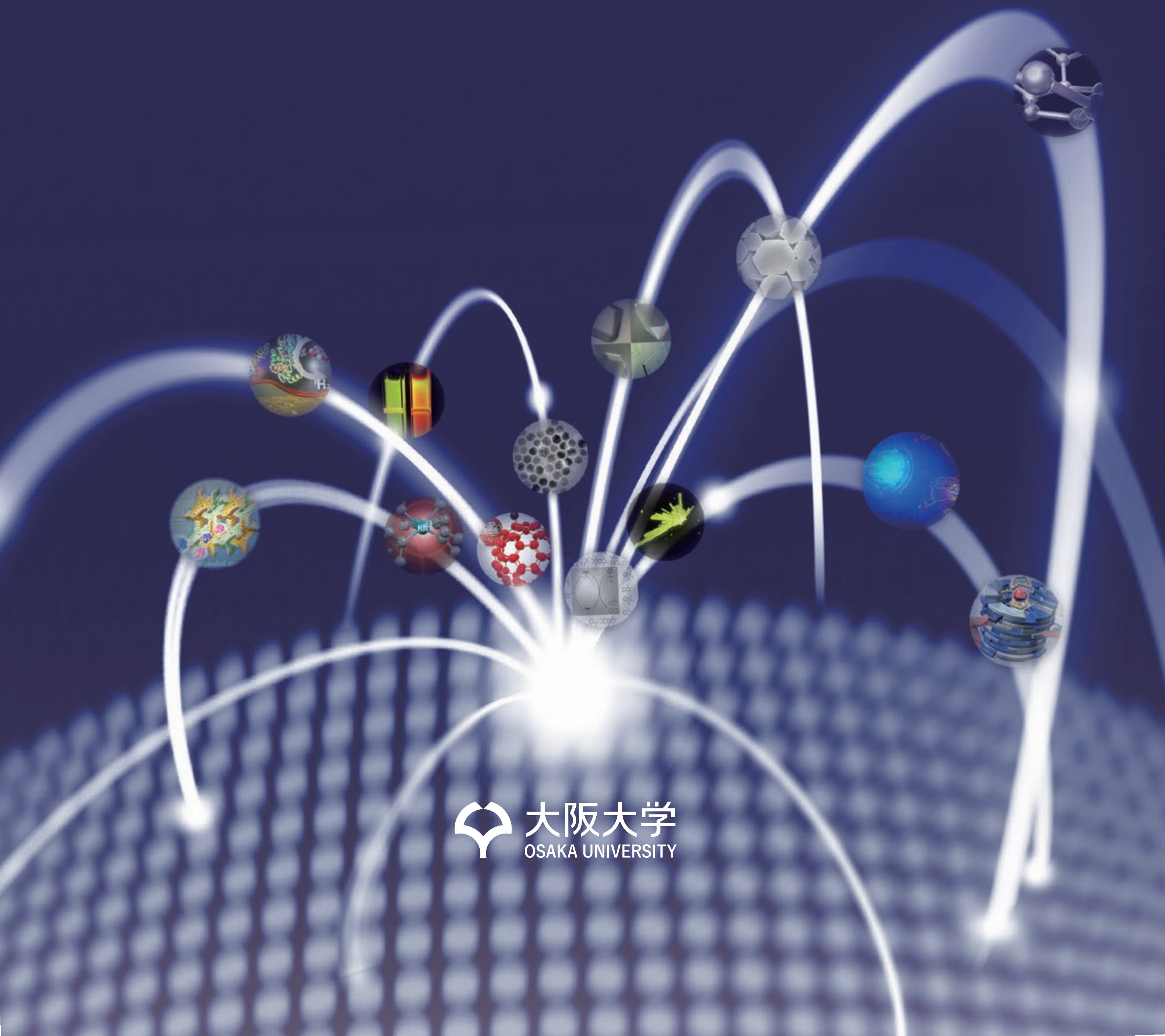
Graduate School of Engineering
Osaka University

Chemical Science Course

2019



大阪大学
OSAKA UNIVERSITY

Chemistry--- the Center of Science

Department Chairman
Makoto YASUDA

Because all the sciences including physics and biology are nowadays improved from the viewpoint of an atomic and molecular size, CHEMISTRY takes the center stage of science and develops various areas of medicine, pharmacy, biotechnology, material science, informatics, and environmental and energy sciences.

Division of Applied Chemistry consists of two research groups, MOLECULAR CHEMISTRY COURSE which focuses on controlling a variety of chemical reactions by a molecular level, and MATERIALS CHEMISTRY COURSE which pursues novel functionalities of materials from an atomic and molecular level.

Four chemistry laboratories in Division of Advanced Science and Biotechnology (Department of Material and Life Science) are also involved in this program, performing chemistry in life science.

These courses are devoted to educating students to develop their ability with sharp creativity and high originality. Our students will gain broad knowledge in chemistry and related fields, and study on novel methods of creating molecules and materials through lectures and their works under a high level and international research environment.

These courses cooperate mutually in promoting at the world-class level to serve as scientific and industrial bases. In addition, we are collaborating closely with other departments, graduate schools, and research institutes in Osaka University to aim at forming a center of nanomaterials and atom/molecular technologies.

Graduate School of Engineering, Osaka University

Chemical Science Course

Molecular Chemistry

- Molecular Reaction Chemistry
- Molecular Design Chemistry
- Molecular Interaction Chemistry
- Industrial Organic Chemistry
- Resources Chemistry
- Catalytic Synthetic Chemistry
- Organometallic Chemistry
- Functional Organic Chemistry
- Molecular Excitation Chemistry 〈Cooperative Area〉
- Soft Nanomaterials 〈Cooperative Area〉
- Environmental Chemistry 〈Cooperative Area〉

Materials Chemistry

- Applied Electrochemistry
- Structural Physical Chemistry
- Physical Organic Chemistry
- Structural Organic Chemistry
- Synthetic Organic Chemistry
- Inorganic Materials Chemistry
- Polymer Materials Chemistry
- Condensed Matter Physical Chemistry
- Advanced Materials Chemistry
- Functionalized Natural Materials 〈Cooperative Area〉
- Beam Materials Science 〈Cooperative Area〉

Material and Life Science

- Chemical Biology
- Chemistry on Supramolecular Recognition
- Biofunctional Chemistry
- Organic Electronic Materials Science

Graduate School of Engineering, Osaka University

- Applied Chemistry
- Advanced Science and Biotechnology
- Precision Science & Technology and Applied Physics
- Adaptive Machine Systems
- Mechanical Engineering
- Materials and Manufacturing Science
- Electrical, Electronic and Information Engineering
- Sustainable Energy and Environmental Engineering
- Global Architecture
- Management of Industry and Technology

Chemical Science Course (Master/Doctor Program)

The Chemical Science Course offers postgraduate students Master and PhD degrees in the wide scope of CHEMISTRY, the center of science. CHEMISTRY provides a broad and indispensable basis of our materials society and offers keys for the future.

The Chemical Science Course is designed principally as a seamless postgraduate program for both Master and PhD degrees in English. In the first years of study, students will establish and acquire the fundamental basis of applied chemistry though the 18 intensive courses given by more than 40 professors in the field of Physical Chemistry, Synthetic Chemistry, and Biological Chemistry. (Students choose 10 courses for their Master Degree.)

From the second year, the program is also designed towards developing within each student the ability to do creative scientific research. Accordingly, the single most important facet of the curriculum for an individual is his or her own research project. During the first semester, students choose a Research Director, with the consent of the faculty member and the advisory board of the course, and will select their thesis advisor after completion of a few weeks rotation. Thereafter, all students become involved in library research for their projects and many begin actual experimental or theoretical work.

In keeping with the goal of fostering an atmosphere of scholarly independent study, formal course requirements are minimal and vary among disciplines; advisor's tailor course requirements to best prepare the student for the chosen research field. For example, a student who chooses to specialize in physical chemistry is normally expected to take two to four courses during the first research period. For instance, the courses may include topics such Statistical Mechanics, Polymer Physics, Interactions of Radiation with Matter, Electrochemistry, and many others. Organic Chemistry involves the field of Synthetic Chemistry, Physical Organic Chemistry, Homogeneous Catalyst (transition-metal catalyst as well as organic catalyst), Heterogeneous Catalyst, and so on. Students are expected to learn the basic principles of synthetic transformation, organic reaction mechanism, and physical organic chemistry including molecular orbital theory through the courses.

The present Chemical Science program is also offering the Internship-on-Campus concept where major Japanese companies have established their on-Campus Branches, and promote collaborative research works with students and professors in the present program, the Work Together concept. This is a unique opportunity to join an internship program alongside private companies while completing PhD study.

We invite you to join the Chemical Science program, study and enjoy Chemistry, leading to a fruitful future for your carrier.

