Department of Chemistry

Department of Chemistry

Introduction

Chemistry is a science dealing with the structure, synthesis, and properties of substances, particularly at the molecular level. We are surrounded by chemical products; e.g., food, clothing, housing, drugs, and so on. In addition, new materials such as those supporting computer memory storage and superconductivity have been playing an essential role in the recent progress of technology and culture. Some chemicals, on the other hand, tend to give rise to serious environmental problems, whose solutions will depend upon chemistry research and education in future. Thus, chemistry and related sciences are much closer to us than one imagines, extensively contributing to the development of science and human society.

The department of chemistry, graduate school of science, Osaka University, comprises the following four divisions covering inorganic, physical, organic, and interdisciplinary chemistry. In addition, the department has cooperative with thirteen research groups of other research institutes.

Experiment in inorganic chemistry

Single Crystal growth of exotic organic functional materials under the oxygen-free condition (< 5 ppm)

Inorganic Chemistry Division

Analytical Chemistry, Inorganic Chemistry, Coordination Chemistry and Radiochemistry laboratories are included in this division.

Analytical Chemistry laboratory is developing nano-chemistry of liquid-liquid interfaces to elucidate specific role of the interface in chemistry. The diffusion dynamics of single molecules and the reaction mechanisms of metal-complex aggregations at the interface are investigated in relation to the separation mechanisms. New principles for migration analysis of biological micro-particles are also developed utilizing specific forces generated by a laser, an electric field and a magnetic field.

Inorganic Chemistry laboratory studies the magnetic and spectroscopic properties of metal complex systems containing unpaired electrons with various types of spin and orbital angular momenta. Novel phenomena generated by the interaction between unpaired electrons under various conditions such as crystal field, magnetic field, light irradiation, and temperature variation are investigated by means of electronic spectroscopy, ESR, NMR, magnetic circular dichroism and magnetic measurements.

In the Radiochemistry laboratory, superheavy elements and actinide elements are synthesized and their chemical properties are studied by some unique techniques. A new chemistry on artificial atoms composed of pion and muon, called an exotic atom, is developed in this laboratory. Nuclear reaction mechanisms of heavy ions and a finding of new nuclear phenomena, together with their application to physical and chemical researches, are also of their subjects.

In the Laboratory for bioinorganic chemistry, they study on relationships between structures and functions of metalloproteins, playing important roles in the biological systems. Furthermore, metal complexes are synthesized as a

Synthetic organic experiment using exhaust equipment for safety

biomimetic model compound of the active site of metalloproteins, and the model complexes are structurally and functionally compared with the active site of proteins.

The purpose of Laboratory of Coordination Chemistry is to prepare novel mononuclear, polynuclear, and metallosupramolecular complexes and to elucidate their molecular structures, electronic states, and functionalities. In particular, our current interest is directed toward the development of fundamental coordination chemistry by utilizing multifunctional metalloligands instead of classical inorganic/organic ligands.

Physical Chemistry Division

In the physical chemistry division, our research and educational activities cover experimental studies of structure, properties and reactivity of molecules and condensed matter and their theoretical analysis.

In the Condensed Matter Physical Chemistry Group, electronic properties of molecular conductors, molecular magnets, metal complexes and their network magnetic systems are studied by calorimetry, transport, and magnetic measurements. Novel features originated from the cooperative effects of spins, charges and molecular motions are discussed.

Surface Chemistry Group is aiming to create molecular functions by controlling the reactions of molecules on the surface and in nano-sized devices. The research will utilize various surface science technique, such as scanning probe microscopy, electron spectroscopy, and the device fabrication and characteristic measurement technique.

Chemical Kinetics and Dynamics Group aims at understanding chemical reactions at single molecule or nano-level using novel methods of scanning probe microscopy. The investigation for devices consisting of small number of molecules based on single molecular reaction and/or properties develops novel features differing from that of bulk molecular materials.

The Molecular Adsorption Group focuses on molecules confined in nanospaces, which exhibit physical properties and intermolecular interactions different from those in bulk phases. Our aim for this research is to elucidate the molecular theory behind physical adsorption on various porous solids by analyzing molecular motion through nuclear magnetic resonance spectroscopy.

In the Quantum and Theoretical Chemistry Group, Computers are utilized for theoretical analysis and prediction of properties and reactivity of chemical substances, design of functional materials. Development of new methodologies for computation is also the subject in this group.

The Research Center for Thermal and Entropic Science is devoted specifically to chemical thermodynamics dealing with various types of condensed matter, including hard materials such as high-T_C superconductors, soft materials such as liquid crystals, and rather complex systems such as adsorbed monolayers. We are particularly interested in "Order and Disorder" created by subtle balance of various intermolecular interactions.

Organic Chemistry Division

In the Division of Organic Chemistry, we observe natural phenomena through the structures and chemical behaviors of organic molecules, and try to discover the underlying principles operating in the life systems. We also actively extend our knowledge through theoretical considerations of the structures and properties of molecules and molecular interactions. These efforts will allow us to interpretate the sophisticated natural system and enable further creation of functionally interesting organic compounds. Division of Organic Chemistry consists of the following four independent research groups.

The research in Laboratory for Functional Molecules and Materials is directed toward molecular design and synthesis of artificial novel compounds with theoretical and functional interests in the materials properties. A wide range of material chemistry research is carried out from the nanoscale to the macroscale.

