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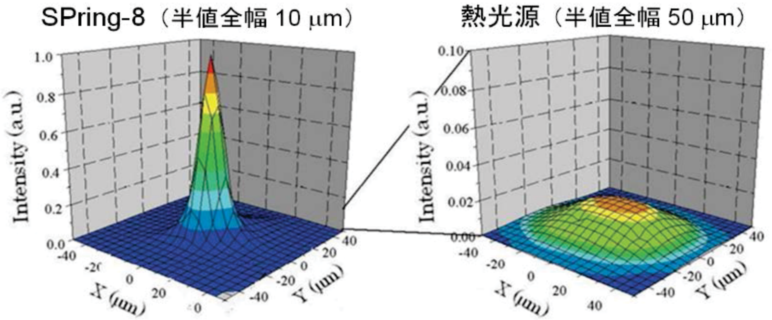
Infrared studies of materials using synchrotron radiation

Professor　Hidekazu Okamura

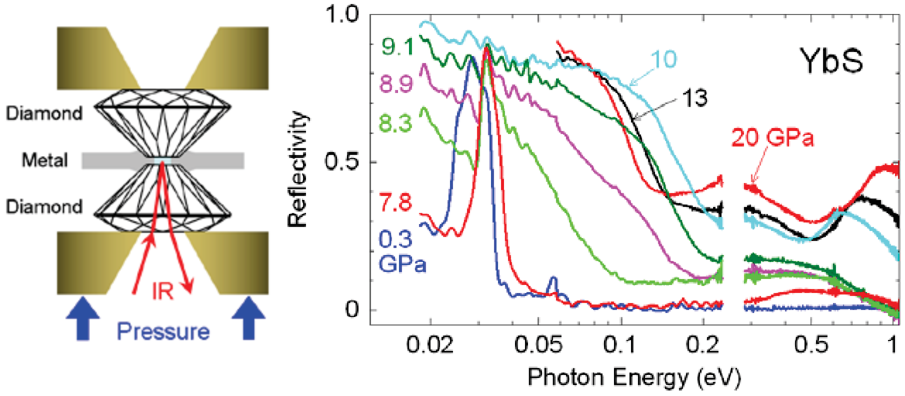
Infrared Synchrotron Radiation

- ✓ 10^2~10^3 times brighter than conventional IR source.
- ✓ Can be focused to a 10 μm diameter spot without an aperture (in the molecular vibration range).

→IR microscopy can be easily performed with a very high spatial resolution.



Comparison between SPring-8 and conventional IR source.



A high pressure IR study of YbS using SPring-8.

<Background>

- ✓ Infrared synchrotron radiation is much brighter than the conventional, black body radiation-based infrared sources. This brightness is utilized to perform infrared studies with high spatial resolution, such as micro-spectroscopy, high pressure studies using a diamond anvil cell (DAC), etc.

<Present research activities>

- ✓ Infrared studies of various materials under high pressure, using DAC and the infrared synchrotron radiation at SPring-8.
- ✓ Materials of main interest are the so-called 'strongly correlated electron systems', where strong electron-electron interaction results in interesting phenomena such as metal-insulator transition, heavy quasiparticle formation, superconductivity, etc.
- ✓ Development of super-spatial resolution IR microscopy using SPring-8 and near-field optics.

Keywords: Infrared spectroscopy, synchrotron radiation, high pressure, diamond anvil cell.

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Development of Estimation Method of Water Adsorbents

Professor Masahiro Katoh

Fig. 1 Volumetric apparatus for measurement of adsorption & desorption velocity of water on adsorbents..

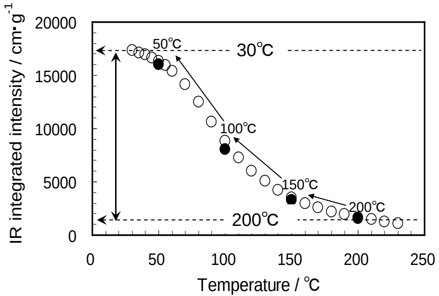

Fig. 2 Temperature dependence of IR integrated intensity of adsorbed H_2O at 10 Torr on NaY zeolite, ○: 1st, ●: 2nd.

Fig. 3 special IR cell.

Content:

The utilization of waste heat for the regeneration of desiccant material in a desiccant dehumidifier system is one of the best alternatives because regeneration cost is eliminated. However, it is only suitable for equipment which can exhaust waste heat at temperature 60 ℃ and 140 ℃. Usually, these types of equipment are only available in factories or supermarkets.

We develop estimation method of water adsorbents (desiccant materials) and propose two kinds of estimation methods for water adsorption.

(1) Estimation of adsorption and desorption velocity of water on adsorbents by volumetric apparatus (Fig .1).

(2) Estimation of temperature behavior of adsorbed water on adsorbents by IR spectroscopy.

In particular, temperature dependence (Fig. 2) of adsorbed water on desiccant can be gotten easily by using special IR cell (Fig. 3). The profile was corresponding to the equilibrium adsorption data.

Keywords：water adsorbent, adsorption velocity,
IR spectroscopy

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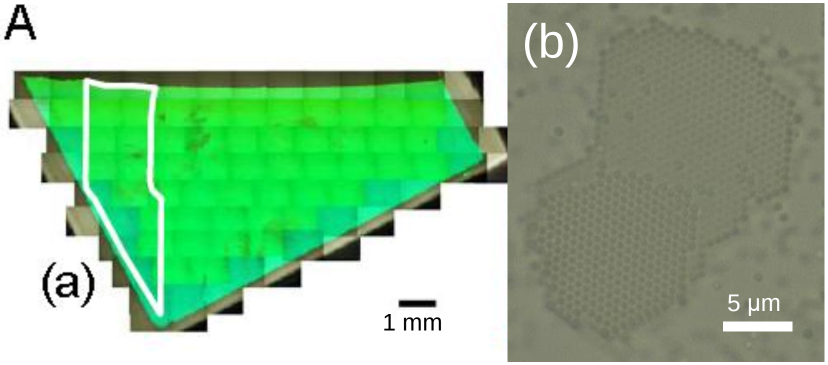
Fundamentals of Crystal Growth of Nano-Submicron Particles

Professor Yoshihisa Suzuki

A



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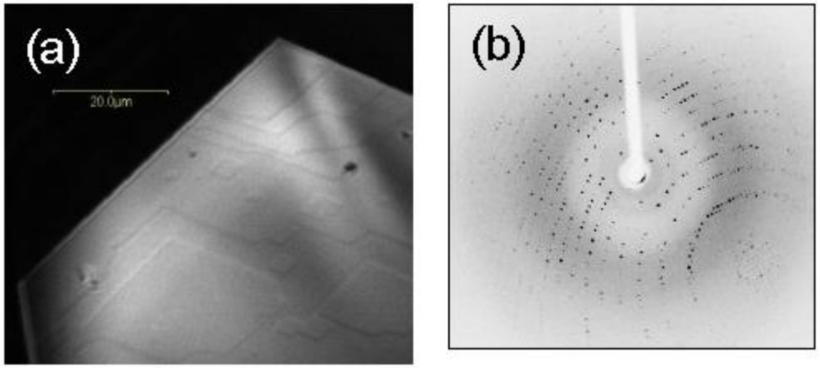

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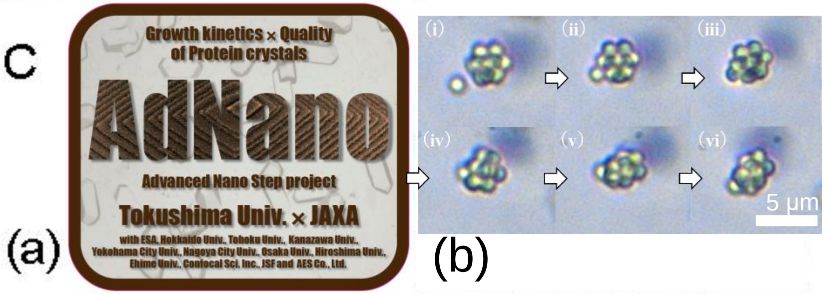

Content:

A. **Colloidal crystallization**: Colloidal crystals are hoping materials for optical circuits and optical computer in the future. We have successfully fabricated bulky grains (~ 6.1 mm^3) of a close-packed polystyrene colloidal crystal ((a)) by centrifugation. Recently, we have also studied dynamical crystallization processes at a single particle level using colloidal crystals with depletion attractions (b).