FIND OUT MORE http://www.chem.eng.osaka-u.ac.jp/appl/course/index.html

Your Career after your degree program

The following organizations are participants in the program: Osaka University, Ajinomoto Co., Inc., Kao Corporation., KANEKA CORPORATION, Kuraray Co., Ltd., Sanyo Chemical Industries, Ltd., Shionogi & Co., Ltd., Nippon Steel & Sumitomo Metal Corporation, Sumitomo Chemical Co., Ltd., SEKISUI CHEMICAL CO., LTD., Daikin Industries, Ltd., Daicel Corporation., Takeda Pharmaceutical Company Limited, TOKYO GAS Co., Ltd., Tosoh Corporation, Toray Industries, Inc., Toyota Motor Corporation, NISSAN MOTOR CO.,LTD., Nitto Denko Corporation, NICHIA CORPORATION, NGK Insulators, Ltd., NIPPON SHOKUBAI CO., LTD., Panasonic Corporation, Bridgestone Corporation, Mazda Motor Corporation, Mitsui Chemicals, Inc., Mitsubishi Chemical Corporation, AGC Inc., DIC Corporation, GS Yuasa Corporation etc.

Molecular Chemistry

Molecular Reaction Chemistry

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Professor
Masahiro MIURA

Associate Professor
Koji HIRANO

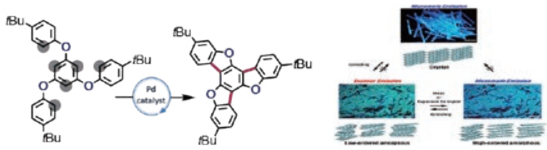
Assistant Professor
Yuji NISHII

We are performing basic and applied studies on the transformation of various organic molecules derived from petroleum and coal. The major objectives of our research group are to develop (1) new, efficient strategies for the synthesis of organic fine chemicals including pharmaceutical intermediates and π-conjugated functional materials and (2) high-performance catalysts that enable effective functionalization of organic molecules.

Transition-metal-catalyzed cross-coupling is now recognized to be one of the most useful carbon-carbon bond formation reactions for synthesizing a wide range of organic fine chemicals including natural products, pharmaceutical intermediates, and organic functional materials. Meanwhile, the organic transformations via cleavage of carbon-hydrogen and carbon-carbon bonds have recently attracted much attention from atom-economic and chemoselective points of view.

We have succeeded in developing catalytic multi-arylation and alkylation of (hetero)aromatic compounds via carbon-hydrogen bond cleavage by using palladium, rhodium, and iridium catalysts. These reactions are quite unique in their mechanistic aspects, in which formation of multiple bonds occurs in one-pot procedures. Furthermore, a number of new catalytic transformation reactions via carbon-carbon bond cleavage have also been developed. The synthetic protocols are applicable to alkyne coupling reactions that enable constructing a series of fluorescent compounds.

Recently, we have developed a palladium-catalyzed multiple annulation reaction via carbon-hydrogen bond cleavage: 6 carbon-hydrogen bonds are cleaved and 3 carbon-carbon bonds form in one shot. The obtained highly fused aromatic compounds show unique photochemical and physical properties such as mechanochromism.



Examples of Multiple Annulation and Mechanochromism

Molecular Chemistry

Molecular Design Chemistry

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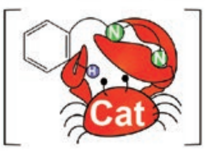
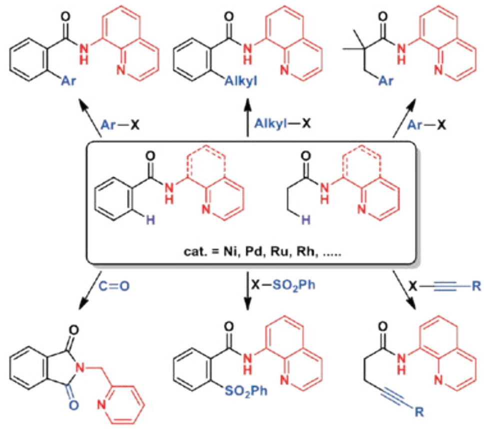
Professor
Naoto CHATANI

Associate Professor
Yoshiya FUKUMOTO

Assistant Professor
Yusuke ANO

Our research interests are primarily focused on the discovery and further development of new synthetic methodologies, with particular emphasis on the design and development of novel catalytic systems by taking advantage of the unique features of transition metal complexes. A representative research topic of our group is the development of transition metal-catalyzed direct C-H bond functionalization under chelation assistance. A functional group in an organic molecule can play an important role as an "anchor" to activate a specific C-H bond by coordination to the metal center of the metal complex. We are currently investigating the development of new types of directing groups such as 2-pyridylmethylamine and 8-aminoquinoline moieties, which coordinate to the catalyst through two nitrogen atoms. These bidentate directing groups permit many catalytic $C(sp^2)$-H and $C(sp^3)$-H transformations to proceed that cannot be achieved using conventional types of directing groups. The development of catalytic reactions involving the activation of various unreactive chemical bonds, such as C-C, C-O, C-S, C-F, C-P bonds are also research topics of interest in this laboratory.





Functionalization of C-H Bonds Using an *N*,*N*-Bidentate Group

Molecular Chemistry

Molecular Interaction Chemistry

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Professor
Toshiyuki KIDA

Associate Professor
Tadashi MORI

Assistant Professor
Hajime SHIGEMITSU

Molecular recognition processes utilizing a variety of molecular interactions play an important role in the formation and function of biological systems. On the basis of a new molecular design concept which is derived from understanding of those molecular recognition processes at a molecular level, we create useful molecules and molecular assemblies. In addition, we evaluate their properties, and apply their functions to various industrial fields. In particular, we focus on the following topics.

(1) Design and synthesis of functional materials with molecular recognition abilities

We developed a novel technique for efficient separation and concentration of harmful substances such as PCBs from oils by utilizing molecular recognition ability of cyclic oligosaccharides.

(2) Design and synthesis of functional materials with self-assembling properties

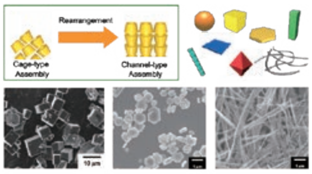
We succeeded in the creation of cyclodextrin supramolecular nano- and microstructures with a variety of morphologies by utilizing self-assembling properties of cyclodextrins.

(3) Controlling weak interactions in chiral photochemistry

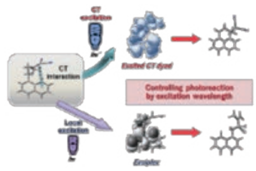
Focusing on weak non-covalent interactions in both ground and electronically excited states, we are pursuing mechanistic and synthetic studies on chiral molecular and supramolecular photochemistry.

(4) Development of light harvesting supramolecular complexes for energy and biological applications

The research purpose is to develop supramolecular complexes or systems to solve the energy problem and apply to optobiological technologies.



Cyclodextrin Supramolecular Structures



CT-controlled Photochemistry

Molecular Chemistry

Industrial Organic Chemistry

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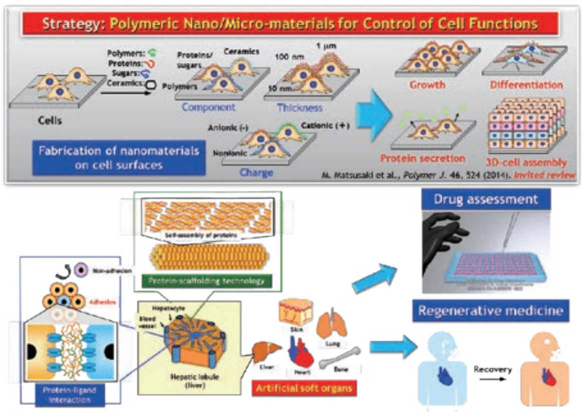
Associate Professor
Michiya MATSUSAKI

In our laboratory, we design and create high performance compounds on the basis of synthetic organic chemistry in consideration of developments at an industrial level. We promote the development of high performance biomaterials, which are safe for internal and surrounding living environments, by the chemical modification of oligomers, polymers, their assemblies, and synthetic macromolecules.

In particular, we focus on "design and synthesis of functional nanobiomaterials with self-assembling properties for fabrication of three-dimensional (3D) human tissue models". We successfully constructed 3D-artificial tissues composed of xenogeneic cells as well as allogeneic cells by combining cells and nanometer-sized polymer/protein films by cell surface modification technique. Since the nanofilms act as a nano-scaffold for cell-cell interaction, 3D-tissues could be constructed *in vitro* including blood and lymph capillary networks. The constructed 3D-human tissues are useful as an implantable tissue in regenerative medicine and a human tissue model for drug assessment in pharmaceutical fields.



Design of functional nanobiomaterials for fabrication of 3D-artificial human tissues.