Major research projects of Laboratory for Structural Organic Chemistry are related to synthesis of novel extended π-electron systems and artificial supramolecules. New synthetic procedures for molecules with conjugated electronic systems are also investigated there. Systematic studies of properties for such various synthetic compounds are expected to result in discovery of novel classes of functionally interesting and versatile compounds.

Marine toxins and other biologically active compounds such as lipids and hormones are dealt with in Laboratory for Biomolecular Chemistry. New methodologies based mainly on NMR spectroscopy are being elaborated for investigation of three-dimensional structures and functions of complex biomolecules.

The research purpose in Laboratory for Organic Biochemistry is to clarify the functions of oligosaccharides in the living cell. Chemical synthesis of glycoproteins, glycopeptides and oligosaccharides are extensively performed and then used it for several bioassays. Several new reactions to construct such biomoleculars are also studied.

Interdisciplinary Chemistry Division

In this Division research works are oriented towards novel fields of both Natural Product Chemistry and Biophysical Chemistry.

Laboratory for Natural Products Chemistry mainly focuses on the functions of glycoconjugates consisting of carbohydrates linked to other structural units such as fatty acids and phosphates. Isolation of unknown bioactive compounds from natural sources, their structural, synthetic and functional studies are being intensively undertaken.

Biophysical Chemistry Group maintains as its primary focus the development and use of laser-based technologies to measure atomic level features of the biological systems. The results of these efforts are contributing to a deeper understanding of the nature of proteins' motions and relating the dynamics to biological function.

Home Page

http://www.chem.sci.osaka-u.ac.jp/graduate/chem-e/index.html

Research Projects

Inorganic Chemistry Division

1. Laboratory for Analytical Chemistry
2. Laboratory for Radiochemistry
3. Laboratory for Inorganic Chemistry
4. Laboratory for Bioinorganic Chemistry
5. Laboratory for Coordination Chemistry

Physical Chemistry Division

6. Laboratory for Condensed Matter Physical Chemistry
7. Laboratory for Surface Chemistry
8. Laboratory for Molecular Adsorption
9. Laboratory for Quantum Chemistry
10. Laboratory for Reaction Dynamics

Organic Chemistry Division

11. Laboratory for Structural Organic Chemistry
12. Laboratory for Functional Molecules and Materials
13. Laboratory for Organic Biochemistry

Interdisciplinary Chemistry Division

14. Laboratory for Natural Product Chemistry
15. Laboratory for Biophysical Chemistry
16. Research Center for Thermal and Entropic Science
17. Laboratory for High-Technology Research for the Analysis and Utilization of Materials
18. Center for Education in Liberal Arts and Sciences
19. Laboratory for Isotope Chemistry, Institute for Radiation Sciences
20. Laboratory for Beam Chemistry, Institute for Radiation Sciences
21. Laboratory for Radiation Science, Institute for Radiation Sciences
22. Laboratory for Radiation Chemical Biology, Institute for Radiation Sciences
23. Laboratory for Advanced Mass Spectrometry
24. Laboratory for Radiation Biological Chemistry

The Institute of Scientific and Industrial Research (Cooperative Division)

25. Laboratory for Bio-Nanotechnology
26. Laboratory for Transcendental Materials Chemistry
27. Laboratory for Regulatory Bioorganic Chemistry
28. Laboratory for Complex Molecular Chemistry
29. Laboratory for Synthetic Chemistry for Molecular Systems

Institute for Protein Research (Cooperative Division)

30. Laboratory for Protein Organic Chemistry
31. Laboratory for Computational Biology

Cooperative Adjunct Division

32. National Institute of Advanced Industrial Science and Technology (AIST) Nanomaterials Research Institute
33. National Institute of Advanced Industrial Science and Technology (AIST) Chubu Center
34. National Institute of Advanced Industrial Science and Technology (AIST) Kansai Center
35. Peptide Institute, Inc.
36. Suntory Foundation for Life Sciences, Bioorganic Research Institute

Department of Chemistry

Laboratory for Analytical Chemistry

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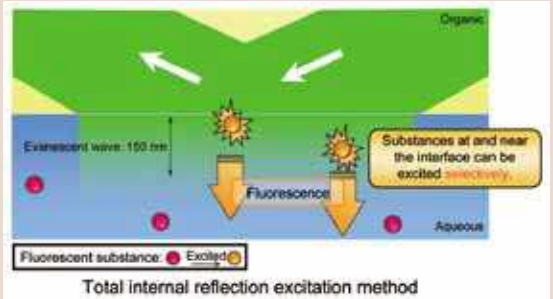
[Research Interests]

1) Metal complex aggregation at liquid/liquid interfaces and its high sensitive spectroscopic analysis
2) Measurements of resonance oscillation of liquid/liquid interfaces to determine the interfacial tensions
3) Measurements of transport kinetics of substances through liquid/liquid interfaces and development of high selective interfaces
4) Development of nano-mechanical measurement utilizing orientation behavior of magnetic nanoparticles under alternating magnetic field
5) Development of analytical separation methods for microparticles exploiting external field
6) Structural analysis of chiral molecules in solutions based on Raman optical activity spectroscopy

Measurements of chemical reactions and phenomena occurring at liquid/liquid interfaces and analysis of nanoparticles and microparticles relating to biological and environmental systems are much important and attractive subjects in Analytical Chemistry. We have invented new methods to measure absorption spectra of metal complex aggregates formed at liquid/liquid interfaces with polarized light; the thickness of the aggregates is only a few nanometers. We also measured reversible adsorption of proteins to hydrophobic interfaces by total internal reflection technique, and investigated the denaturation of proteins there. We have also invented novel analytical methods for microparticles by using magnetic field. Magneto-optical imaging microscopy and analytical separation method are being developed in order to detect paramagnetic compounds in microparticles.



