

# Division of Synthetic Chemistry – Advanced Inorganic Synthesis –

[http://www.scl.kyoto-u.ac.jp/~teranisi/index\\_E.html](http://www.scl.kyoto-u.ac.jp/~teranisi/index_E.html)



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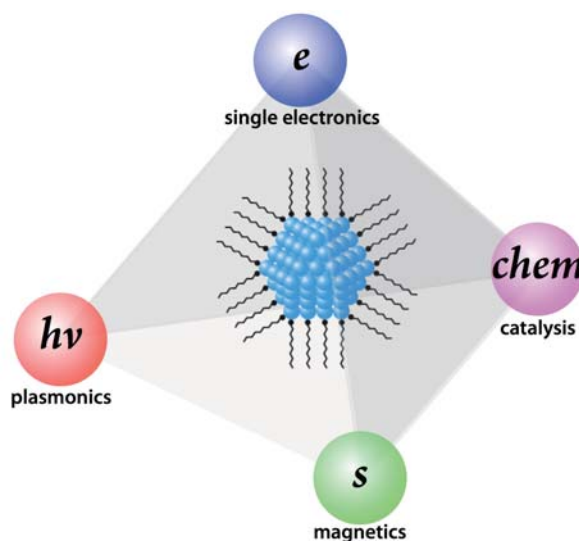
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## Scope of Research

We are focusing on the precise synthesis of inorganic nanoparticles by controlling the primary (size, shape, composition, etc.) and secondary (spatial arrangement) structures to tune their properties, such as electron confinement, carrier oscillation, spin, and catalysis. These high quality inorganic nanoparticles are applied to both high-performance nanodevices (single electron transistor, plasmon waveguide, nanocomposite magnet) and photo-energy conversion materials (overall water splitting, solar cell).

### KEYWORDS

Inorganic Nanoparticles    Nanocomposite Magnet  
Single Electronics        Photocatalysts  
Plasmonics

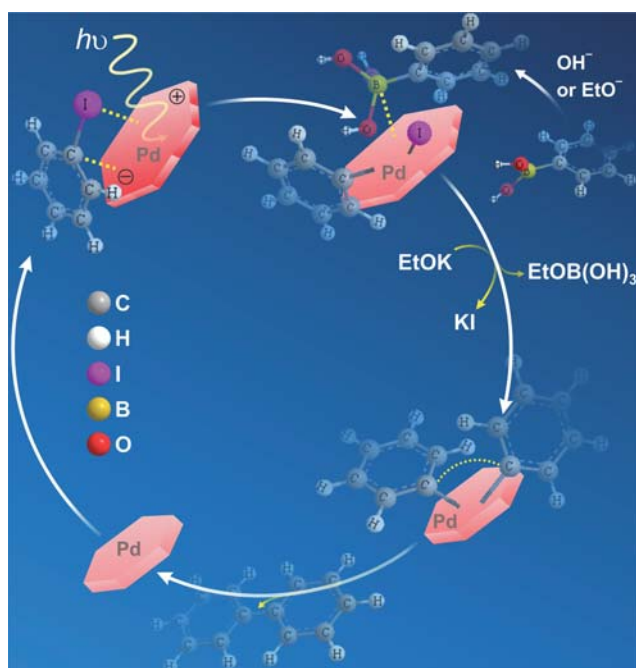


## Selected Publications

- Sakamoto, M.; Inoue, K.; Saruyama, M.; So, Y.-G.; Kimoto, K.; Okano, M.; Kanemitsu, Y.; Teranishi, T., Investigation on Photo-Induced Charge Separation in CdS/CdTe Nanopencils, *Chem. Sci.*, **5**, 3831-3835 (2014).
- Ihara, T.; Sato, R.; Teranishi, T.; Kanemitsu, Y., Delocalized and Localized Charged Excitons Single CdSe/CdS Dot-in-Rods Revealed by Polarized Photoluminescence Blinking, *Phys. Rev. B*, **90**, [035309-1]-[035309-5] (2014).
- Tanaka, D.; Inuta, Y.; Sakamoto, M.; Furube, A.; Haruta, M.; So, Y.-G.; Kimoto, K.; Hamada, I.; Teranishi, T., Strongest  $\pi$ -Metal Orbital Coupling in a Porphyrin/Gold Cluster System, *Chem. Sci.*, **5**, 2007-2010 (2014).
- Okano, M.; Sakamoto, M.; Teranishi, T.; Kanemitsu, Y., Assessment of Hot-carrier Effects on Charge Separation in Type-II CdS/CdTe Heterostructured Nanorods, *J. Phys. Chem. Lett.*, **5**, 2951-2956 (2014).
- Xiong, A.; Yoshinaga, T.; Ikeda, T.; Takashima, M.; Hisatomi, T.; Maeda, K.; Setoyama, T.; Teranishi, T.; Domen, K., Effect of Hydrogen and Oxygen Evolution Cocatalysts on Photocatalytic Activity of GaN:ZnO, *Eur. J. Inorg. Chem.*, **2014**, 767-772 (2014).