Molecular Chemistry

Resources Chemistry

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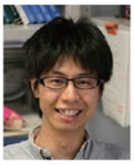
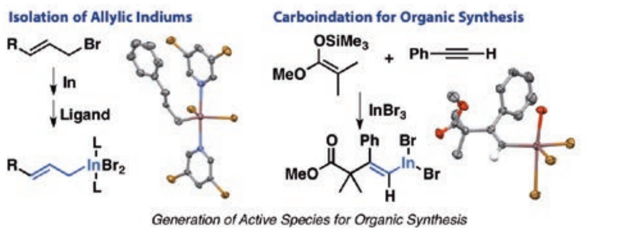


Professor
Makoto YASUDA

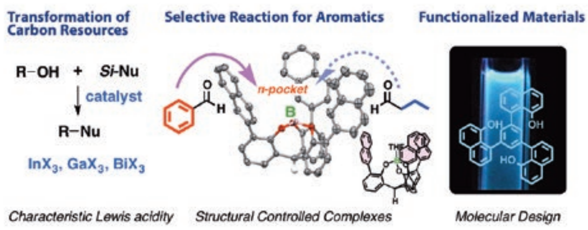
Assistant Professor
Yoshihiro NISHIMOTO

Assistant Professor
Akihito KONISHI

Our research is currently focused on designing a methodology for organic synthesis using novel organometallics and catalyst systems. Novel reactive organometallic species have been isolated and characterized based on spectroscopic methodology and X-ray crystallographic analysis. These species have been applied to the synthesis of functionalized organic compounds. Our group also focuses on utilizing characteristic Lewis acids in the conversion of carbon resources to valuable organic compounds. Metal complexes that have cage-shaped organic ligands are synthesized and used for new types of selective reactions for practical organic syntheses. We also target functionalized materials that are based on organic compounds with novel physical properties and special intramolecular interactions. All projects are supported by organic synthetic approaches that extend to various fields of chemistry.



Synthesis of Novel Organometallics



Creation of Novel Catalysts and Materials

Molecular Chemistry

Catalytic Synthetic Chemistry

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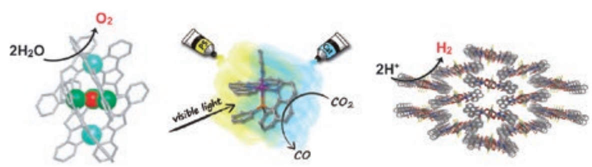
Professor
Shigeyuki MASAOKA

Artificial photosynthesis is a solar energy conversion technology that mimics natural photosynthesis, and considered to be one of the next big breakthroughs in the research field. Our group studies the development of functional metal complexes toward the realization of artificial photosynthesis. Specific areas of research include (i) creation of cluster catalysts for multi-electron transfer reactions, (ii) frontier-orbital engineering of metal complexes for multi-electron transfer reactions, (iii) application of proton-coupled electron transfer toward multi-electron transfer reactions, (iv) electrochemical analysis of catalytic reactions, (v) development of novel photo-induced electron transfer systems, (vi) establishment of electrochemical method for the photoreactions of metal complexes in homogeneous solutions, and (vii) development of framework catalysts for small molecule conversion via the self-assembly of catalyst modules.

We have succeeded in constructing a highly active catalyst for the water oxidation reaction, which is considered a bottleneck in artificial photosynthesis. Inspired by the catalyst in the natural photosynthetic system, we have employed a pentanuclear iron complex as a catalyst because the complex includes key elements to achieve efficient catalysis: (a) multinuclear structures to facilitate multi-electron transfer and (b) adjacent catalytic active sites separated to promote intramolecular O-O bond formation. The reaction rate of the complex is more than 1,000 times greater than the values of other iron-based catalysts and considerably greater than that of the natural system.



Molecular Catalysts for Artificial Photosynthetic Reactions

■ Molecular Chemistry

Organometallic Chemistry

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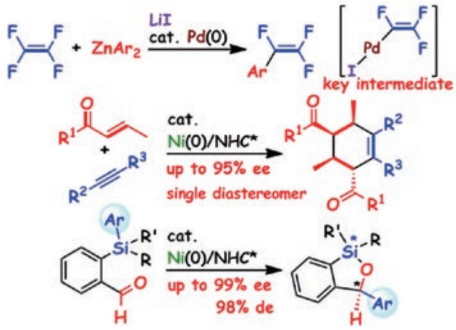
Professor
Sensuke OGOSHI

Associate Professor
Yoichi HOSHIMOTO

One of the major interests of our research is focused on the development of a transition metal-catalyzed selective transformation of tetrafluoroethylene (TFE) via C–F bond activation. Although TFE is an example of the economical bulk organofluorine feedstock, the use of TFE is mostly limited to the production of poly(tetrafluoroethylene) and co-polymers with other alkenes. We have demonstrated the first palladium-catalyzed arylation of TFE by using diarylzinc reagents to yield α,β,βtrifluorostyrene derivatives in excellent yield and with high selectivity. In this reaction, C–F bond cleavage of TFE was achieved by the synergetic effects of the Pd(0) catalyst and lithium iodide to generate the trifluorovinyl palladium(II) intermediate.

We have also been focusing on nickel-catalyzed transformation reactions via a hetero-nickelacycle intermediate as well as on their reaction mechanisms. We have reported the oxidative cyclization reactions of carbon-carbon unsaturated compounds and aldehyde, ketone or imine with nickel(0). These reactions have been proposed as an important key step in multicomponent-coupling reactions as well as [2+2+2] cycloaddition reactions. We recently demonstrated for the first time the nickel(0)-catalyzed enantio- and diastereoselective synthesis of benzoxasiloles with the simultaneous generation of carbon- and silicon-stereogenic centers. This reaction would proceed via an (η-aldehyde)Ni(NHC*) key intermediate (NHC*: chiral *N*-heterocyclic carbene ligand).



■ Molecular Chemistry

Functional Organic Chemistry

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Professor
Mamoru TOBISU

Lecturer
Toru AMAYA

Assistant Professor
Takuya KODAMA

Our research interests span various aspects of organic chemistry, ranging from new reactions, new molecules, and new functions. Regarding the reaction development, our goal is to invent the synthetic methods that involve unprecedented mechanism or unusual bond transformation. We are also exploring design and synthesis of new molecules with unique structure and properties.

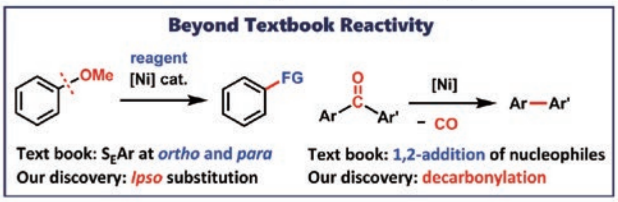
We believe that the diversity of our research projects facilitates generating breakthrough ideas.

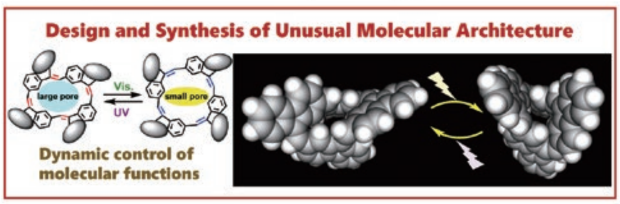
Representative research subjects include:

(1) Catalytic Reactions Involving Activation of Strong Chemical Bonds

(2) Unusual Reactions Using Organometallic Complexes Having a Metal-Heteroatom Bond

(3) Design and Synthesis of Unique π-Conjugated Molecules





Materials Chemistry

Applied Electrochemistry

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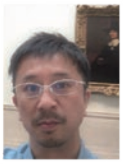
Professor
Susumu KUWABATA



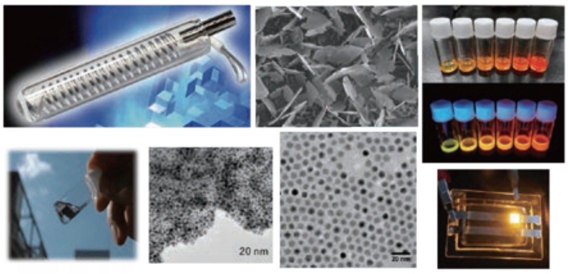
Associate Professor
Tetsuya TSUDA

Assistant Professor
Taro UEMATSU

Electrochemistry relates to a variety of fields ranging from batteries and energy conversion to trace analyses and nanomaterials. Conversion between electric and chemical energies is one of the appeals of electrochemistry, and we are investigating to elucidate phenomena occurring at the solid / liquid interface.

Liquid materials composed only of ions known as "ionic liquids" are one of our greatest interests being different from either water or organic solvents. We succeeded in nanoscale observation of electrode reactions in a high vacuum electron microscopy using non-volatility of the liquid. In addition, these findings promote the development of next-generation energy storages. For example, lithium ion batteries with improved energy density and novel battery systems using other multivalent, abundant natural resources are being developed.

Another topic of interest is fluorescent semiconductor nanoparticles (quantum dots). Although semiconductors are just dark-colored solids in the bulk state, they become efficient fluorophores when they are made into nanoparticles as small as ten nanometers. We have developed new materials with strong emission intensity using less toxic elements. The improvement of cadmium-free quantum dots are most intriguing topic. Besides, we are attempting to understand deeply about their structures and properties using the photoelectrochemical techniques. Modifications of quantum dots are as important as their synthesis, since materials fitting for each device and application are required. Highly stable wavelength converters and electroluminescence are our challenges to future devices.