Total internal reflection excitation method

Department of Chemistry

Laboratory for Radiochemistry

Members Yoshitaka KASAMATSU (Professor), Masashi KANEKO (Associate Professor), Hiroyuki KAZAMA (Assistant Professor)

Home Page http://www.chem.sci.osaka-u.ac.jp/lab/kasamatsu/index_e.html

[Research Interests]

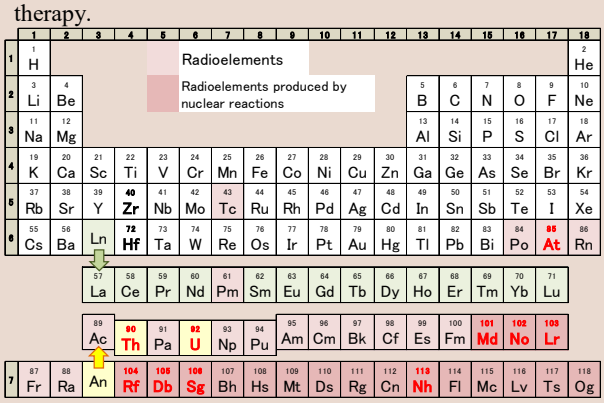
1) Heavy and superheavy element chemistry
2) Chemistry related with radioactive elements and nuclear properties
3) Radiochemical studies on radionuclides for medical use

Approximately 30% of elements in the current periodic table (Figure) have no stable isotopes; radioelements. In particular, heavy elements with larger atomic numbers are all artificial radioelements. Chemical researches on these elements need radiochemical techniques.

Heavy element chemistry: Our purpose is to investigate the chemical properties of heavy elements which might have unique properties due to the influence of relativistic effects on their orbital electrons. Development of apparatuses for "single atom chemistry", related chemical experiments using radiotracers of homologues of heavy elements, and relativistic quantum calculations are in progress.

Nuclear properties: Clear and large chemical effects on the nuclear decays are investigated for ultra-low energy isomers: ^{229m}Th and ^{235m}U. Half-lives and decay modes are expected to vary by changing their chemical states.

For medical applications: It is very important to effectively use radioisotopes for various applications such as medical use. We conduct fundamental researches on some complexes of Cu and Pb, etc. which appear promising for cancer therapy.



Department of Chemistry

Laboratory for Inorganic Chemistry

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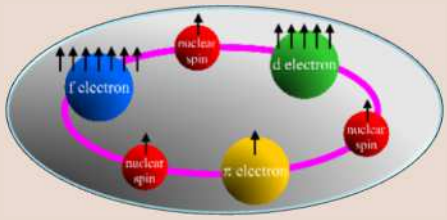
[Research Interests]

1) Fundamental research on electronic structures and molecular magnetism of molecular systems with f, d and π unpaired electrons
2) Basic Research on Interaction between Excited Cyclic π Systems and f Electrons (J-L interaction)
3) Elucidation of Quantum State Time Evolution of Systems with Multiple Magnetic Sites with Different Magnetic Anisotropy and Magnetic Relaxation Times
4) Synthesis and Magnetism of Complexes with New Coordination Structures

Compounds with metal ions such as "metal complexes" can have "unpaired electrons".
These "unpaired electrons" have a magnetic moment and cause magnetism. The nuclei also have their own magnetic moments. These magnetic moments interact with each other to form complex quantum states. This interaction creates a variety of magnetic properties. By controlling these interactions, we can create compounds with new functions and properties. This laboratory aims to develop new research fields for molecular magnetic materials with various types of spins.



Department of Chemistry

Laboratory for Bioinorganic Chemistry

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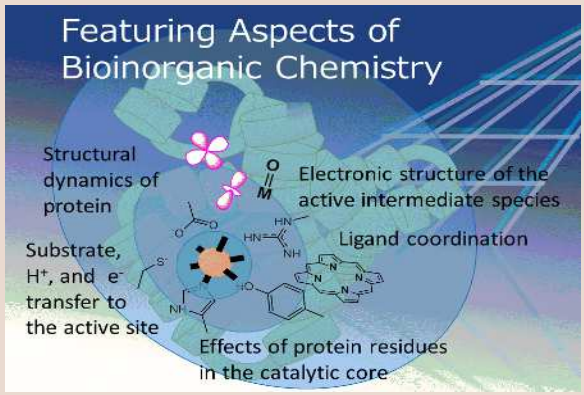
[Research Interests]

1) Synthesis of mono- and multi-nuclear metal complexes activating bonds in molecules
2) Synthesis of hetero-metallic complexes activating bonds in molecules
3) Biomimetic study of metalloenzymes, and development of metal catalysts, using 3d-block elements
4) Investigation of relationships between structures and functions of active metals in biology
5) Synthetic and mechanistic study on metal complexes for chemotherapeutic treatments and human health

The energy transduction and metabolism involve photo-excitation, electron transfer process, and activation of substrates including small molecules such as O_2, N_2, and so on.