B. **In situ observation of molecular steps on protein crystal surfaces and novel crystallization techniques without any precipitants**: Fundamental studies and developments of novel techniques of protein crystallization are important for obtaining high quality crystals, which are prerequisites of genomic drug discovery. We are now studying kinetic bahaviors of molecular steps on the surface of a glucose isomerase crystal ((a)). We have also succeeded in fabricating high quality lysozyme crystals without using any precipitants ((b)) for the first time.

C. **Precise growth mechanisms of crystals under microgravity**: Microgravity is known to be a good environment for obtaining high quality protein crystals. Our Advanced Nano Step (AdNano) mission ((a)) in the international space station (ISS) has successfully finished in 2025. We are currently investigating the homogeneous nucleation of levitating attractive colloidal clusters under density-matched conditions achieved with heavy water((b)).

Keywords：Crystal Growth, Protein, Colloid, Microgravity

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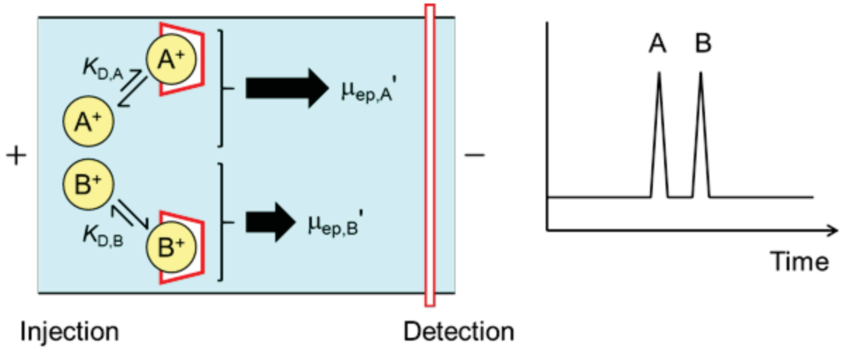
Development of Analytical and Separation Methods with Nano-sized Molecular Assembly

Professor Toshio Takayanagi



(a) Molecular recognition with affinity (b) Chromatogram

Fig. 1 Separation improvement by affinity interaction

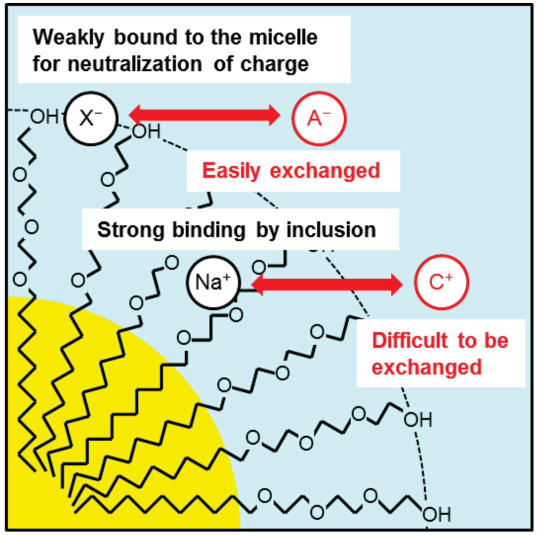


Fig. 2 Partition selectivity of ionic species toward nonionic surfactant micelle

Content:

Nano-sized molecular assemblies of surfactant micelles, vesicles, microemulsions, and polymer gels possess hydrophobic environment. Specific surface area of the molecular assemblies is greatly larger than that of bulk water-organic solvent interface. Extraction-separation with the characteristic hydrophobic environment of the molecular assemblies works in pseudo-homogeneous aqueous solution. Liquid-liquid extraction is done in the pseudo-homogeneous aqueous solution without mechanical shaking of the two phases, with fast extraction kinetics, as well as with the selectivity towards ionic substances. Functional Molecular Assembly including micelles, microemulsions, and hydrophobic matrices are to be developed.

Based on equilibria and kinetics in aqueous solution, development of affinity reagents, analysis of affinity interactions, and investigation of selectivity expression factors are studied.

Keywords : Surfactant micelle, microemulsion, hydrophobic partition, aquatic solvent, analytical separation

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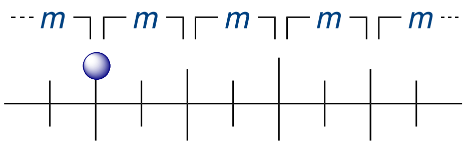
Stereoregular thermoresponsible polymers

Professor Tomohiro Hirano

Representative stereoregular polymers

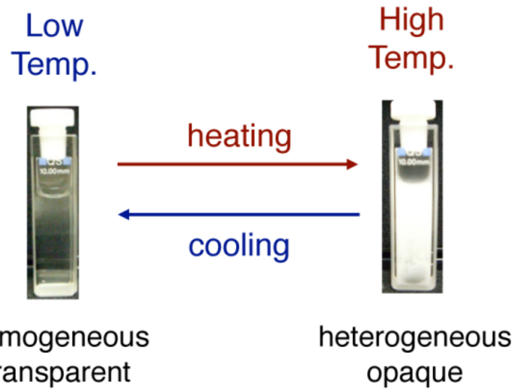


Isotactic

Syndiotactic

Heterotactic

Phase transition behavior of aqueous polymers.



Low Temp.

High Temp.

heating

cooling

homogeneous
transparent

heterogeneous
opaque

Content:

Our main research interest is “synthesis of stereoregular polymers, which exhibit thermoresponsibility in aqueous solutions”. The stereospecificity of the radical polymerizations of amide-containing monomers, such as *N*-isopropylacrylamide (NIPAAm) and *N*-*n*-propylacrylamide (NNPAAm), has been successfully controlled by utilizing complex formation of monomers through hydrogen bondings.

In addition, the effect of stereoregularity (isotactic, syndiotactic and heterotactic) on the LCST (lower critical solution temperature)-type phase transition has been investigated. It has been revealed that diad tacticity plays an important role to determine the phase transition temperature in the heating process, whereas configurational sequences longer than triad do in the cooling process.

A final goal of our research is development of novel functional polymeric material by controlling the primary structures of synthetic polymers.

Keywords : radical polymerization, stereoregularity, LCST

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Electroanalytical systems using track-etched microporous membrane electrodes

Professor Hitoshi Mizuguchi

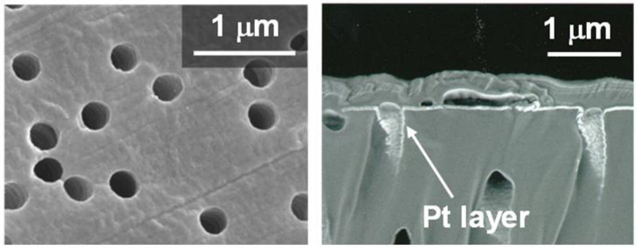

Fig.1 SEM images of track-etched microporous membrane electrode. Surface of the electrode (left), and cross sectional view (right).

