

Division of Synthetic Chemistry – Advanced Inorganic Synthesis –

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Georgia Institute of Technology, U.S.A., 12 June-13 June

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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 properties such as electron confinement, carrier oscillation, spin, and catalysis. These high-quality inorganic nanoparticles are applied to both high-performance nanodevices (e.g., single electron transistor, plasmon waveguide, and nanocomposite magnet) and photo-energy conversion materials (e.g., overall water splitting and solar cell).

KEYWORDS

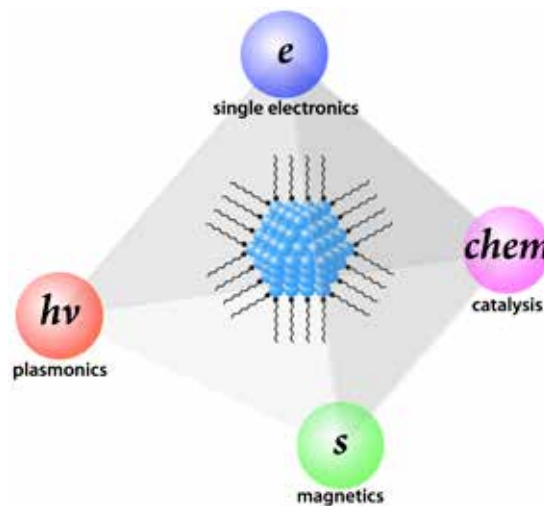
Inorganic Nanoparticles

Plasmonics

Photocatalysts

Single Electronics

Nanocomposite Magnet



Selected Publications

Sakamoto, M.; Chen, L.; Okano, M.; Tex, D. M.; Kanemitsu, Y.; Teranishi, T., Photoinduced Carrier Dynamics of Nearly Stoichiometric Oleylamine-protected Copper Indium Sulfide Nanoparticles and Nanodisks, *J. Phys. Chem. C*, **119**, 11100-11105 (2015).

Chen, L.; Sakamoto, M.; Sato, R.; Teranishi, T., Determination of a Localized Surface Plasmon Resonance Mode of Cu₇S₄ Nanodisks by Plasmon Coupling, *Faraday Discuss.*, **181**, 355-364 (2015).

Frake, J. C.; Kano, S.; Ciccarelli, C.; Griffiths, J.; Sakamoto, M.; Teranishi, T.; Majima, Y.; Smith, C. G.; Buitelaar, M. R., Radio-frequency Capacitance Spectroscopy of Metallic Nanoparticles, *Sci. Rep.*, **5**, 10858 (2015).

Trinh, T. T.; Sato, R.; Sakamoto, M.; Fujiyoshi, Y.; Haruta, M.; Kurata, H.; Teranishi, T., Visible to Near-Infrared Plasmon-Enhanced Catalytic Activity of Pd Hexagonal Nanoplates for the Suzuki Coupling Reaction, *Nanoscale*, **7**, 12435-12444 (2015).

Photo-induced Carrier Dynamics of Nearly Stoichiometric Oleylamine-protected Copper Indium Sulfide Nanoparticles and Nanodisks

Copper indium sulfide (CuInS_2) nanocrystals (NCs) are nontoxic and inexpensive, making them attractive for use in high-efficiency solar cells. However, direct observations of the photo-induced carrier dynamics of CuInS_2 NCs to examine the relationship between carrier dynamics and structural parameters, with the aim of optimizing NC properties for specific applications, are limited. Here, we synthesized nearly stoichiometric oleylamine-protected CuInS_2 NCs using two convenient one-pot methods to produce CuInS_2 nanoparticles and nanodisks. Transient absorption measurements using femtosecond laser flash photolysis revealed that the use of oleylamine as a protecting ligand leads to the formation of vacancy-doped NCs. The rapid decay of the photogenerated excitons in the oleylamine-protected NCs was not sensitive to the crystal structure or shape of NCs, and could be explained by defect trapping and energy transfer to the hole-based localized surface plasmon resonance in the oleylamine-protected NCs. Our results confirm that careful selection of a protecting ligand is important to obtain CuInS_2 NCs with optimized properties for specific applications.