The 1st transition metals are frequently contained as essential trace elements in natural organisms, efficiently working at the active sites in proteins. Furthermore, metal complexes sometimes show pharmaceutical activity applicable for medical use.

We learn functions and roles of metals in biology, and we newly develop metal complexes with inspirations from chemistry in nature.



Department of Chemistry

Laboratory for Coordination Chemistry

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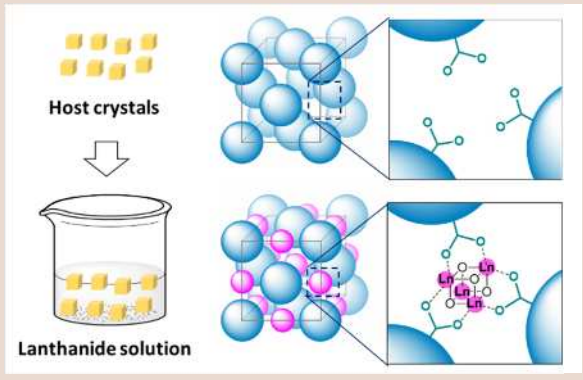
[Research Interests]

1) Stepwise construction of heterometallic polynuclear and supramolecular structures based on multifunctional metalloligands.
2) Creation of nanosized interstices by aggregating spherical metal clusters for ion migration and molecular adsorption.
3) Studies on the chiral recognition and self-assembly of metal complexes.
4) Studies on the control of structures and properties of sulfur-bridged polynuclear complexes.

The purpose of our research projects is to prepare novel mononuclear, polynuclear, and metallosupramolecular complexes and to elucidate their molecular structures, electronic states, and functionalities. Our current interest is directed toward the development of fundamental coordination chemistry by utilizing multifunctional metalloligands by using simple ligands.



Department of Chemistry

Laboratory for Condensed Matter Physical Chemistry

Members Yasuhiro NAKAZAWA (Professor), Hiroki AKUTSU (Associate Professor)
Satoshi YAMASHITA (Assistant Professor)

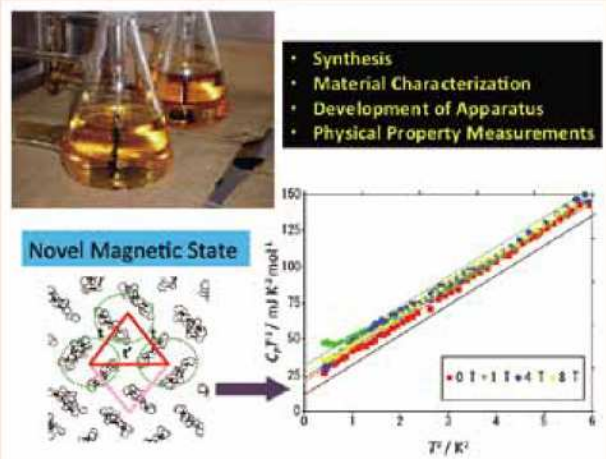
Home Page http://www.chem.sci.osaka-u.ac.jp/lab/Nakazawa/

[Research Area]

1) Phase Transitions and Low-Energy Excitations in Molecular Superconductors.
2) Novel Quantum Behavior in Strongly Correlated Electron Systems.
3) Magnetic Behaviors of Molecular Magnets and Metal Complexes.
4) Search for Novel Quantum Phenomena under Various External Conditions.

We are studying the physical and chemical properties of condensed matter systems which consist of molecules and atoms.

Especially we are interested in finding novel phenomena and their possible mechanisms with regard to superconductivity and magnetism. Along this line, we have constructed our original low-temperature calorimeters for measuring heat capacities of small single-crystal samples. To see the behavior induced by changing the external condition, the calorimetry under external magnetic fields up to 15 T is also performed. Throughout the thermodynamic research, we are aiming at solving the mechanisms of many mysterious behaviors in condensed matter systems.



Department of Chemistry

Laboratory for Surface Chemistry

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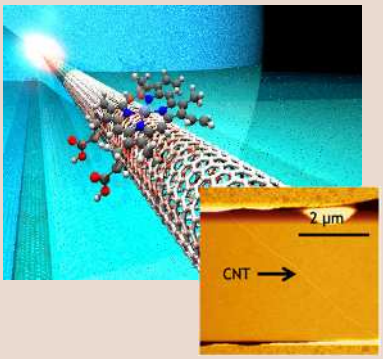
[Research Interests]

(1) Photoemission microspectroscopy for organic films
(2) Electronically excited states of adsorbed molecules
(3) Dynamical molecular redox responses at heterointerfaces
(4) Research of ionic novel functions on metal surfaces
(5) Exploitation of protonic functions in two-dimensional molecular films



[Research Area]

Materials surfaces are important in both basic and applied science, because complex and special reactions of atoms and/or molecules proceed on surfaces. These surface reactions can yield various functions that enable the exchange of energy and information.

In our laboratory, through focusing on the chemical reactions of various molecules occurring on surfaces or within devices with nanoscale metal electrodes, we intend to characterize new molecular functions.

Utilizing various surface analysis methods such as scanning probe microscopy (SPM), photoemission spectroscopy (PES), and nano-scale molecular devices with characteristic measurements, we will elucidate the basic reaction mechanisms and physical properties of molecules.