## Visible to Near-Infrared Plasmon-Enhanced Catalytic Activity of Pd Hexagonal Nanoplates for the Suzuki Coupling Reaction

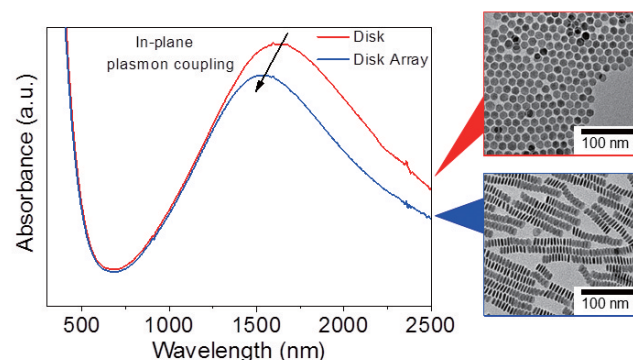
The photocatalytic conversion of solar energy to chemical energy is a sustainable and efficient process for chemical reactions because solar light is an abundant resource and it can facilitate room-temperature chemical transformations by generating electronically excited states in photocatalysts. Pd hexagonal nanoplates with a well-defined and tunable longitudinal local surface plasmon resonance (LSPR) peak enabled the direct harvesting of visible to near-infrared light for chemical reactions. Upon plasmon excitation, the catalytic Suzuki coupling reaction between iodobenzene and phenylboronic acid was accelerated by the plasmonic photocatalytic effect with plasmon induced hot-electrons. The turnover frequency (TOF) of the Pd hexagonal nanoplates in a reaction illuminated with a  $\lambda = 300 - 1000$  nm Xenon lamp at  $176 \text{ mWcm}^{-2}$  was 2.5 and 2.7 times higher than that of non-plasmonic  $\{111\}$ -enclosed Pd nanooctahedra and  $\{100\}$ -enclosed Pd nanocubes, respectively. It was also 1.7 times higher than that of a reaction that was thermally heated to the same temperature.



**Figure 1.** Proposed mechanism for the Suzuki coupling reaction catalyzed by heterogeneous plasmonic Pd hexagonal nanoplates.

## Determination of a Localized Surface Plasmon Resonance Mode of Cu<sub>7</sub>S<sub>4</sub> Nanodisks by Plasmon Coupling

Plasmon properties such as peak position, extinction cross-section, and local electric field intensity, are strongly dependent on excited, localized surface plasmon resonance (LSPR) modes. In non-spherical copper chalcogenide nanoparticles, assignment of the LSPR peaks to the corresponding oscillation modes has been controversial and requires experimental verification. We determined the transversal LSPR mode of roxbyrite Cu<sub>7</sub>S<sub>4</sub> nanodisks from the plasmon coupling effect of nanodisks in solution. Compared with individual Cu<sub>7</sub>S<sub>4</sub> nanodisks, self-assembled Cu<sub>7</sub>S<sub>4</sub> nanodisk arrays in chloroform exhibited a blue-shifted LSPR peak with weaker optical density. This strongly suggests that the singular LSPR peak in the near-infrared region mainly originates from the in-plane oscillation mode. In addition, we demonstrate that the same LSPR peak can be readily tuned by controlling the number of disks in the array.



**Figure 2.** Spectral shift through the formation of Cu<sub>7</sub>S<sub>4</sub> nanodisk array.