Materials Chemistry

Structural Physical Chemistry

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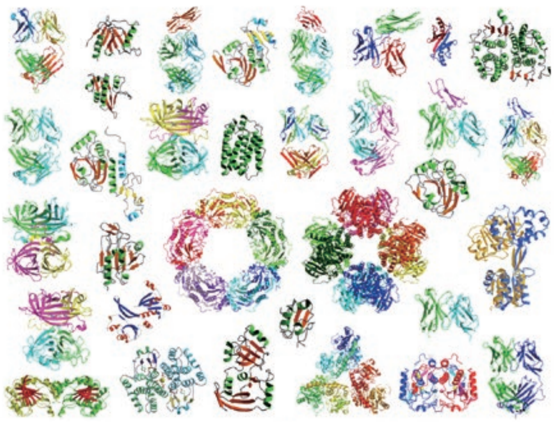
Associate Professor
Eiichi MIZOHATA

Our aim is to understand structure/function relationships of proteins. We directly visualize their three-dimensional structures at an atomic level by X-ray crystallography. To do this, we crystallize proteins and collect X-ray diffraction data from the crystals, and process the data with computers to reveal the electron-density map. We then perform to uncover the structure/function relationship and design novel molecules that control its function. Development of small-molecule medicines, the 3rd generation antibody drugs, and improvement of global environment and crop productivity are now in study.

Especially, we focus on structure-based antibody drug development. There are many kinds of cancers in human and each cancer expresses specific antigen protein on its cell surface. Our goal is to develop multifunctional antibodies that can be used for targeted treatments in advanced cancers. We aim to create engineered low immunogenic antibody drugs that specifically recognize cancer cells, in combination with drug delivery system. These antibody drugs will be useful for precise diagnosis and treatment of cancer with minimal side effects.



Crystal structures of drug target proteins

Materials Chemistry

Physical Organic Chemistry

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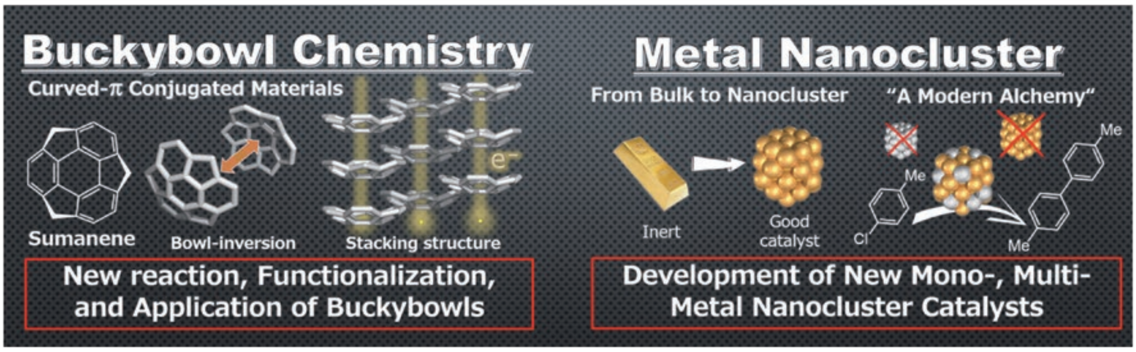
Professor
Hidehiro SAKURAI

Associate Professor
Yumi YAKIYAMA

Specially Appointed Assistant Professor
Yuta UETAKE

Bowl-shaped π-conjugated compounds including partial structures of the fullerenes, which are called "buckybowls", are of importance not only as model compounds of fullerenes but also as their own chemical and physical properties. Only very few buckybowls have been prepared mainly due to their strained structure. We develop the rational route to the various buckybowls and investigate their unique reactivity and physical properties.

As another main project, we investigate novel catalytic properties of metal nanoclusters. We especially focus on the preparation of size-selective gold and gold-based multi-metal nanoclusters and its catalytic activity. Development of designer metal nanocluster catalyst using the highly-functionalized protective polymers is also the hot topic in our laboratory.



Materials Chemistry

Structural Organic Chemistry

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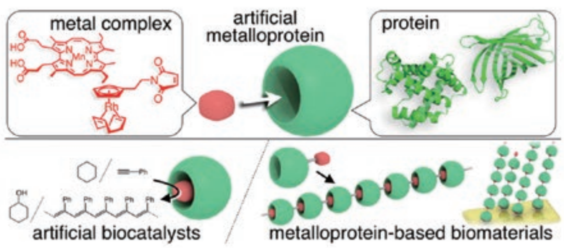
Professor
Takashi HAYASHI

Associate Professor
Akira ONODA

Assistant Professor
Koji OOHORA

Metalloproteins are important biomolecules and widely exist in nature. Metal ions and metal-dependent cofactors in protein matrices have the potential to provide catalytic, redox, sensing, and/or small molecule storage/transport properties. Our group has focused on the modification of various heme- and non-heme proteins to understand the molecular mechanisms of metalloproteins and prepare new biomaterials. A hemoprotein possesses iron porphyrin (heme) as a cofactor in the protein matrix. The corresponding apoprotein obtained after removal of native heme provides a unique scaffold or cavity which acts as a binding site of various metal complexes as well as an effective outer coordination sphere. From this point of view, we are engaged in the following researches: (1) modification of hemoproteins to enhance their catalytic activities; (2) modeling of metalloenzymes by conjugation of an artificial cofactor to apomyoglobin; (3) molecular design and construction of a new biohybrid catalyst prepared by incorporation of organometallic species into a protein matrix; (4) construction of hemoprotein assemblies to generate new bionanomaterials; (5) attachment of a redox active protein to metal or carbon material surfaces; and (6) preparation and characterization of a new artificial porphyrinoid; and (7) construction of nonprecious metal carbon catalysts. These broad research efforts require knowledge of chemistry (e.g. organic chemistry, inorganic chemistry, biological chemistry, physical chemistry, analytical chemistry and supramolecular chemistry) and our goal is to generate biomolecule-based functional devices and catalysts and create a new interdisciplinary research field.



Applied Bioinorganic Chemistry: Creation of New Biomaterials.

Synthetic Organic Chemistry

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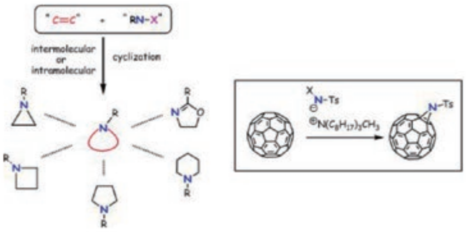
Professor
Satoshi MINAKATA

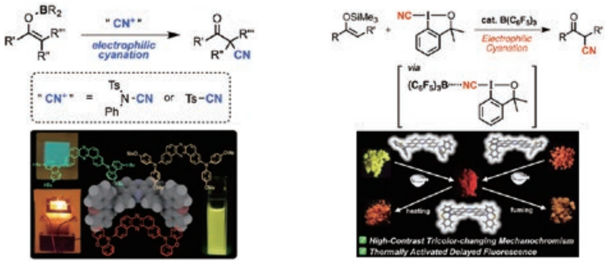
Associate Professor
Youhei TAKEDA

Assistant Professor
Kensuke KIYOKAWA

Research in our group is to seek new methodologies and tactics in organic chemistry. Especially, our interests are focused on efficient, selective, and environmentally benign methodologies for the synthesis of valuable functional molecules. Also, the creation of functional molecules based on the developed reactions is pursed. So far, a variety of synthetic methods have been developed for the preparation of useful building blocks, fullerene derivatives, and natural products. Recent studies involve the development of a new synthetic method of β-keto nitriles using boron and silyl enolates, and the development of novel functional π-conjugated molecular materials such as OLED emitters and stimuli-responsive luminescent materials.



Utilization of N–X bonds in the synthesis of *N*-heterocycles



Recent examples of our studies

Inorganic Materials Chemistry

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Professor
Nobuhito IMANAKA

Associate Professor
Shinji TAMURA

Assistant Professor
Naoyoshi NUNOTANI

Imanaka Laboratory researches on the field of “Inorganic Materials Chemistry”. Especially, we focus on Rare Earth elements for appearing the unique properties of the materials, and develop various novel functional materials such as Solid Electrolytes, Gas Sensing Materials, Environment Catalysts, Environment-friendly Pigments, and Phosphors for achieving the safe and convenient lives. Until now, we have succeeded in developing the following unique functional inorganic materials, and we are continuing an effort to improve their performance as well as newly developing materials.

1) High valent cation (tri- and tetravalent) conducting solid electrolytes: First demonstration of such high valent cation conduction in the solids in the world!
2) CO oxidizing catalyst at moderate temperatures (around room temperature) with high stability
3) NO decomposition catalyst with high activity
4) New environment-friendly (Non-toxic) pigments with high hue (Yellow, Red, Blue, Green, Orange)
5) Various gas sensors with high chemical and thermal stability with above solid electrolytes and catalysts
6) New inorganic phosphors (Red, Green) with high emitting intensity

Yellow pigment developed

The dish is displayed in the Gallery.
(1F Lobby, GSE Common West building)

A trial dish of Arita Ware

Materials Chemistry

Polymer Materials Chemistry

■tel: 06−6879−7364 ■fax: 06−6879−7367 ■mail: uyama@chem.eng.osaka-u.ac.jp ■address: Engineering Bldg. C4, 4F

Professor
Hiroshi UYAMA

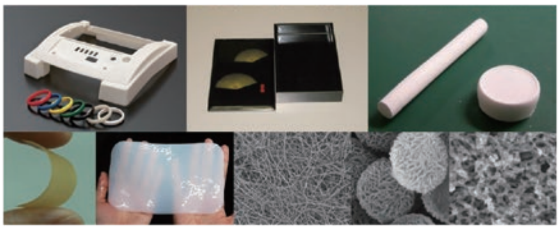
Associate Professor
Taka-Aki ASOH

Polymer Materials Chemistry Area (Uyama laboratory) focuses on development of new functional materials by precise design and synthesis of polymers. We mainly deals with three research projects as follows.