Department of Chemistry

Laboratory for Molecular Adsorption

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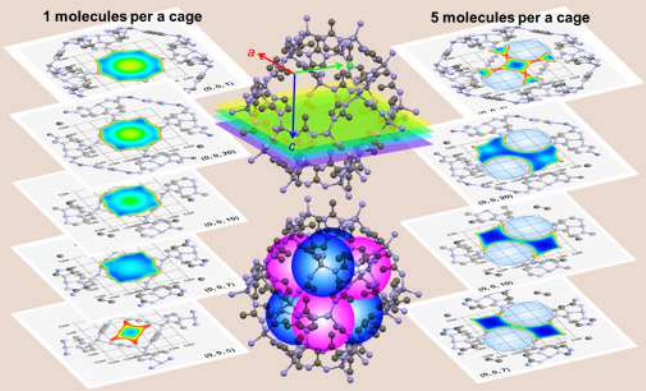
[Research Interests]

1) Investigation of the physical properties and intermolecular interactions of molecules confined in nanospaces
2) Structural and kinetic studies on physisorption in porous materials
3) Development of novel properties and functions by controlling molecular arrangement using nanospaces
4) Development of a brand-new method of porosimetry based on NMR techniques

We primarily focus on molecules confined in nanospaces, which exhibit physical properties and intermolecular interactions different from those in bulk phases.

We elucidate the molecular theory behind physical adsorption on various porous solids by analyzing molecular motion using nuclear magnetic resonance spectroscopy.



Department of Chemistry

Laboratory for Quantum Chemistry

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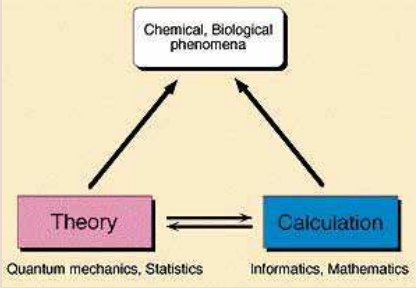
[Research area]

1) Theoretical studies on molecular and electronic structures for atoms, molecules and their clusters.
2) Theoretical studies on chemical reaction.
3) Theoretical studies on electronic, magnetic and photo properties.
4) Theoretical studies on functional, informatics and mathematical systems.

In this laboratory the investigations depending on only theory and calculation are performed for many chemical subjects. We employ quantum mechanics, statistics and informatics as fundamental theory for investigation of electronic and molecular structures.

Moreover, ab initio MO program packages based on our own theory are developed to challenge cluster, biological sciences and etc., which expand possibilities of chemical subjects.

Accurate and huge calculations as well as visualization of their results using super-computers are also applied to the elucidation of intriguing chemical phenomena before experimental studies.



Department of Chemistry

Laboratory for Reaction Dynamics

Members Takuya MATSUMOTO (Professor), Dock-Chil CHE (Associate Professor), Tomoki MISAKA (Assistant Professor)

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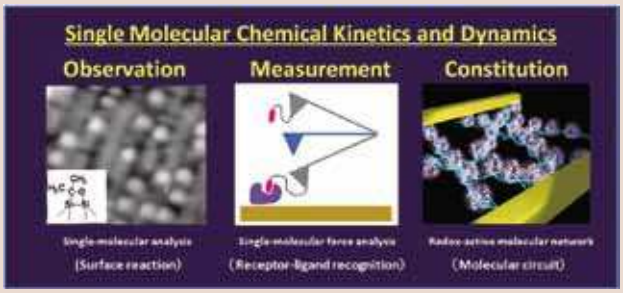
[Research Interests]

1) Time-resolved electrostatic force microscopy for electron- transfer dynamics.
2) Molecular recognition force microscopy for receptor-ligand reaction.
3) Molecular electronics based on redox-active molecular array.
4) Multi-dimensional stereodynamics in the molecular-molecular reactions.
5) Stereodynamics in the molecular-radical reactions.

The chemistry of individual molecules has been a chemist's dream for long time, but today, it is realized by scanning probe microscopy. The method enables us to observe, measure, and manipulate individual molecules in nano-scale.

We are studying molecular recognition and electron transfer using scanning probe microscopy in single molecule level, and interested in finding novel phenomena which differ from those of bulk molecular materials. Along this line, the devices consisting of small number of molecules are also developed from a perspective of molecular electronics.



Department of Chemistry

Laboratory for Structural Organic Chemistry

Members Takashi KUBO (Professor), Tomohiko NISHIUCHI (Associate Professor), Yosuke TANI (Assistant Professor)

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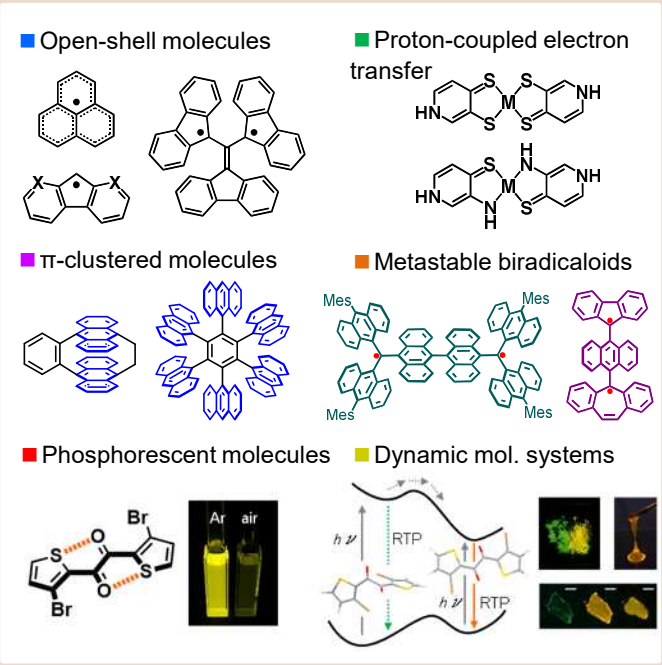
[Research Interests]