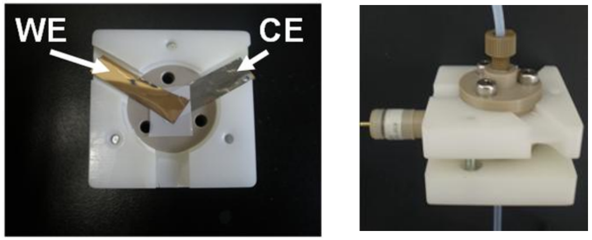

Fig.2 Structure of the proposed flow cell

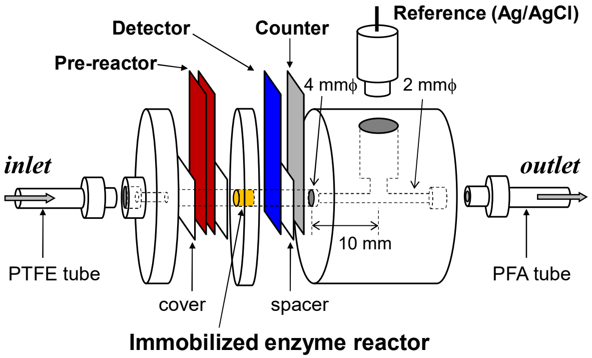

Fig.3 Amperometric enzyme biosensor

Content:

We recently reported an electrochemical flow cell in which the track-etched microporous membrane electrodes had been mounted. The electrode was prepared by sputter deposition of platinum or gold on the track-etched microporous membrane filters. The coatings were produced on the smooth flat surface and entrance of the cylindrical pores. Sample solution flows through the membrane filter while performing electrolysis. In this case, the sample solution flows through the cylindrical pores of the electrodes (Fig.1). The electrode enables efficient electrolysis in a flow condition. This property would be attributed to the limitation of growth of the diffusion layer at the entrances of pores. Various analytical systems can be built merely by piling up the track-etched microporous membrane electrodes which have a 10 μm thickness (see Fig.3). Although many researchers have investigated for quantitative electrolysis, the simplicity and flexibility of arrangement of electrodes as well as high efficiency of electrolysis is the greatest feature of the track-etched microporous membrane electrodes.

Keywords: track−etched membrane,
biosensor, flow−based analysis

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Development of Advanced Inorganic Materials

Professor Kei-ichiro, Murai

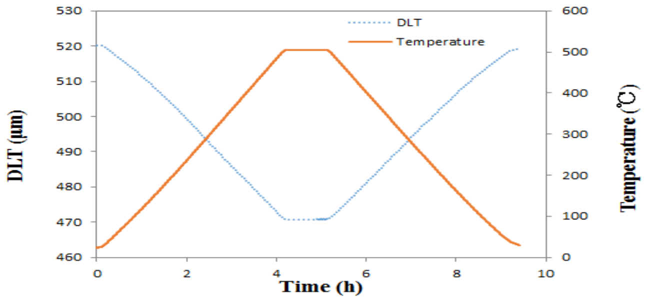

Fig.1. Diagram for dilatometry of $Zr_2(WO_4)(PO_4)_2$.

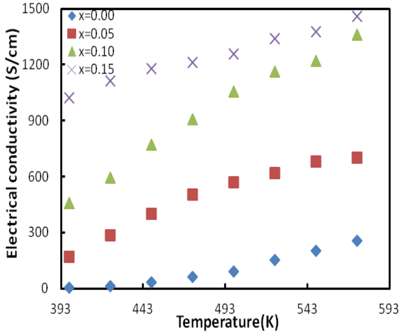

Fig. 2. Electric conductivities of $La_{1-x}Ca_xCoO_3$ (x = 0.00, 0.05, 0.10, 0.15)

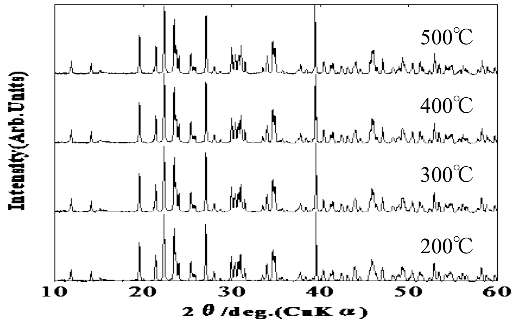

Fig. 3. Variation of in-situ XRD patterns for $Zr_2(WO_4)(PO_4)_2$ at the given temperatures.

Content:

The research work is developments of advanced inorganic materials such as negative thermal expansion materials (Fig. 1) or thermoelectric materials (Fig.2) made of oxides which is low in price, harmless and stable from physical and chemical viewpoint. X-ray diffraction (XRD) techniques are also used in materials characterization in our lab (Fig. 3). Crystal structure of materials has a close connection with its properties.

Negative thermal expansion oxide have a range of potential engineering, photonic, electronic, and structural applications. If a negative thermal expansion material is mixed with a "normal" material which expands on heating, it could be possible to make a zero expansion composite material.

Today, some alloys are in practical use as thermoelectric materials. However, Perovskite-type materials are more stable in high temperature region. In our lab., it was found that some cation-doping oxides had higher values than non-doped materials in thermoelectric properties.

Crystal structures of materials above mentioned are investigated by XRD and Rietvelt analysis.

Keywords：Advanced Materials, Crystallography

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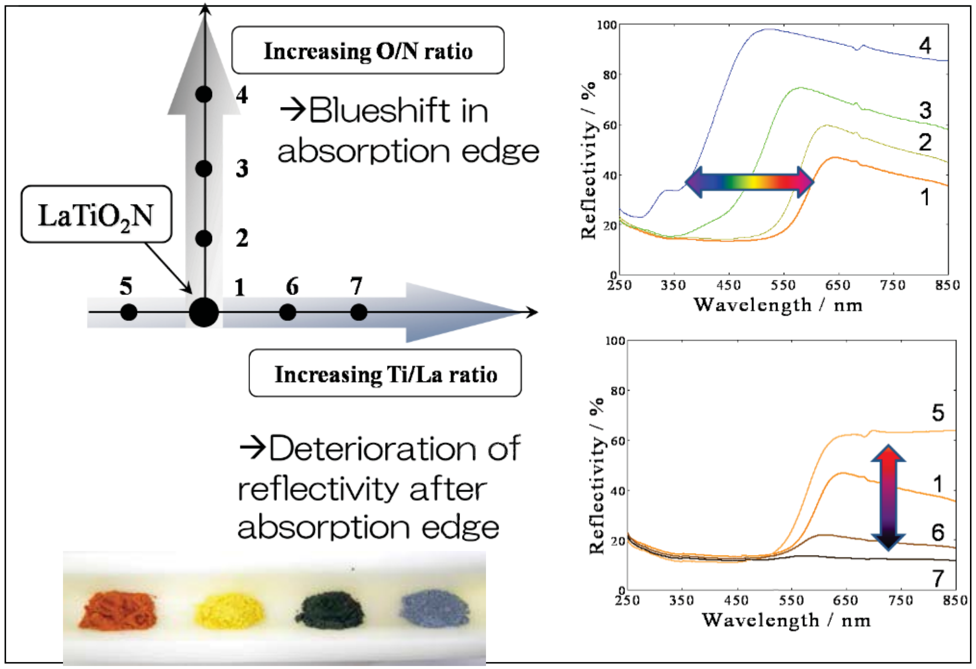
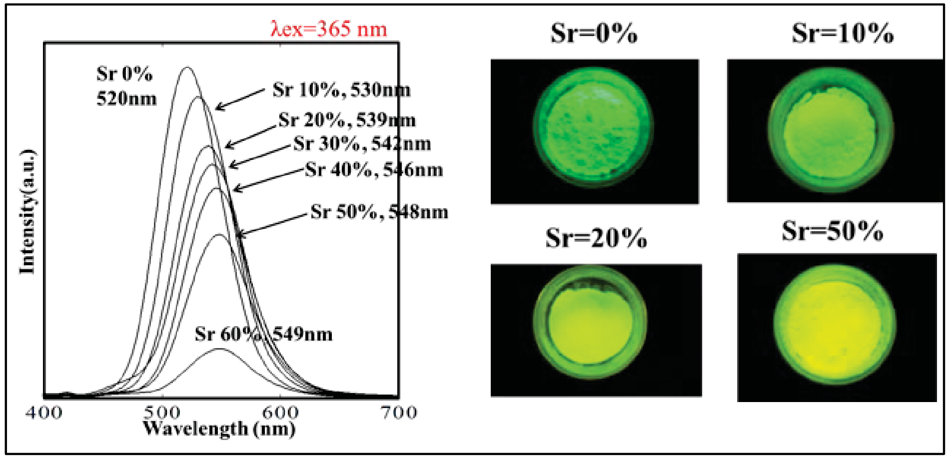
Optimization of Optical Properties of Eco-friendly Oxynitrides through control of Stoichiometries Professor, Toshihiro MORIGA