Bio-based Plastics
There has been great interest in bio-based polymers, since the use of bioresources as starting substrates for polymeric materials would help halt greenhouse warming and contribute to global sustainability without the depletion of scarce fossil resources. We have developed high-performance bio-based polymers utilizing plant oil, cellulose, and polyester as bioresources.

Functional Polymer Monoliths
Monolithic materials with interconnected porous structure are suitable as chromatographic separation media, ion exchange resins, battery materials, and catalyst supports. We have fabricated nanoporous monoliths from a variety of polymers by phase separation technique and developed their applications for bio-related separations and batteries.

High-performance Hydrogels
Hydrogels are similar to the macromolecular-based components in the body, therefore, hydrogels have found numerous applications as human-friendly materials. We have fabricated functional hydrogels based on cellulose nanofibers and developed novel hydrogel architectures by adhesion control of hydrogels.



Functional Polymers Developed in Our Lab.

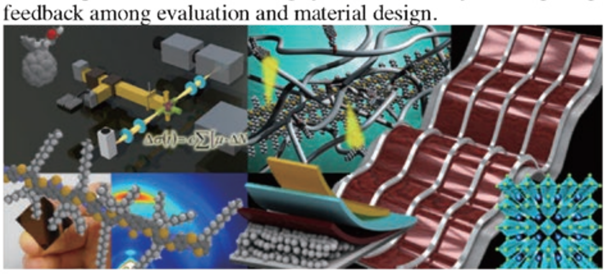
Materials Chemistry

Condensed Matter Physical Chemistry

■tel: 06−6879−4587 ■fax: 06−6879−4588 ■mail: saeki@chem.eng.osaka-u.ac.jp ■address: Engineering Bldg. U1E, 13F

Professor
Akinori Saeki

Due to the compelling prospect of renewable energy sources, there is currently a growing interest in the development of organic photovoltaic (OPV) and perovskite solar cell (PSC). Light-weight and cost-effective these solar cells have witnessed a significant progress in this decade, by virtue of rational design of high-performing organic molecules as well as emergence of organic-inorganic hybrid perovskite. Our research group, Condensed-Mater Physical Chemistry (CMPC), have focused on elucidating fundamental physical chemistry taking place in optical, electronic, and dielectric materials. Our interest is lying on the dynamics of excited state and charge carriers (hole and electron), which play a key role in photoelectric conversion process. In this regard, we have utilized a unique technique: time-resolved microwave conductivity (TRMC), together with conventional transient photocurrent and photoabsorption/emission spectroscopies. A gigahertz electromagnetic wave used in TRMC allows us to directly evaluate photoconductivity, charge mobility, and lifetime on nanosecond to millisecond scale without preparing electronic devices, of which outputs often suffer unpredictable extrinsic factors. Unravelling the intrinsic aspect of charge dynamics is at the heart of our interest. We have been evolving the TRMC system, such as frequency-modulation, light-pulse modulation, and electric field modulation. Furthermore, we have been developing novel conjugated polymers for not only solar cell but also other optical and dielectric applications, based on the knowledge of fundamental physical chemistry and prompt feedback among evaluation and material design.



Conceptual image of research on electronics.

Materials Chemistry

Advanced Materials Chemistry

■tel: 06−6879−4209 ■fax: 06−6879−4209 ■mail: machida@chem.eng.osaka-u.ac.jp ■address: Office for Industry-University Co-Creation Bldg. A, 1F

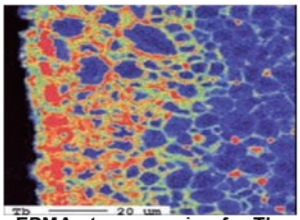
Professor
Ken-ichi MACHIDA

Our laboratory is mainly focusing on the fundamental and application researches for inorganic and metallic materials.

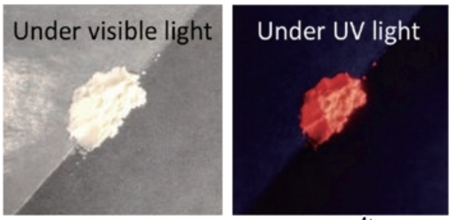
Rare earth magnets, *e.g*. Nd-Fe-B one, as the first subject since they have excellent magnetic properties for high-performance motors or generators. We have recently found the special technique by which Dy or Tb element is selectively diffused through the inter granular phase to the inside of Nd-Fe-B magnet pieces, so that the resulting magnets show the higher coercivity which far exceeds commercially-available magnets (see the below EPMA photo).

Development of novel red phosphors for LED illumination lamp is the second subject. Especially, we are working on the synthesis and characterization of Mn^{4+}-activated fluoride phosphors such as $KNaSiF_6:Mn^{4+}$, $K_3AlF_6:Mn^{4+}$ in which Mn^{4+} ions are situated at fluoride hosts with octahedral coordination (see the below photo).

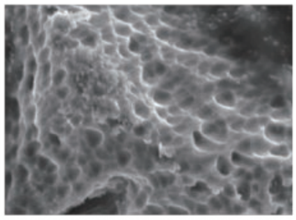
Finally, the development of both anode and cathode materials for Li ion batteries is the third subject. We are working on the synthesis of active materials with unique structures, surface states and mixed anions (see the below photo).



EPMA atom mapping for Tb-introduced Nd-Fe-B magnet



Photographs for $K_2NaAlF_6:Mn^{4+}$ Phosphor powders



Porous silicon particles for Li ion battery

Material and Life Science

Organic electronic materials science

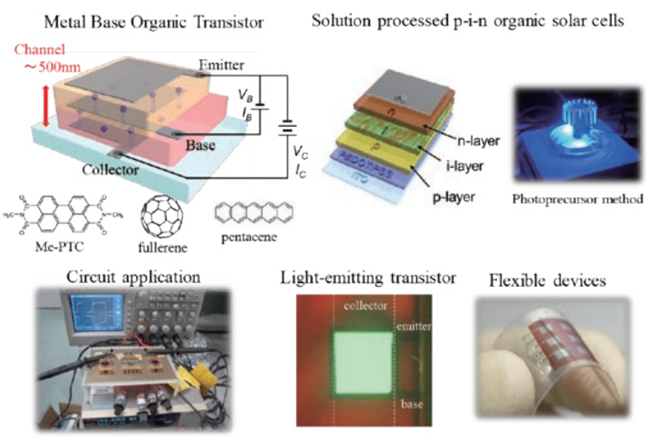
■tel: 06−6879−7368 ■fax: 06−6879−7370 ■mail: nakayama@mls.eng.osaka-u.ac.jp ■address: Engineering Bldg. U1E, 12F

Professor
Ken-ichi NAKAYAMA

Associate Professor
Mitsuharu SUZUKI

Assistant Professor
Tomoyoshi SUENOBU

We are studying organic electronic materials and their application to electronic devices such as organic light-emitting diodes, organic thin-film transistors and organic solar cells. This research field is called “organic electronics”, which aims to realize ultra-light and thin electronic devices that can be produced with low-cost printing processes. Our primary interest is in developing new-concept devices based on unique π-conjugated molecules by understanding fundamental properties of organic materials from both chemical and physical viewpoints. For example, we have developed an original vertical-type organic transistor, named as Metal-Base Organic Transistor (MBOT), that can operate with low voltage and extremely high current density. It pioneers new applications of organic devices such as telecommunication circuits and organic light-emitting transistors. Organic electronics is truly interdisciplinary and includes a wide range of academic areas from organic chemistry for designing molecules to physical chemistry for understanding solid-state properties, and to device physics based on semiconductor engineering for improving performances.



Our proposed organic electronic devices and their application.

Material and Life Science

Chemistry on Supramolecular Recognition

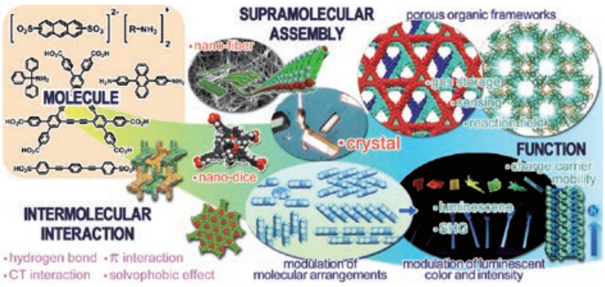
■tel: 06−6879−7404 ■fax: 06−6879−4584 ■mail: tohnai@mls.eng.osaka-u.ac.jp ■address: Engineering Bldg. U1E, 11F

Associate Professor
Norimitsu TOHNAI

Nature has created exotic biological systems with effective and selective functionality by adapting reversible intermolecular interaction such as hydrogen bond. Such systems inspire us to construct artificial functional materials beyond nature by using well-designed intermolecular interactions. Our research includes the following four phases: (1) Design and synthesis of functional organic compounds capable of self-assembling in desired crystalline state. (2) Structural characterization of the crystals and precise identification of intermolecular interactions. (3) Control of molecular arrangements. (4) Development of new functional materials with significant optical and electrical properties provided by self-assembled architectures.