1) Synthesis and properties of open-shell molecules
2) Development of proton and electron transfer system
3) Synthesis and functions of π-clustered molecules
4) Physical properties of biradicaloids with reactive metastable forms.
5) Fast & efficient organic phosphorescence
6) Molecular solid/liquid with dynamic functions

π-Electrons in conjugated molecules play decisive roles for the electronic and photo-physical properties of organic compounds. We have been studying designs, syntheses, structures, and physical properties of novel extended π-conjugated systems, with particular emphasis on functional properties such as electron-transport, magnetism, photo-switching, and chiro-optics. Work in these areas is highly synthesis-driven, and is also strongly based on physical organic chemistry. Our wide variety of chemistry will lead to discovery of new class of electronic- and photonic-materials as well as of fundamental scientific ideas.



Department of Chemistry

Laboratory for Functional Molecules and Materials

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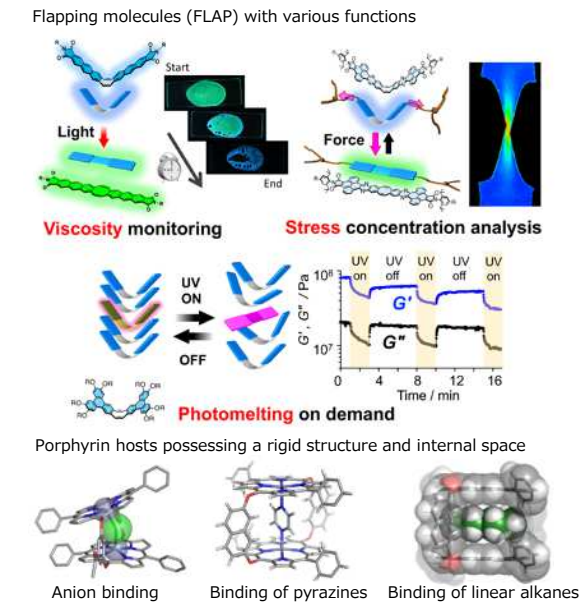
We design, synthesize and materialize unique functional molecules and manipulate their optical, electronic and mechanical properties by controlling their motion and assembly in materials. With the design of organic molecules, we create molecular systems and organic materials that advance science and technology. Our laboratory takes a broad view of research opportunities and fosters academic researchers that will play a leading role in the next generation of science and technology, based on both fundamental science and applied technology.



Department of Chemistry

Laboratory for Organic Biochemistry

Members Yasuhiro KAJIHARA (Professor), Yuta MAKI (Assistant Professor)
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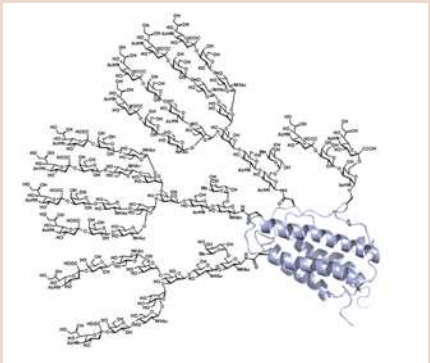
[Research Interests]

1) Chemical synthesis of oligosaccharides
2) Chemical synthesis of glycoproteins and glycopeptides
3) Elucidation of oligosaccharide functions

The oligosaccharides of protein have been thought to concern with protein conformation, dynamics, protein trafficking and glycoprotein lifetime in blood. We have examined synthesis of homogeneous glycoproteins having human complex type oligosaccharide in order to evaluate oligosaccharide functions. We have synthesized several small glycoproteins (amino Acids 40-76 residues), erythropoietin analogue (amino acids 166 residues), and co-stimulate glycoprotein of T-cell (amino acids 120 residues). We have also evaluated the effect of oligosaccharide during protein folding process.



Department of Chemistry

Laboratory for Natural Product Chemistry

Members Koichi FUKASE (Professor), Atsushi SHIMOYAMA (Associate Professor), Yoshiyuki MANABE (Assistant Professor)

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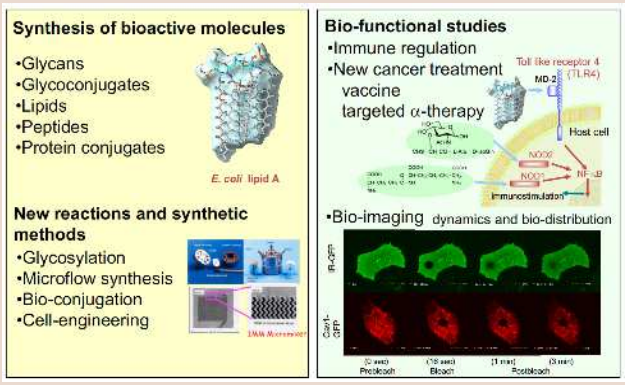
[Research Interests]

- Chemistry and function of immunomodulating substances from microbes and hosts
- Efficient and selective methods for glycosylation and oligosaccharide synthesis
- Bio-imaging of glycans and proteins for the new functional studies
- Targeted α-radiation therapy for cancer

We have studied the syntheses and biofunctions of microbial and host-derived molecules related to important biological phenomena such as immunity, infection, allergy, cancer, and etc. In particular, we have investigated glycans and glyco-conjugates in order to identify the active principle, elucidate the action mechanism, and control the biological responses.