Figs. 1 Color tuning in $LaTiO_2N$ via control of anion and cation stoichiometries



Figs. 2 Redshift of emission for $Ba_3Si_6O_{12}N_2$:Eu-type phosphors by substitution of Ba by Sr.

We have demonstrated that a color of the perovskite-type $LaTiO_2N$ oxynitride could be tuned from orange through yellow and green to pale gray or white by proper adjustment of the O/N ratio. (Moriga et al., *phys. stat. sol.* (a), 203, 2818 (2006)), whereas increasing Ti/La ratio deteriorates the reflectivity after the absorption edge (Moriga et al., *J. Ceram. Soc. Jpn.*, 115, 637 (2007)). We are now trying to make a redder or bluer oxynitride powders by partial substitution of the constituent cations, and by controlling of the cation and/or anion stoichiometries as well.

Oxynitride phosphors are recently spotlighted as yellow or red phosphors for white LEDs because oxynitrides have no toxicity, blue light are available for excitation source and oxynitrides possess low thermal quenching behavior, compared with oxide phosphors. We have found that $Ba_3Si_6O_{12}N_2$:Eu-type phosphors showed considerable redshift in emission wavelengths from 520nm for the Sr-free oxynitride up to 550nm for 50%-substituted oxynitride by Sr, with increasing Sr content (Sarda, Moriga et al., *J. Nano Res.*, 36, 1 (2016)).

Keywords：oxynitrides, eco-friendly pigment/phosphors,

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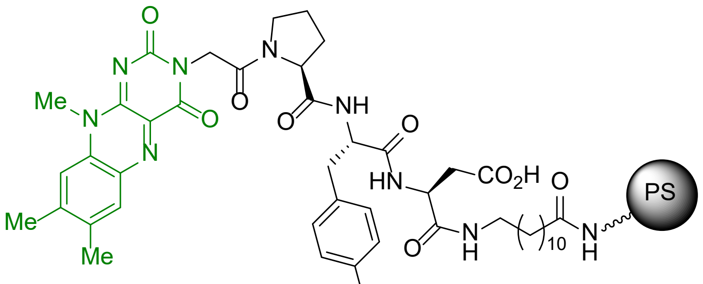
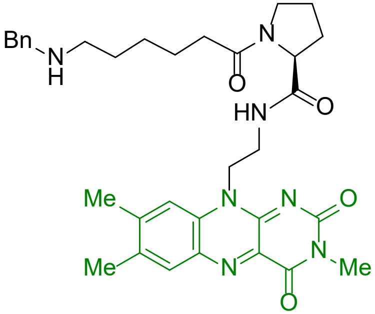
Organic Molecules and Polymers with Catalytic Function

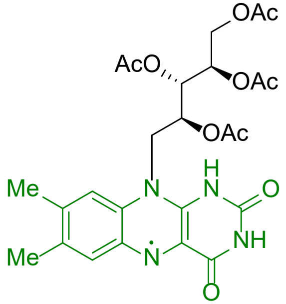
Associate Professor Yukihiro Arakawa



Oxidation catalyst
Chem. Sci. **2017**, *8*, 5468

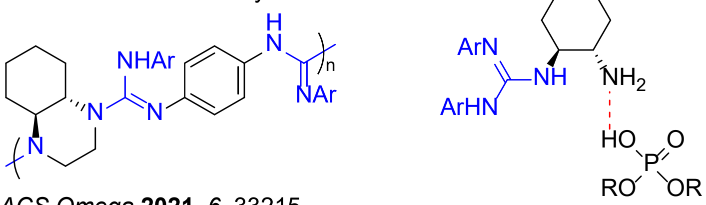


Photoredox catalyst
Org. Lett. **2019**, *21*, 6978



Brønsted acid catalyst
Chem. Commun. **2020**, *56*, 5661

Chiral Brønsted base catalysts



ACS Omega **2021**, *6*, 33215

Content:

A central theme of our research is to design and provide new organic synthetic methods that contribute to the green and sustainable chemistry, which includes the development of organic molecules and polymers with catalytic function (especially for asymmetric synthesis), environmentally friendly and metal-free syntheses, visible-light-driven organic reactions, and molecular transformations utilizing a flow microreactor.

As for the catalyst development, we have recently reported a flavin-based oxidation catalyst (*Chem. Sci.*, **2017**, *8*, 5468), photoredox catalyst (*Org. Lett.*, **2019**, *21*, 6978), and Brønsted acid catalyst (*Chem. Commun.*, **2020**, *56*, 5661). In addition, we are also interested in developing the synthesis of chiral polymers bearing guanidines in the main chain and their application as asymmetric catalysts (*ACS Omega*, **2021**, *6*, 33215).

Keywords : organocatalyst, polymeric catalyst, photoredox catalyst, asymmetric catalyst

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Electron and Molecular Dynamics in Materials under High Pressure

Associate Professor Naoki Noguchi

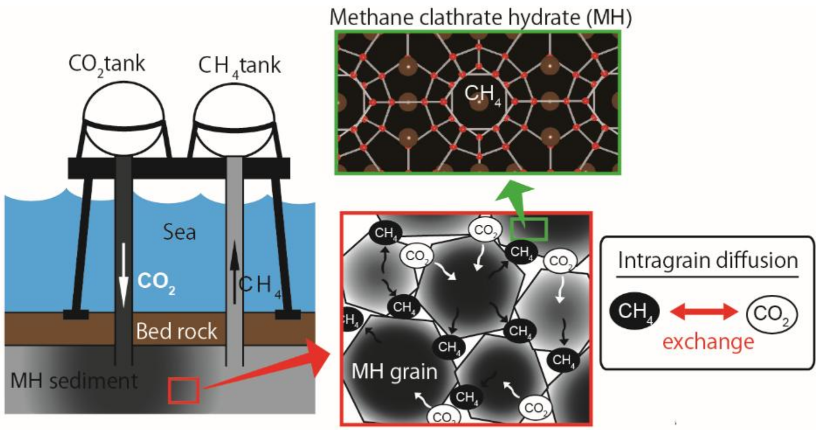
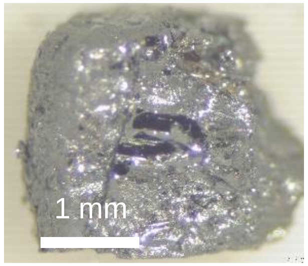


Fig.1. CH_4-CO_2 replacement in CH_4 clathrate hydrate (MH) bearing sediments below seafloor



