Plasmonic enhancement in molecular-based photo-energy conversion system

Katsuyoshi Ikeda, Kenji Takahashi, Takuya Masuda and Kohei Uosaki
Division of chemistry, Graduate School of Science, Hokkaido University

Conversion and storage of solar energy are recognized as a fundamental issue in various fields of modern science. Natural photosynthesis is one of the most elegant examples, and then a large number of researchers have attempted to construct molecular-based photosynthesis systems artificially. We have reported that self-assembled monolayers (SAMs) of porphyrin-ferrocene-thiol-linked molecule, constructed on well-defined gold substrates, exhibited highly efficient photo-energy conversion.1) In this study, a metal nano-gap system2) was introduced as a photon antenna in order to improve the photo-energy conversion efficiency.

Figure 1 shows theoretically calculated extinction spectra of an Au-nanoparticle (NP) above an Au-substrate with the gap-distance of 5 nm in electrolyte solution. As the diameter of the Au-NP is increased, the peak position is red-shifted along with the stronger intensity. This behavior indicates that particle plasmons and surface plasmons hybridize strongly in the Au-NP/Au-substrate system when the diameter of the Au-NP is large. Since such hybridized plasmons are accompanied with photon energy concentration within the gap region, one can expect that photo-induced phenomena would occur more efficiently. In the system of the porphyrin-SAM/Au-substrate, similar metal nano-gap systems can be constructed by adsorption of Au-NPs onto the organic layer. Figure 2 shows photocurrent action spectra of porphyrin-SAM with and without adsorption of 50-nm Au-NPs. Photocurrent was significantly increased by the presence of adsorbed Au-NPs, as expected. The wavelength dependence of the enhancement factor was similar to the calculated extinction spectrum. Therefore, it is concluded that the plasmonic resonances in the nano-gap systems increased the effective photo-energy conversion efficiency.3)

Name: Katsuyoshi IKEDA

Position and Affiliation: Associate Professor, Hokkaido University
Postal Address: North 10, West 8, Kita-ku, Sapporo 060-0810, Japan
Phone/Facsimile: +81-11-706-2708/+81-11-706-3440
Email: kikeda@pchem.sci.hokudai.ac.jp

Research Interest and Keywords:
Physical chemistry and photochemistry, plasmonics, surface science, molecular devices, and linear/nonlinear spectroscopy

Recent Publications:

Biographical Sketch:

2002: PhD, The University of Tokyo
1997: Researcher, Fujikura, Ltd.
1999: Researcher, Kanagawa Academy of Science and Technology (KAST)
2003: JSPS fellow (PD), Tokyo Institute of Technology
Visiting researcher, Department of Physics, University of California at Berkeley
2005: Special Postdoctoral fellow, The Institute of Physical and Chemical Research (RIKEN)
2006: Lecturer, Division of Chemistry, Hokkaido University
2008-present: Associate Professor, Division of Chemistry, Hokkaido University