiency of the PMC-containing DSSC obtained 4.1% under 570-nm light irradiation, and the highest incident photon-to-current conversion efficiency reached 11.1% by inclusion effect of CD. Similar, the fill-factor and the open-circuit voltage were improved by CD layer. The incident photon-to-current conversion efficiency value of PMC/CD-containing DSSC was decreased by visible light treatment, and it was considered that decrease of IPCE values are attributed to the formation of PMC isomer. Therefore, we demonstrated the photovoltaic conversion and photoresponsivity of the DSSC by incorporating a noncarboxylated PMC with inclusion effect of CD layer. In addition, we report an investigation of the fabrication and characterization of glass-based organic electroluminescence in the presence of cyclodextrin polymer (CDP) as an interlayer.

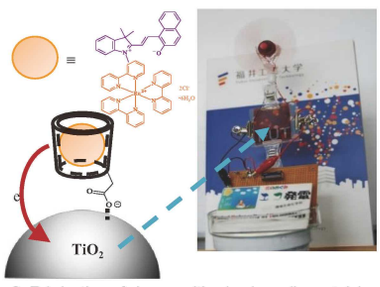

Fig 2. Fabrication of dye-sensitized solar cell containing non anchored dye compound and CD.

Major academic publications

1. Michihiro Hara, Sachiko Tojo, Tetsuro Majima
"Three-color Three- Laser Photochemistry of Di(p-methxyphenyl)methyl Chloride"
The Journal of Physical Chemistry A,107(2003) 4778-4783.

2. Tatsuya Takeshita, Takao Umeda, Michihiro Hara
"Fabrication of a dye-sensitized solar cell containing a noncarboxylated spiropyran-derived photomerocyanine with cyclodextrin"
Journal of Photochemistry and Photobiology A: Chemistry,333,2016,87-91.

3. Michihiro Hara, Tatsuya Takeshita, Takao Umeda, "Effect of cyclodextrin cavity size on the photovoltaic performance of unanchored ruthenium(II) polypyridine complex-containing dye-sensitized solar cells",
Journal of Photonics for Energy, 10(2020)045503.

4. Michihiro Hara, Takao Umeda, Hiroyuki Kurata, "Fabrication and Characterisation of Organic EL Devices in the Presence of Cyclodextrin as an Interlayer", Sensors,21 (2021) 366-3674.