～2 GPa, 1000℃

Fig. 2. Se doped black phosphorous

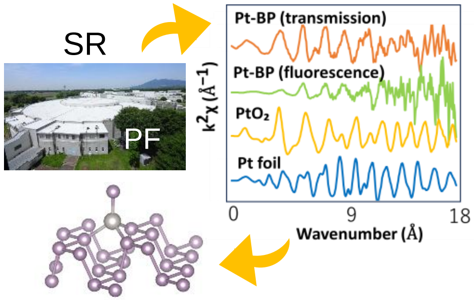


Fig. 3. Investigation of local structure of doped black phosphorous by EXAFS

Content:

Dynamics of electrons and molecules in materials control transport properties such as electrical conductivity, and thermal and mass diffusivities. Investigating these dynamics contributes to a better understanding of the elementary processes underlying transport phenomena. Our research focuses on (1) proton and molecular dynamics in ice and gas clathrate hydrates, and (2) high-pressure synthesis of doped black phosphorus. For the first topic, we investigate the CH_4–CO_2 replacement reaction in CH_4 hydrate (MH) using infrared spectroscopy and a diamond anvil cell. This study will help enable the recovery of CH_4 from MH-bearing sediments beneath the seafloor (Fig. 1). A high-pressure reactor dedicated to MH synthesis has been constructed for this project. For the second topic, we optimize growth conditions for large single crystals of doped black phosphorus (BP) (Fig. 2). Doping techniques for BP are essential for improving its tunability and stability. We also elucidate the local structure and electronic states around dopant atoms in BP using various spectroscopic methods (Fig. 3).

Keywords：proton dynamics, IR spectroscopy, high pressure, diamond anvil cell

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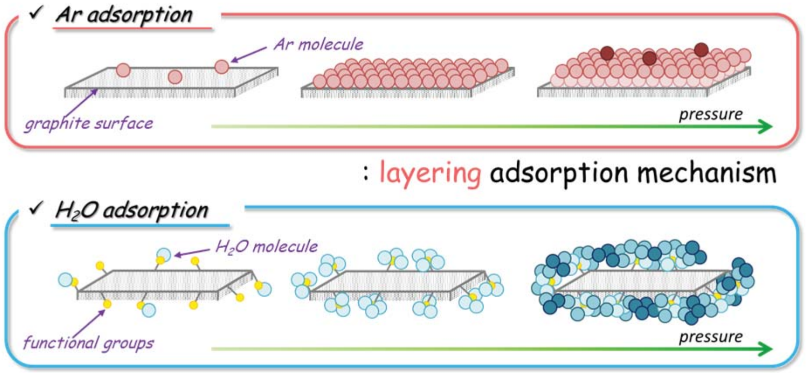
Elucidating the gas adsorption mechanism and developing its applications

Associate Professor Toshihide HORIKAWA

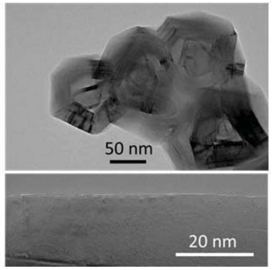
□ *Non-polar vs. polar molecules adsorption on graphite surface*

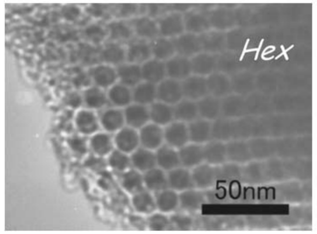


: layering adsorption mechanism

: clustering adsorption mechanism

- Non-porous graphite
- Highly ordered mesoporous carbon





* J. Phys. Chem. C (2011), pp. 2720–2726

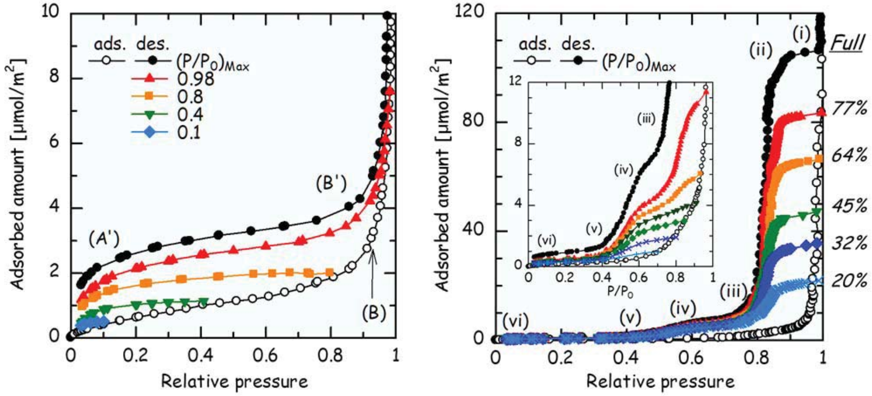


Fig. Water desorption scanning curves on (a) Carbopack F and (b) Hex at 273K [1].

Content:

Adsorption phenomena is applied many separation technologies, e.g. gas separation, environmental purification. When you use those technologies, you need to choose a suitable adsorbent from many types of adsorbents. If you could choose right one from those, you can save energy, time and cost. Therefore, it is very important to choose an optimized adsorbent.

However, sometimes there are no suitable or optimized adsorbents for the process, so we might need to develop an optimized adsorbent. When you develop a new material, you must understand what kind properties you want for the process according to the adsorption phenomena. I can help you to develop the material using my adsorption knowledge.

E-mail *C-2 lab HP* *EDB*

Keywords: gas adsorption
carbon materials
adsorption mechanism

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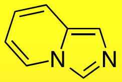
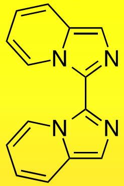
Synthesis and Functionalization of Heterocycles

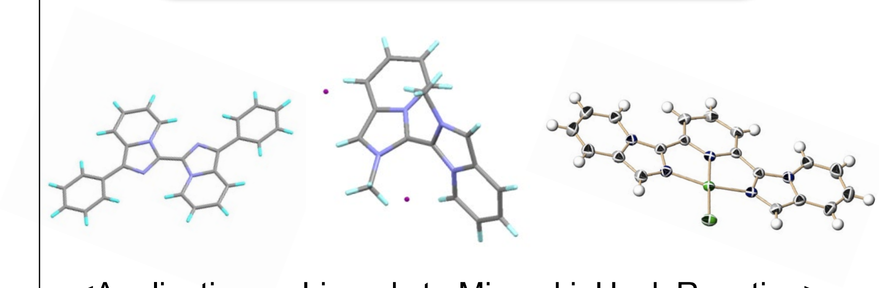
Associate Professor Fumitoshi, Yagishita



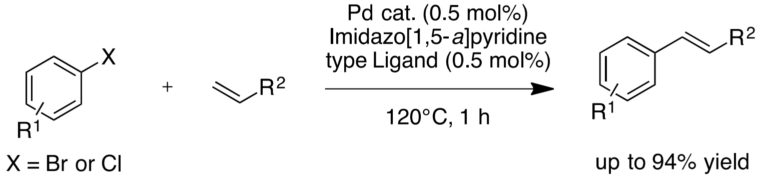
Imidazo[1,5-*a*]pyridine



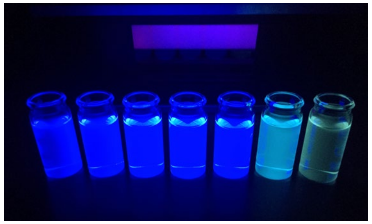
Dimeric structure

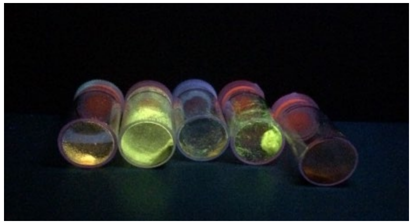


<Application as Ligands to Mizoroki–Heck Reaction>



<Fluorescence in solution and in the solid state>





Content:

Imidazo[1,5-*a*]pyridine derivatives have been drawn considerable attention because of their potential application as pharmaceutical agents and functional materials. Therefore, various molecules featuring imidazo[1,5-*a*]pyridine skelton have been synthesized and characterized.