For example, we established a new methodology to control arrangements of functional molecules in solid states. That is co-crystallization of sulfonic-acid-substituted π-conjugated molecules with various amines as structural modulators. Based on this, we obtained various arrangements of functional molecules, which achieved wide ranges of photoelectronic properties: luminescence, SHG, and charge carrier mobility depending upon the molecular arrangements. We are sure this is a quite important paradigm for development of functional organic solid materials.

We also applied other intermolecular interactions with various strength and directionality to build various molecular architectures which include nano-sized molecular dices, porous molecular grids, nano-wires, and so on.



Construction of functional supramolecular architectures by well thought-out design

Material and Life Science

Chemical Biology

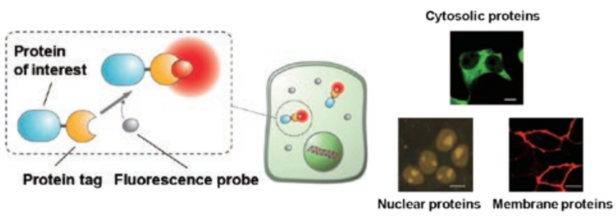
■tel: 06−6879−7924 ■fax: 06−6879−7875 ■mail: kkikuchi@mls.eng.osaka-u.ac.jp ■address: Engineering Bldg. U1E, 6F

Professor
Kazuya KIKUCHI

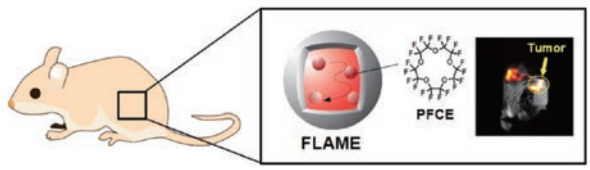
Associate Professor
Yuichiro HORI

Assistant Professor
Masafumi MINOSHIMA

Chemical biology is an interdisciplinary research field, which focuses on elucidation of biological phenomena by utilizing "chemical tools". These chemical tools are developed by the combinatorial use of organic chemistry, nanotechnology, and genetic engineering. In our group, we design and synthesize novel fluorescence and magnetic resonance imaging (MRI) probes that are applied to answer various biological questions. The representative examples of our chemical tools are fluorescence probes for detection of protein localization and enzymatic activity and MRI probes for in vivo imaging of cancer and gene expression. We develop new tools to give new findings that are not verified by conventional biological methods. By using these tools, we are currently studying various biological fields such as epigenetics, immunology, and cancer biology.



Fluorescence probe for live-cell imaging of proteins



MRI probe for in vivo imaging

Material and Life Science

Biofunctional Chemistry

■tel: 06−6879−7932 ■fax: 06−6879−7933 ■mail: shinobu@mls.eng.osaka-u.ac.jp ■address: Engineering Bldg. U1W-3



Professor
Shinobu ITOH

Associate Professor
Hideki SUGIMOTO

Assistant Professor
Yuma MORIMOTO

The general goal of our research is to understand enzymatic catalysis at a molecular level. Particular attention has focused on the redox chemistry of non-heme transition-metal reaction centers. Our main approach involves synthetic modeling including (i) rational design and syntheses of appropriate active site models for non-heme metalloenzymes, (ii) elucidation of structures and physicochemical properties using NMR, IR, UV-Vis, resonance Raman, and ESR spectroscopies as well as X-ray crystallography and cyclic voltammetry, and (iii) reactivity and mechanistic studies by means of low-temperature (stopped-flow) kinetics.

1. Modeling study of active site of copper containing metalloenzymes

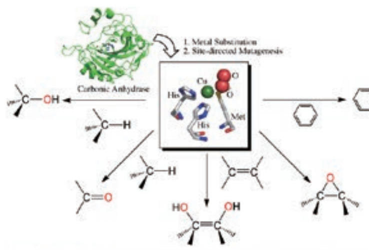
Copper containing enzymes activate molecular oxygen to catalyze various types of oxidation. Synthesis of chemical analogues of their active site structures and their structural characterization and reactivity studies give us understanding of the reaction mechanism of the enzymatic reaction.

2. Rational design of novel functions of metalloenzymes

Based on the various properties of model compounds, mononuclear and dinuclear metalloproteins is redesigned as metal ligands to construct more efficient artificial metalloenzymes than naturally occurring enzymes. On the other hands, the self-hydoxylation of the side chains of amino acid around metal ion in protein provided us the fundamental insight into the post-translationally chemical modification process.

3. Bio-inspired catalysts

New catalysts are developed based on knowledge obtained by the modeling study to give clean reaction systems.



Artificial metalloenzymes for chemical transformations

Molecular Chemistry 〈Cooperative Area〉

Department of Materials Excitation Chemistry

■tel: 06−6879−8496 ■fax: 06−6879−8499 ■mail: fuji@sanken.osaka-u.ac.jp, kiyohiko@sanken.osaka-u.ac.jp ■address: ISIR Bldg. 1, 4F



Associate Professor
Mamoru FUJITSUKA

Associate Professor
Kiyohiko KAWAI

Associate Professor
Yasuko OSAKADA

Assistant Professor
Sachiko TOJO

"Materials excitation chemistry" based on photo- and radiation-induced chemistry of organic and inorganic compounds has been investigated from both basic and application points of view. The following research projects are underway with respect to developments of photo- and radiation-controlled chemistry and bioscience, functional materials, ultra-sensitive analytic and diagnostic methods.

1. Formation and reactivity of reactive intermediates in photochemistry and radiation chemistry, and photochemistry of reactive intermediates
2. Multi-laser chemistry with multi-step irradiation by two-color two lasers, three-color three lasers, and electron pulse-laser
3. Charge transfer mechanism during TiO_2 photocatalytic reactions
4. Single-molecule fluorescence measurements to study dynamic motions and reactions of DNA, RNA, and peptides
5. Kinetic analysis based on the control of fluorescence blinking
6. Bio-imaging using photo-functional nanoparticles using light and radiation
7. Two dimensional polymers for photocatalytic reaction

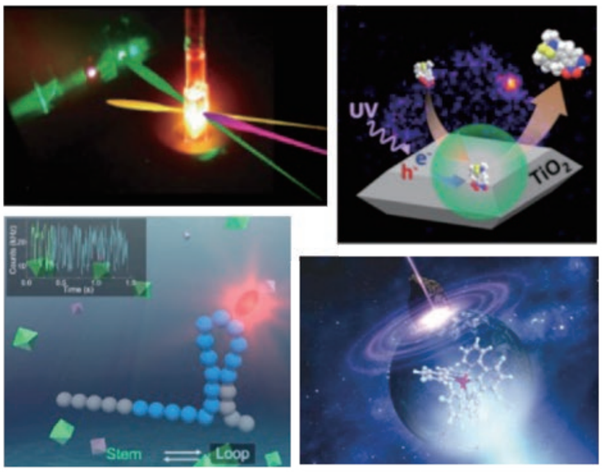


Photo- and radiation-induced Materials Chemistry

Molecular Chemistry 〈Cooperative Area〉

Department of Soft Nanomaterials (The Institure of Scientific and Industrila Research)

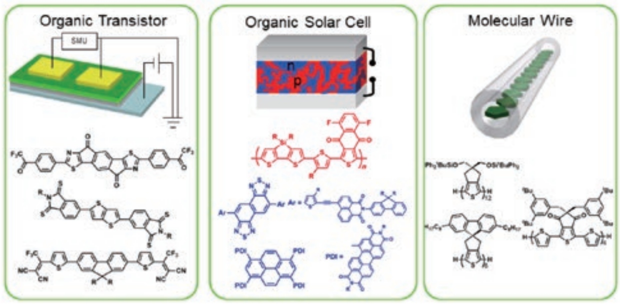
■tel:+81-6-6879-8476 ■fax:+81-6-6879-8479 ■address:8-1 Mihogaoka, Ibaraki, Osaka 567-0047

Professor
Yutaka IE
(E-mail: yutakaie)

(for e-mail add @sanken.osaka-u.ac.jp)

Research Topics

The main subject in the Department of Soft Nanomaterials is the development of novel molecular-based materials with promising electronic and photoelectronic properties for organic electronics. The research is based on the elucidation of the relationship between molecular structures and physical properties to control and improve the functions. We have been focusing our research on the design, synthesis, and properties of (1) novel extended conjugation systems as active materials for organic electronic and photoelectronic devices and (2) nano-scale conjugated molecules for promising functional molecular wires. These nano-scale molecular materials have potential use as a fundamental framework for organic electronic devises.