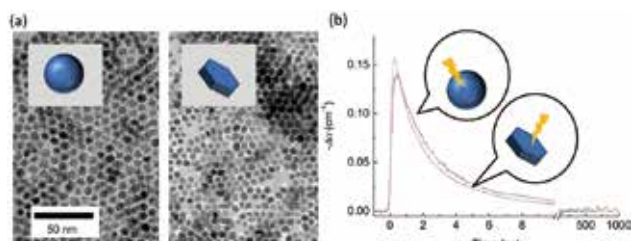


Figure 1. TEM images (a) and decay profile of photogenerated excitons in the CuInS_2 nanoparticles and nanodisks (b).

Simple Surfactant Concentration-Dependent Shape Control of Polyhedral Fe_3O_4 Nanoparticles and Their Magnetic Properties

Magnetite (Fe_3O_4) is one of the most studied magnetic nanoparticle (NP) materials, with uses in magnetic resonance imaging (MRI), drug delivery, biosensors, magnetic separation, and medical diagnostics. Characteristic magnetic features of Fe_3O_4 NPs depend strongly on their shape and size because of shape- and size-determined differences in surface states such as exposed crystal planes and specific surface area of NPs. In this study, we developed a facile solution approach to synthesize a series of polyhedral Fe_3O_4 NPs with sizes between 20 and 200 nm using cetylpyridinium chloride (CPC) and oleic acid (OAc) as surfactants. The concentrations of CPC and OAc in the reaction solution

play an essential role in the shape and size evolution. The shape of Fe_3O_4 NPs is tuned simply by the amount of CPC. Cubic Fe_3O_4 NPs surrounded by six $\{100\}$ planes are obtained in the absence of CPC. Increasing the CPC content during synthesis causes the shape of the resulting Fe_3O_4 NPs to change from cubic to truncated cubic, cuboctahedral, truncated octahedral, and finally octahedral. During this evolution, the predominantly exposed planes of the Fe_3O_4 NPs vary from $\{100\}$ to $\{111\}$. The shape control results from the synergistic effect of the chloride anions, pyridinium cations, and long-chain alkyl groups of CPC. The size of the cubic Fe_3O_4 NPs can also be tuned from 50 to 200 nm by changing the concentration of OAc. These polyhedral Fe_3O_4 NPs clearly exhibit shape- and size-dependent magnetic properties, including saturation magnetization, remanent magnetization, and coercivity.

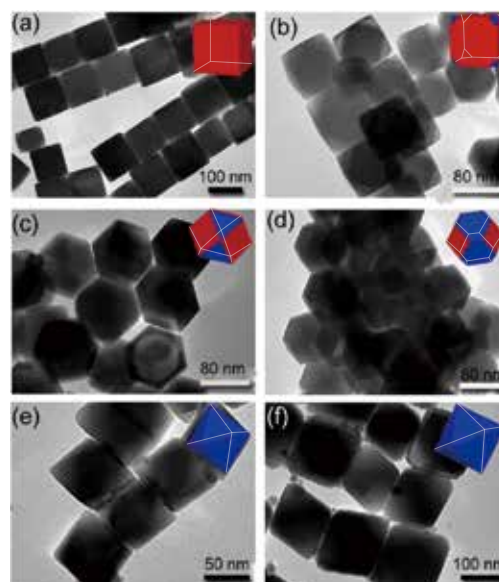


Figure 2. TEM images of (a) cubic, (b) truncated cubic, (c) cuboctahedral, (d) truncated octahedral, and (e,f) octahedral Fe_3O_4 NPs synthesized by varying only the amount of CPC. Insets show the $\{100\}$ and $\{111\}$ planes in red and blue, respectively.