Recently, we have synthesized the novel dimeric imidazo[1,5-*a*]pyridine. These compounds have been examined to apply as the ligand in catalytic systems and functional materials such as sensing molecules and high efficient light emitting molecules. For example, the palladium-catalyzed Mizoroki–Heck reaction of aryl bromides and chlorides with alkenes using our imidazo[1,5-*a*]pyridine-$PdCl_2$ system afforded the desired products in good-to-high yields with the low palladium loadings and short reaction times. On the other hand, the substituted dimeric imidazo[1,5-*a*]pyridines exhibited relatively strong emissions.

Keywords：Heterocycle, Functionalized molecule

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In situ NMR monitoring of Conversion of Polysaccharides into Value-Added Chemicals

Associate Professor Ken Yoshida

<図表>

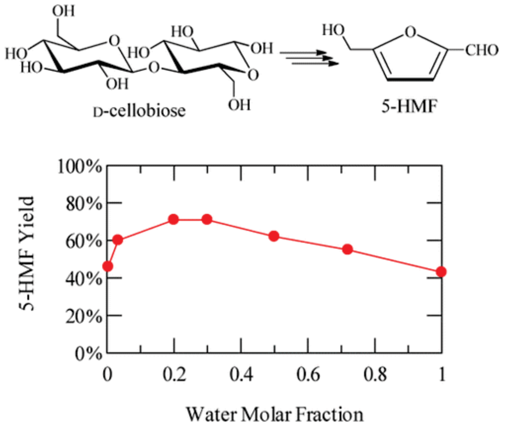

Fig. 1. 5-HMF yield in the cellobiose decomposition in DMSO/water mixture solvent.

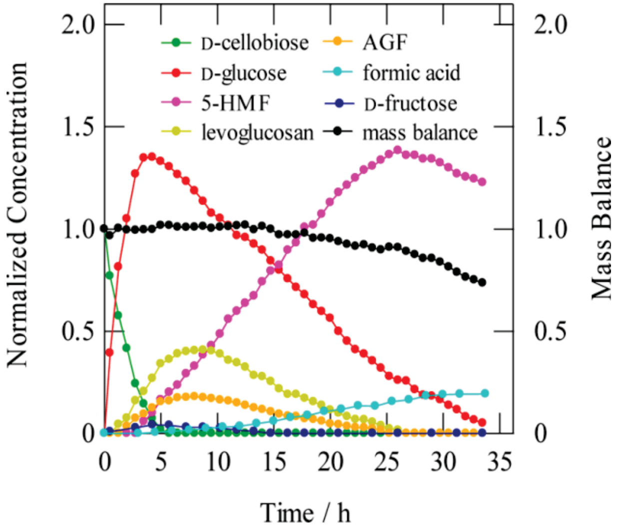

Fig. 2. Time course of the reactant and product of the decomoposition of cellobiose determined by using ^{13}C in situ NMR monitoring.

Content:

Biomass-derived poly-saccharides have attracted attentions as the novel renewable sources. Recently we succeeded in the production of 5-hydroxymethyl-2-furaldehyde (5-HMF) from cellobiose, the model disaccharide for cellulose (H. Kimura et al., J. Phys. Chem. A, 117, 10987 (2013); Fig. 1). 5-HMF is a center of focus today as a biomass-derived valuable that can be converted into biofuels, fine chemicals, and polymers.

In the decomposition reaction steps of saccharides, a variety of isomers, tautomers, and precursors are generated as intermediate products. Solution NMR spectroscopy is a powerful method to monitor all of those species involved in the reactions. By using ^{13}C NMR, each of the individual species can be distinguished from each other. The positions of the glucose units in the oligomers can be specified. The in situ NMR method allows us to determine the time course of the product and reactant species. As shown in Fig. 2, reliable data are obtained with a single setup of the in-situ experiment. The best conditions for the target species can be determined on the basis of the reaction kinetics.

Keywords：saccharides, in situ NMR, 5-HMF

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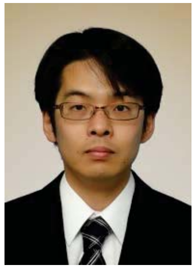

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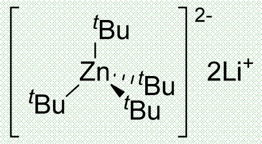
Chemoselective Transesterification and Polymer Synthesis Using Zinc Art Complex

Senior Lecturer Miyuki Oshimura

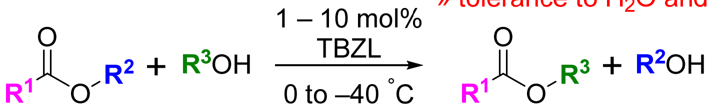
dilithium tetra-*tert*-butylzincate (**TBZL**)



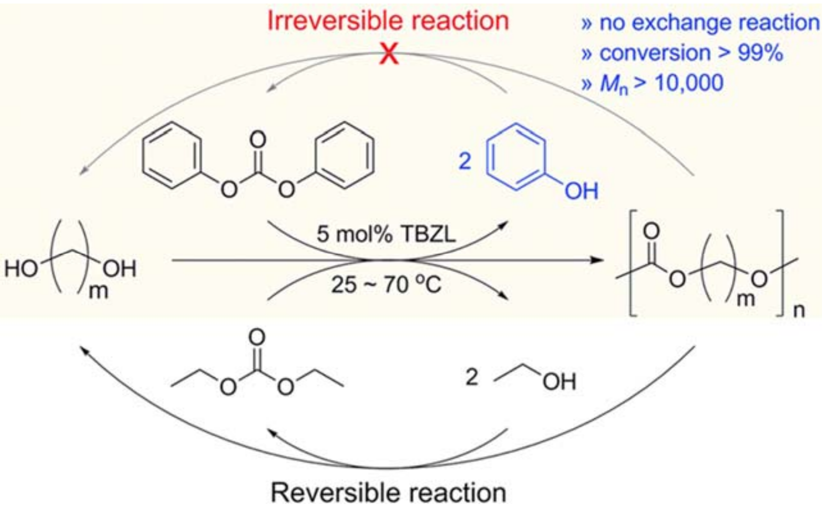
- » easy to prepare
- » low basicity, high nucleophlicity
- » tolerance to H_2O

1. Transesterifications under mild conditions

- » at low temperature
- » tolerance to H_2O and amines



2. Synthesis of Aliphatic polycarbonates



- » no exchange reaction
- » conversion > 99%
- » M_n > 10,000

Content:

I am doing research using zinc art complex, $^t\mathrm{Bu}_4\mathrm{ZnLi}_2$ (TBZL), based on polymer synthesis having biodegradability and biocompatibility.

1. Transesterifications under mild conditions

Transesterification is a useful method for preparing various esters. However, strong acid/base and severe conditions are generally required. The transesterification of alcohols with carboxylic esters were investigated in the presence of a catalytic amount of TBZL as a catalyst. The transesterification occurred at low temperature. In addition, the transesterification proceeded even in the presence of H_2O and amines.

2. Synthesis of Aliphatic polycarbonates

The polycondensation of diphenyl carbonate with diols catalyzed by TBZL were carried out. The irreversible polycondensations proceeded under moderate polymerization temperature and atmospheric pressure. This polymerization system is a useful to obtain aliphatic polycarbonates without requiring a tedious procedure.