Bio-imaging study of glycans, peptides, and proteins have been investigated by using fluorescent microscopy. Targeted α-particle therapy for cancer is also important project.



Department of Chemistry

Laboratory for Biophysical Chemistry

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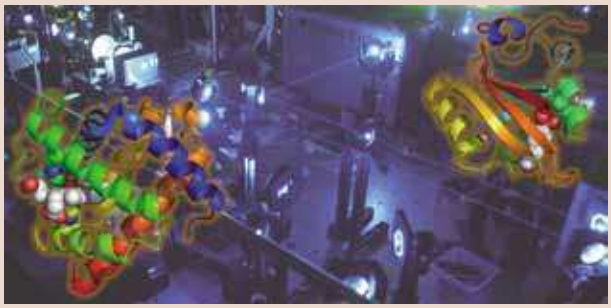
[Research Area]

1) Structural chemistry on allosteric proteins.
2) Creation Energy flow in proteins.
3) of artificial proteins with allostery
4) Allostery and functionality of proteins.
5) Development of techniques for time-resolved spectroscopy.

Our research focuses on functionally-important protein dynamics to elucidate mechanism how they function. Protein dynamics are intimately connected to the structure/function relationship of biological systems. In numerous biological processes, the ensuing protein structural changes accompanying a reaction at a specific site must spatially extend to the mesoscopic dimensions of the protein to achieve a biological function. Protein dynamics span over a wide range of time scales. To answer questions on protein dynamics, we need the concatenation of experimental results recorded over many orders of magnitude of time. In this regard it is important that a single experimental technique can examine protein structures evolving from the earliest moments, such as the picosecond regime, toward time scales that are highly relevant to biological functions, such as the microsecond or millisecond regimes. We are studying protein dynamics in the wide time window by using various time-resolved spectroscopic techniques, such as resonance Raman, absorption, and fluorescence spectroscopy.



Department of Chemistry

Research Center for Thermal and Entropic Science

Members Motohiro NAKANO (Prof.), Yuji MIYAZAKI (Assoc. Prof.), Daisuke TAKAJO (Asst. Prof.), Ewa JUSZYŃSKA-GAŁĄZKA (Assoc. Prof., Cross-Appoint.)

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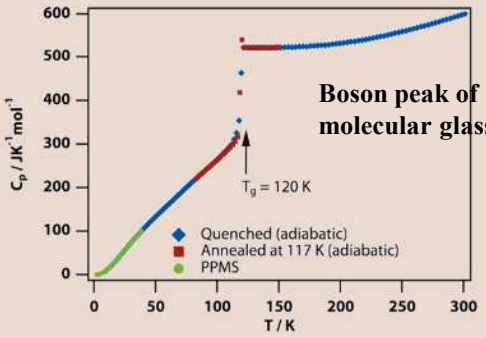
Home Page http://www.chem.sci.osaka-u.ac.jp/lab/micro/

[Research Interests]

1) Thermodynamic investigation on molecule-based magnets.
2) Thermodynamic investigation on biomolecules and macromolecules in aqueous solutions.
3) Thermodynamic approach to biological phenomena.
4) Thermochemical approach to chemical bonds.
5) Structure and thermodynamics of molecular monolayers.

We are particularly interested in "Order and Disorder" created by subtle balance of various intermolecular interactions. Among many experimental techniques used in chemical science, our specialty is to measure the "Energy and Entropy" very accurately by means of calorimetry. Our goal is to combine all the information obtained from both the microscopic and macroscopic investigations to uncover the nature of condensed matter, which leads us to harmonize "*molecular*" sciences and chemical "*thermodynamics*".

Applicability of thermodynamics allows us to target at hard samples including metals, ceramics, and molecular crystals in addition to soft ones like biopolymers, solutions, monolayers, and living things.



Boson peak of molecular glass TBOS

Department of Chemistry

Laboratory for High-Technology Research for the Analysis and Utilization of Materials (The Museum of Osaka University)

Members Jiro TOYODA (Associate Professor), Keisuke MIYAKUBO (Associate Professor)

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Home Page https://www.museum.osaka-u.ac.jp/en/home-en/

[Research Theme]

We are going to apply physical chemistry methods to cultural heritage science, which explores the identification of the date and place, and method of production of cultural heritages, conservation science, which seeks to preserve materials through the study of cellulose and other materials, and exhibition science, which balances the exhibition and conservation of materials.

We are also conducting research of digital databases of information on academic materials stored in museums and other departments, so that researchers of all over the world can use of them.