Application Arias

Potovoltaic Devices (Organic Solar Cells)
Field-effect Transistors
Single Molecule Electronics

http://www.sanken.osaka-u.ac.jp/labs/omm/

Molecular Chemistry 〈Cooperative Area〉

Environmental Chemistry

■tel: 06-6879-8974 ■fax: 06-6879-8978 ■mail: shibata@epc.osaka-u.ac.jp ■address: Research Center for Environmental Preservation, 1F

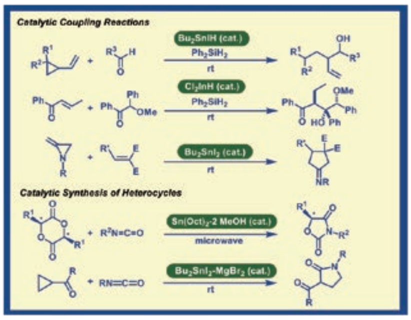
Professor
Ikuya SHIBATA

Associate Professor
Shinji TSUNOI

Assistant Professor
Itaru SUZUKI

Based on the proposal of the Environmental Protection Commission, the Research Center for Environmental Preservation was founded in 1994 as the administrative organ that plays a central role in the research, education and instruction related to the environment and the safety on an all-campus level.
Green Chemistry is the foundation of strategies that respond to various environmental issues, which are continuing to grow in complexity and diversity. This center is currently involved in the development of environmental benign method in organic synthesis, and highly selective and sensitive methods for the analysis of hazardous chemical substances.
Our topics are directed to environmental chemistry as follows.
1. Development of environmentally benign method of organic synthesis and catalysts.
2. Development of highly sensitive analytical method for hazardous chemical substances by using GC-MS.

Research Center for Environmental Preservation



Recently developed original reactions (2013-2015)

Materials Chemistry 〈Cooperative Area〉

Department of Functionalized Natural Materials

■fax: 06-6879-8444 ■mail: nogi@eco.sanken.osaka-u.ac.jp ■address: ISIR Bldg. 2, S-207

Professor
Masaya NOGI

Associate Professor
Hirotaka KOGA

Assistant Professor
Kojiro UETANI

Cellulose is the most common and abundant bioresources, mainly originating from higher plants. We have successfully extracted cellulose nanofibers with widths of 3~15 nm from wood pulps, and have developed cellulose nanofiber-based materials, such as transparent paper, especially for electronic applications.

Our targets
1. Optically transparent nanofiber paper
2. Paper electronics
3. Optically transparent composites reinforcing with cellulose nanofibers
4. Thermally conductive materials

Optically transparent nanopaper

Materials Chemistry 〈Cooperative Area〉

Department of Beam Materials Science

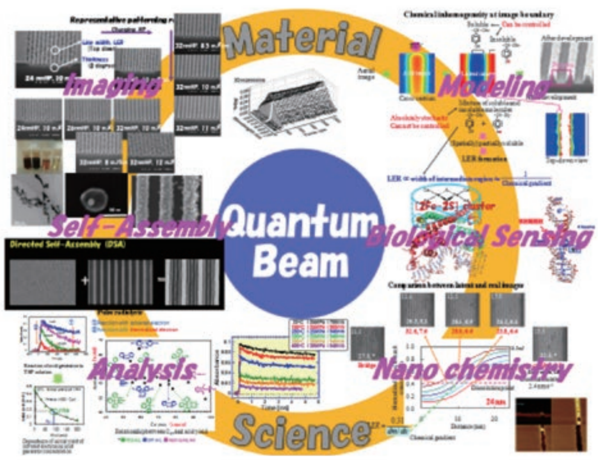
■tel: 06-6879-8502 ■fax: 06-6879-4889 ■mail: kozawa@osaka-u.ac.jp ■address: ISIR Bldg. 1, 5F

Professor
Takahiro KOZAWA

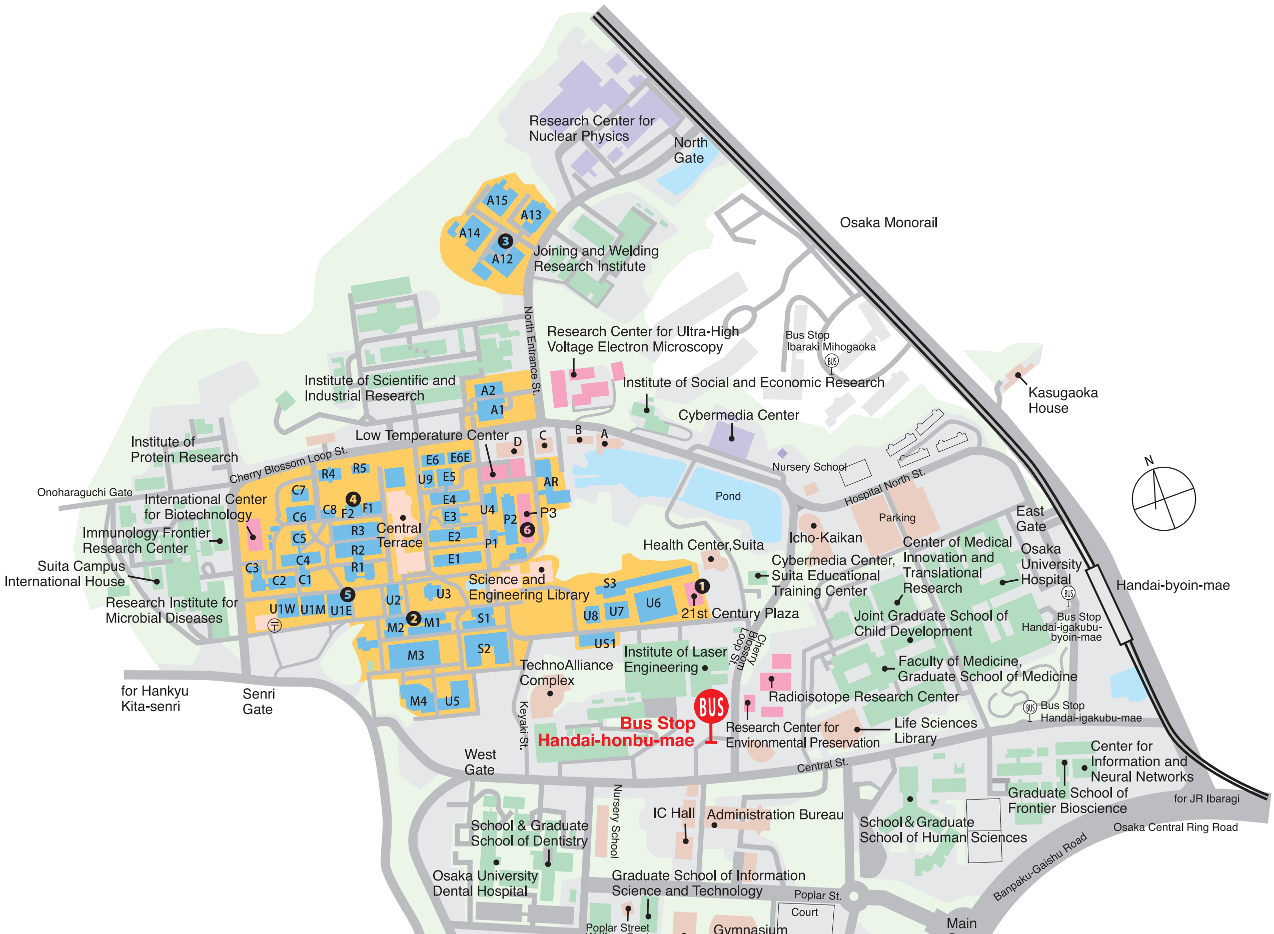
Associate Professor
Yusa MUROYA

Assistant Professor
Kazumasa OKAMOTO

The industrial application of quantum beam will rapidly expand in the field such as high-volume production of semiconductor devices. Cancer therapy using ionizing radiation has also attracted much attention. In department of beam materials science, the radiation-induced chemical reaction and reaction field have been investigated using state-of-the-art quantum beam (electron, extreme ultraviolet radiation, laser, synchrotron radiation, X-ray, gamma-ray, ion beam). We have studied the chemical reaction system from the energy deposition on materials to the expression of material function. On the basis of these studies, we have designed a noble chemical reaction system. Current research projects are challenge toward nano-chemistry in high-volume production of semiconductor devices, radiation chemistry in the energy range of extreme ultraviolet, design of next generation resist materials - electron, hole, and energy transfer in condensed matter, study on radiolysis of water at extreme conditions, study of radiation-induced reaction of organic and bio-materials using pulse radiolysis, mechanism of genetic damage caused by ionizing-radiation, study on nano-materials using quantum beam.