Keywords : high-functional materials, biodegradable polymer

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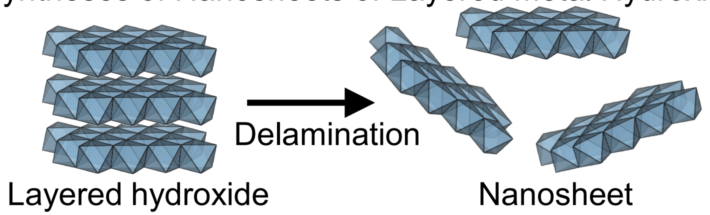
Syntheses and Applications of Layered Metal Hydroxides

Associate Professor Masashi Kurashina

I. Syntheses of Nanosheets of Layered Metal Hydroxides



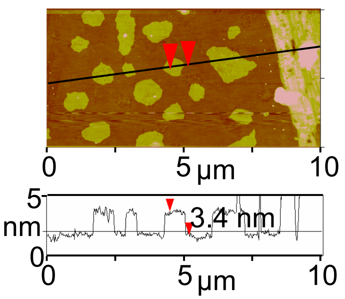


Fig. 1 AFM image of cobalt hydroxide nanosheets

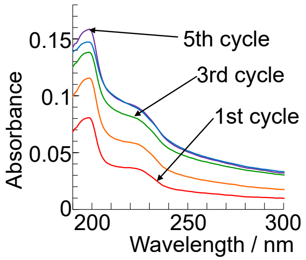
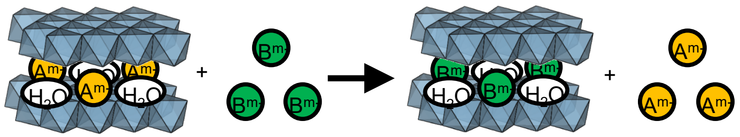


Fig. 2 UV absorption spectra of restacking of nickel hydroxide nanosheets

II. Control of Interlayer ions in Layered Metal Hydroxides



- Adsorption of polyoxomolybdate and borate
- Control of elution of phosphate

Fig. 3 Growing tests of Japanese mustard spinach using a Mg/Fe-type layered double hydroxide

Content:

The layered metal hydroxide is a layered compound consisted of repeating stacking of nano-meter-sized metal hydroxides. This compound is mainly synthesized by addition of base into the metal solution.

Inorganic nanosheets have been prepared by delamination of layered materials. Nanosheet has an ultimate two-dimensional anisotropy and manifests unique physical properties arising from size effects. We have synthesized nickel and cobalt hydroxides nanosheets (Fig. 1) and assembled these nanosheets by stacking on the glass slide to make new lamella structure(Fig. 2).

Layered double hydroxide is a layered compound that contains divalent and trivalent metal ions. It consist of hydroxide layer and interlayer anion, and the interlayer anion is captured and able to exchange. We use this property for adsorption and controlled-release of anions. Adsorption of polyoxomolybdate and borate control of elution of phosphate have been investigated and try to apply it to fertilizer(Fig. 3).

Keywords：layered compound, metal hydroxide,
nanosheet, ion exchange

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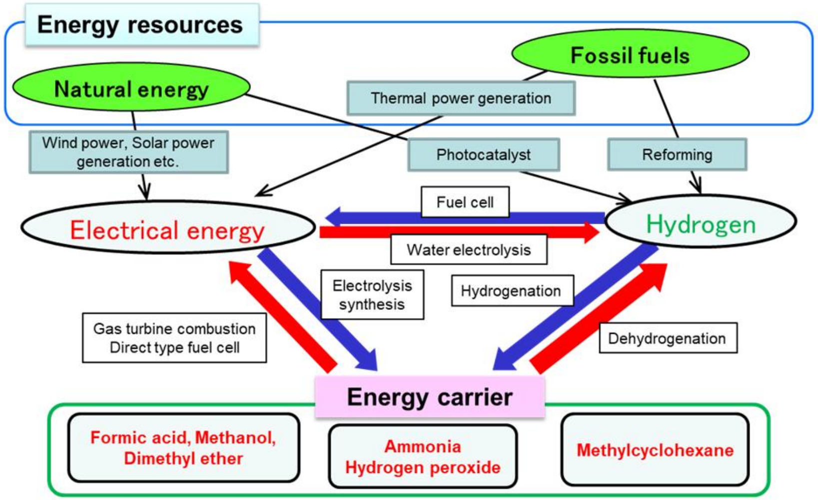
Development of Heterogenous Catalysts for Synthesis and Utilization of Hydrogen Energy Carrier

Associate Professor Naohiro, Shimoda

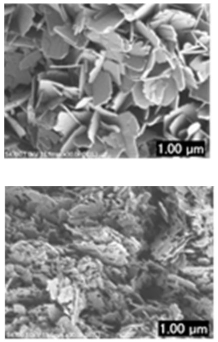


- Supply Instability in power generation from natural energy
- “Green hydrogen” synthesis from water using surplus electricity
- Portability and storability issues in hydrogen utilization

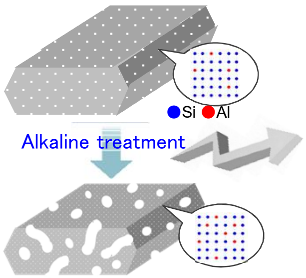
⇒ Utilization of hydrogen energy carrier substances

Research

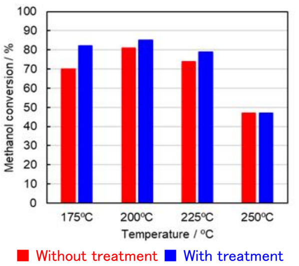
Dimethyl ether synthesis from methanol over zeolite catalyst



FER type zeolite



Catalytic reaction test of Methanol dehydration



☑ Formation of meso-pores
☑ Reduction of Si/Al ratio

- ➢Improvement of MeOH conversion
- ➢Suppression of carbon deposition

Content:

Toward the realization of a hydrogen energy society

In order to efficiently use the limited fossil fuel resources as energy, it is important to build a hydrogen energy society centered on the fuel cell power generation system. In addition, electric energy produced from natural energy such as wind power and solar power is inefficient in transportation and storage. Therefore, the problem is that the supply and demand peaks of electricity do not match. Under such circumstances, hydrogen energy has been attracting attention as an energy storage medium in recent years. However, hydrogen alone is a substance that is difficult to handle due to its poor storability and transportability. Therefore, it is desired to convert and handle hydrogen as another chemical substance that can easily extract and store hydrogen, so-called hydrogen energy carrier.

Development of solid-sate catalyst

In our laboratory, we are focusing on ammonia, methane, methanol, and dimethyl ether, which are candidate materials for hydrogen carrier substances. We are also developing solid catalyst materials such as supported metal catalysts and zeolite catalysts to efficiently proceed various heterogeneous reactions of synthesizing hydrogen carrier substances and of extracting hydrogen from them.

Keywords: Hydrogen, Solid-state catalyst,
C1 chemistry

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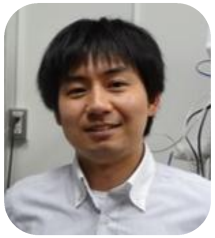

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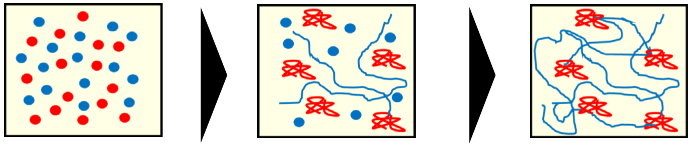
Development of Though Hydrogels by Focusing on Monomer Structure and Polymerization Mechanism

Assist. Prof. Ryo Kawatani

PR: Polymerization Rate

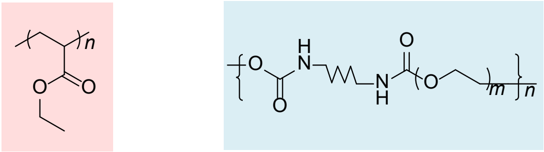
①

	Hydrophobicity	Hydrophilicity
PR	Fast	Slow
Intermol. Interaction	Hydrophobic interaction	Hydrogen bonding



Before	Early Stage	Later Stage
Homogenous	Entanglement network with hydrophilic monomers	Entanglement network with hydrophilic networks

②



	Hydrophobicity	Hydrophilicity
Type	Radical	Polyaddition
PR	Fast	Slow
Intermol. Interaction	Hydrophobic Interaction	Hydrogen bonding

Content:

Development of Tough Hydrogels

By introducing intermolecular interactions into the gel, molecular interactions can preferentially fragmentation when mechanical loads are applied, allowing for the consumption of mechanical energy. Intermolecular interactions in the gel is key point.

Two methods have been employed to develop tough hydrogels, with the aim of efficiently introducing intermolecular interactions into the gel:

①Exploiting Differences in Polymerization Reactivity (Radical Polymerization)

Radical polymerization is carried out using two monomers with significantly different polarities and polymerization rates simultaneously. This leads to the preparation of a hydrogel where molecular entanglement is promoted, resulting in a tough hydrogel.

②Combination of Two Polymerization Mechanisms

Combining a monomer that undergoes radical polymerization and a monomer that undergoes addition polymerization, both polymerization mechanisms are employed simultaneously to prepare the hydrogel. This approach results in a tough hydrogel.

Keywords：Hydrogel, Radical Polymerization, Polyaddition

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Photofunctional Materials Based on Organic Molecules

Assistant Professor Shunta Nakamura

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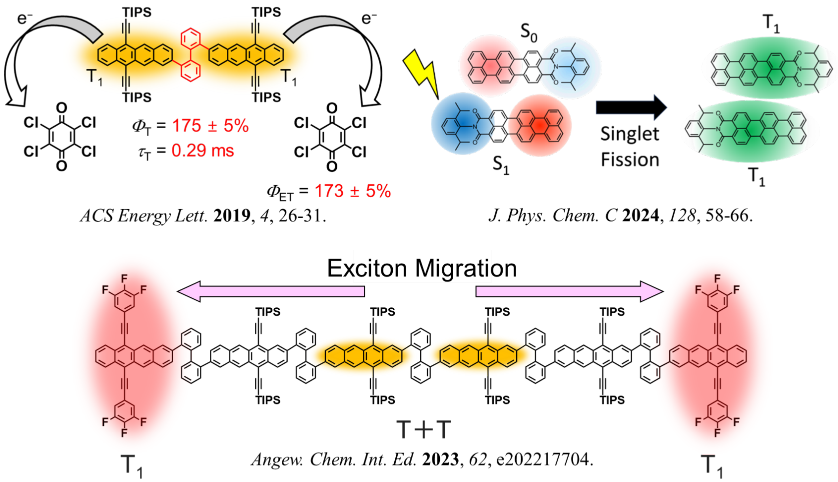
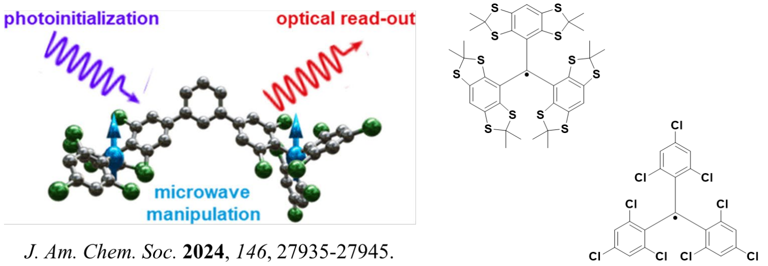


ACS Energy Lett. **2019**, *4*, 26-31.

J. Phys. Chem. C **2024**, *128*, 58-66.

Angew. Chem. Int. Ed. **2023**, *62*, e202217704.

Fig. 1 Examples of SF materials.



J. Am. Chem. Soc. **2024**, *146*, 27935-27945.

Fig. 2 Examples of stable organic radicals for quantum materials.

Content:

1, Materials for Improving Conversion Efficiency of Organic Photovoltaics

Singlet fission (SF), a photophysical process that can produce two triplet excitons from one photon absorption, has been actively studied in recent years because it can improve the conversion efficiency of organic photovoltaics. However, there is still no example of quantitative utilization of excitons via SF to develop organic photovoltaics with high conversion efficiency. In order to overcome the above situation, in this study, we will create materials in which charge-separated states can be generated quantitatively via SF and excitons can be freely controlled within molecular assemblies (Fig. 1).

2, Quantum Materials Based on Organic Molecules

Quantum material is a general term for materials that utilize quantum states such as quantum entangled states. By precisely controlling the excited and spin states of organic molecular materials, applications such as quantum computing and quantum sensing can be realized. In this study, we will work on the creation of materials in which quantum states (especially spin states in excited states) can be precisely controlled by combining stable organic radical materials and SF materials (Fig. 2).

Keywords：Photochemistry, Singlet Fission,
Quantum Materials

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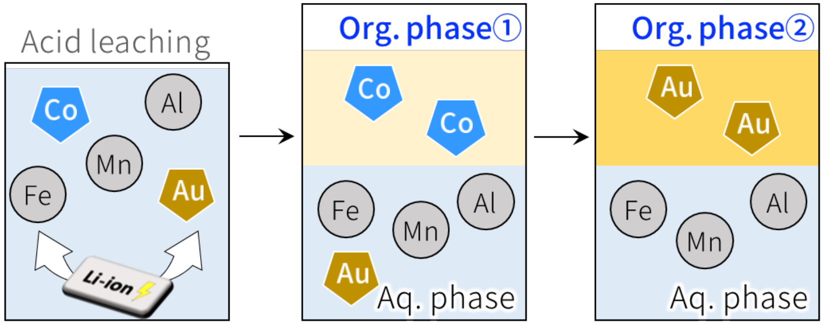
Deep Eutectic Solvents for Critical Metal Refining and Recycling

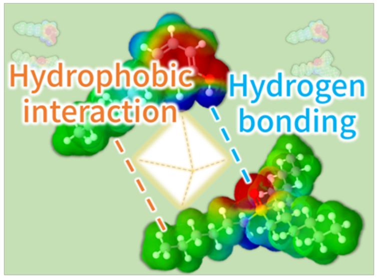
Assistant Professor Takafumi Hanada

A) Conventional method: Solvent extraction process



✓ Rapid & High purity ✘ Harmful chemicals

B) Green alternative：deep eutectic solvents (DESs)



✓ Less volatile & easy preparation

▶ Environmentally benign separation system

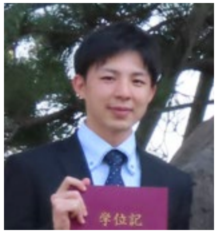
Content:

The solvent extraction method, which is one of the rare metal separation techniques, is a practical process that allows for rapid and high-purity separation and recovery of target metals. However, concerns about environmental pollution arise from the use of inorganic acids and organic solvents in the leaching and extraction stages.

In recent years, deep eutectic solvents (DESs) have gained attention as alternative solvents to inorganic acids and organic solvents. DES is a mixture that becomes a liquid simply by combining hydrogen bond donor and acceptor compounds. It was first reported in 2003 as a new solvent of the 21st century (Abbott *et al.*, *Chem. Commun.*). DES is known as an environmentally friendly solvent due to its low volatility and low toxicity. However, most existing DESs are hydrophilic, making it difficult to apply them to separation techniques such as solvent extraction.

Therefore, this study focuses on hydrophobic DES, which are immiscible with water, with the aim of applying them to the solvent extraction process for rare metals. Furthermore, by utilizing the unique intermolecular interactions between the hydrogen bond donor and acceptor compounds that constitute DES, the study aims to develop advanced rare metal separation systems.

Keywords：Deep eutectic solvents,
critical metals, extraction, separation



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