Beam Molecular Science and Technology



Graduate School of Engineering

C2, C3, M1, U1E, U1W	Division of Advanced Science and Biotechnology
C4～C7, U1E	Division of Applied Chemistry
M1, M2, P1, P2, P3, AR	Division of Precision Science & Technology and Applied Physics
F1, M4, R1, R3, U1W	Department of Adaptive Machine Systems
M1, M3, M4, AR,	Division of Mechanical Engineering
R1～R5, AR, A	Division of Materials and Manufacturing Science
E1～E6E, U1W, U9,	Division of Electrical, Electronic and Information Engineering
A1, A2, A12~A15, M3, AR, U1W	Division of Sustainable Energy and Environmental Engineering
S1～S3, AR, U1W, U5	Division of Global Architecture
US1	Department of Management of Industry and Technology

Educational Research Facilities Attached to Graduate School of Engineering

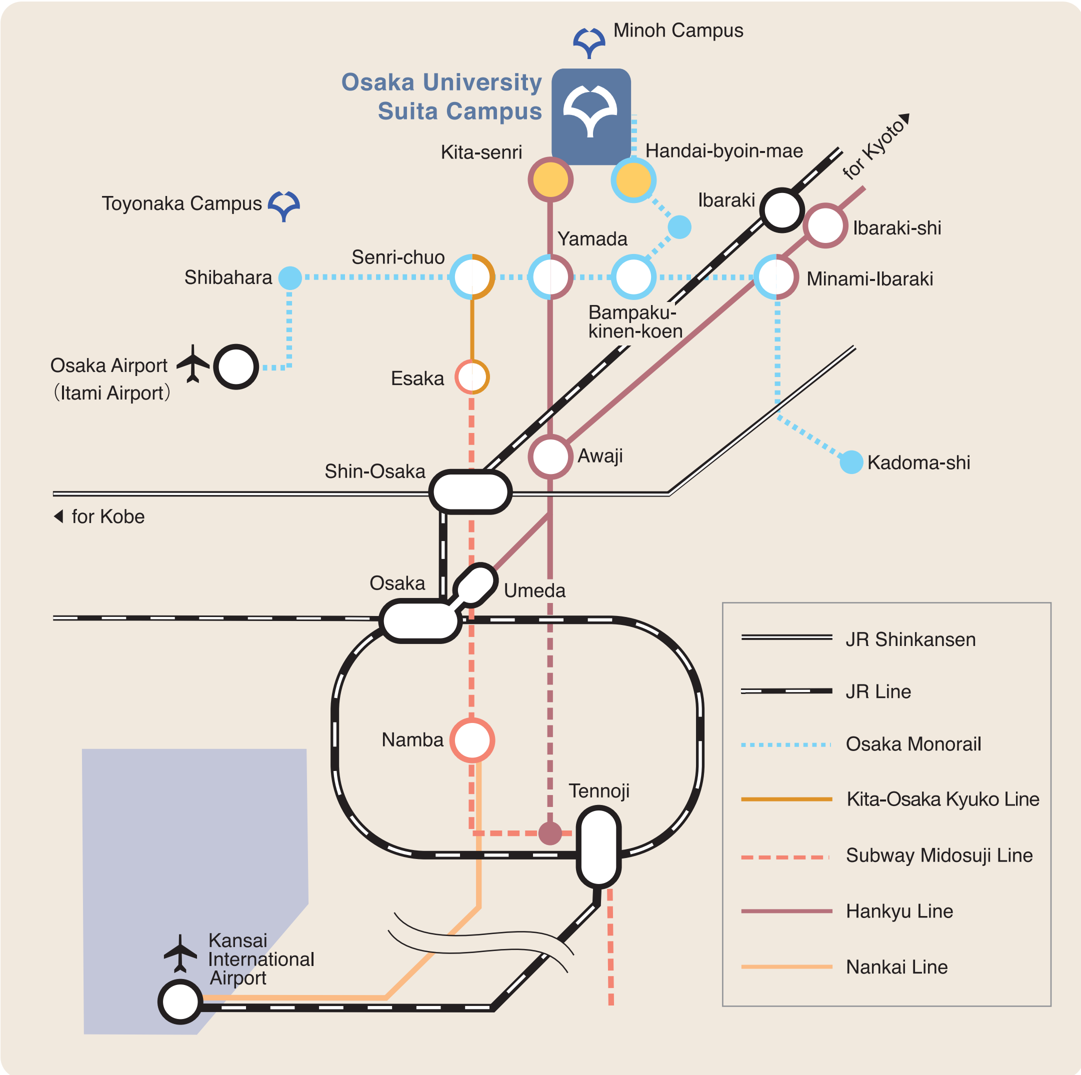
❶,❷Research Center for Ultra-Precision Science and Technology
❸ Center for Atomic and Molecular Technologies
❹ Education and Research Center for Advanced Structural and Functional Materials Design
❺ Center for Open Innovation Research and Education
❻ Photonics Center

School of Engineering

C1～C7, M1, P1, P2, P3, AR	Division of Applied Science
M1, M3, M4, R1～R5, AR, A	Division of Mechanical, Materials and Manufacturing Science
E1～E6E, U1W, U9, A14	Division of Electronic and Information Engineering
A1, A2, A13～15, M3, AR, U1W	Division of Sustainable Energy and Environmental Engineering
S1～S3, AR	Division of Global Architecture

Common Facilities

U1M	GSE Common Middle (Administration Office)
U1W	GSE Common West
U1E	GSE Common East
U2,U3	Lecture Hall
AR	Advanced Research Building
U4	Computation Center
U5	Material and Structural Laboratory
U6	Common Testing Hall
U7	Wind Tunnel for Research
U8	Construction Center
C7,C8	Analytical Instrumentation Facility
U9	Ion Beam Surface Analysis Facilities
A2	Radio Isotope Laboratory
US1	GSE Common Satellite
A12	Center for Atomic and Molecular Technologies
F1	Frontier Research Center I
F2	Frontier Research Center II
❶	Creative Design Studio on Technology



Access from the Main Terminals

From the **Shin-Osaka** Station

- Take the Subway Midosuji Line and get off at **Senri-chuo** Station.
- Get off at **Ibaraki** Station on the JR Kyoto Line.

From **Kansai International Airport**

- Get off at JR **Osaka** Station, and change to the Subway Midosuji Line bound for **Senri-chuo** Station.
- Get off at JR **Osaka** Station, change to JR Kyoto Line and get off at **Ibaraki** Station.
- Get off at **Namba** Station on the Nankai Line. Take the Subway Midosuji Line and get off at **Senri-chuo** Station.

From **Osaka Airport** (Itami Airport)

- Take the Osaka Monorail, and get off at **Senri-chuo** Station or **Handai-byoin-mae** Station.

Access from the nearest station

- From **Kita-senri** on Hankyu Senri Line 15 min. east on foot.
- From **Senri-chuo** on Kita-Osaka Kyuko Line Take the Hankyu Bus bound for **Handai-honbu-mae** or **Ibaraki-Mihogaoka** to **Handai-honbu-mae**, walk 5 min. to north-west.
- From **Ibaraki-shi** on Hankyu Kyoto Line or **Ibaraki** on JR Kyoto Line Take the Kintetsu Bus bound for **Handai-honbu-mae** to **Handai-honbu-mae**, walk 5min. to north-west.
- From **Handai-byoin-mae** on Osaka Monorail 15 min. north-west on foot

Application Schedule

The application forms and other materials must be submitted to the Admission and International Students Section, Student Affairs Division, Graduate School of Engineering, Osaka University by post or by hand, to be reached strictly by the following deadline.

Schedule for 2020 admission is not announced, yet.
For details, please get information from http://www.eng.osaka-u.ac.jp/ja/entrance/f_admissions.html

For Japanese Government (Monbukagakusho / MEXT) Scholarship Students (once per year, Five-year Master's and Doctoral courses)

Period of Application
October to December, 2019 (to be announced)

Selection
Screening by reviewing the application materials and documents submitted: By the end of January 2020
Interviews by the representative professors: By the end of February 2020

Announcement of the Results
Successful Applicants: By the end of July 2020

NOTE: We will open two position for Five-year course, and three position for Three-year course For MEXT scholarship students for 2020 admission

【Reference】
[Enrollment in October 2019]

For Privately Financed International Students (Master's and Doctoral courses)

Period of Application
May 1 to 24, 2019

Selection
・For applicants who do not reside in Japan (Examination in Fall and Spring):
Screening will be conducted by reviewing the application materials and documents submitted.
An interview and/or academic examination might be conducted if deemed necessary.

・For applicants who do reside in Japan:
Screening will be conducted via an interview and academic examination
Early June 2019

Announcement of the Results
By the end of June 2019 (Examination in Spring)

For Privately Financed International Students (Three-year Doctoral course)

Period of Application
July 16 to 19, 2019

Selection
・For applicants who do not reside in Japan (Examination in Fall and Summer):
Screening will be conducted by reviewing the application materials and documents submitted.
An interview and/or academic examination might be conducted if deemed necessary.

・For applicants who do reside in Japan:
Screening will be conducted via an interview and academic examination.
the end of August 2019 (Examination in Summer)

Announcement of the Results
Middle of September 2019 (Examination in Summer)

All inquiries to

Admission and International Students Section
Student Affairs Division
Graduate School of Engineering
Osaka University
2-1 Yamadaoka, Suita,
Osaka 565-0871, JAPAN
Telephone: +81-6-6879-7226
Facsimile: +81-6-6879-7229
E-mail: iso-staff@eng.osaka-u.ac.jp

CAREN
Center for the Advancement of Research and Education Exchange Networks in Asia