Department of Chemistry

Center for Education in Liberal Arts and Sciences

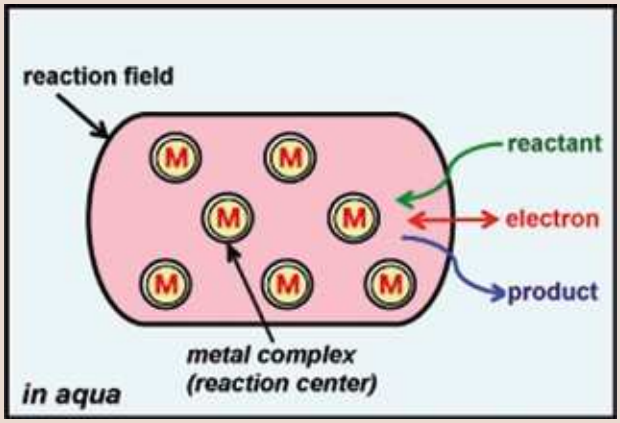
Members Kazuya YAMAGUCHI (Professor)

[Research Interests]

1)Effect of reaction field on the function of model complexes for the active site of metalloenzyme
2)Function conversion of dinuclear metalloenzymes
3)Preparation of new functional materials with biological metal complexes

Metal ions play important roles to maintain structures and functions in biological systems. Our current works are focused on (1) studies of structures and functions of metal proteins (Cu, Ni, Fe etc.) by various spectroscopy, and (2) syntheses and structural and functional characterization of transition metal complexes as models for the active sites of metalloproteins. Specially, we investigate the effect of reaction filed on the function of metal complexes.

Moreover, we challenge the function conversion of metalloenzyme with the metal ion substitution and recombinant DNA methods. We believe that the studies will give the important information for preparation of new functional materials with biological metal complexes.



Department of Chemistry

Laboratory for Isotope Chemistry

(Institute for Radiation Sciences)

Members Takashi YOSHIMURA (Professor), Kazuhiro OOE (Associate Professor)
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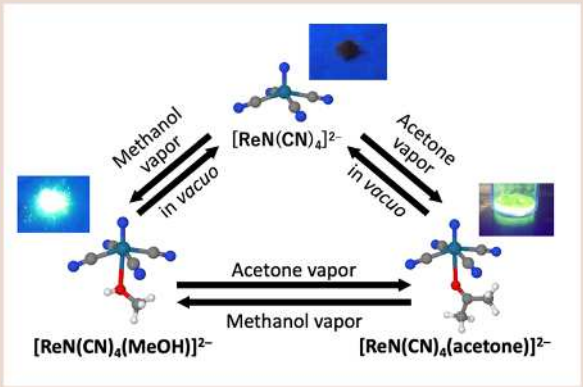
[Research Interest]

1) Synthesis and photoluminescent properties of metal complexes
2) Synthesis and properties of new chelate agents and metal complexes for nuclear medicine
3) Environmental chemistry related to the accident of Fukushima Daiichi Nuclear Power Plant

Our laboratory conducts inorganic chemistry focusing on radioactive and related elements. The purpose of our research is to synthesize new complexes and to investigate the properties. Moreover, we are developing research trace radioactivity in the environment related to the accident of Fukushima Daiichi Nuclear Power Plant.



Department of Chemistry

Laboratory for Beam Chemistry

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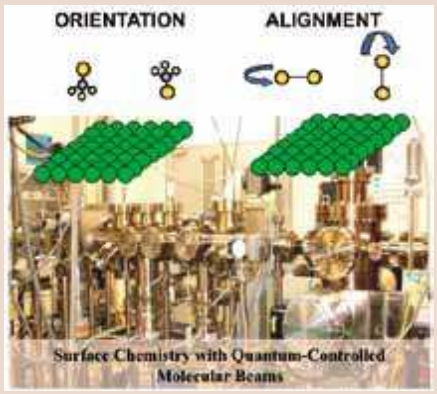
[Research Interests]

1) Stereodynamics of surface chemical reactions induced by molecular beams
2) Surface chemical reactions explored with various surface-spectroscopy techniques
3) X-ray photoemission spectroscopy at SPring-8 for surface chemistry
4) Surface phase transition induced by the low dimensionality
5) Tuning of surface reactivity with surface alloying
6) Development of new type of secondary ion mass spectroscopy with very low-energy ions

We mainly focus on surface chemistry explored with newly developed original experimental techniques and their related equipments.

Particularly, our group is developing molecular-beam and ion-beam facilities for the studies of the elementary processes of surface-chemical reactions and of the surface modification including sputtering.



Department of Chemistry

Laboratory for Radiation Science

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[Research Interests]

1) Research on alpha-ray nuclear medicine therapy using astatine
2) Research on drug manufacturing methods by neutron activation
3) Research on decommissioning of the Fukushima Daiichi Nuclear Power Plant
4) Research on tensan (Japanese oak silkworm) aimed at promoting the Hamadori region of Fukushima Prefectur

Radiation refers to the collective term for high-energy particles and electromagnetic waves, each having different characteristics and utilized in various research and societal applications.
In this laboratory, we conduct research in radiation science with the aim of addressing societal issues and promoting societal applications using radiation and radioisotopes (RI). One of our focuses is on nuclear medicine therapy, a cancer treatment method. We synthesize targeting molecules using medical RIs such as astatine, develop RI labeling methods, and research drug manufacturing methods using neutron irradiation.

Additionally, the recovery of Fukushima Prefecture, which suffered significant damage from the Fukushima Daiichi Nuclear Power Plant (1F) accident, is a societal issue related to radiation. We conduct research on the development of real-time monitoring methods for RI dust necessary for the decommissioning of 1F and silk production aiming to promote local industries in Fukushima Prefecture.

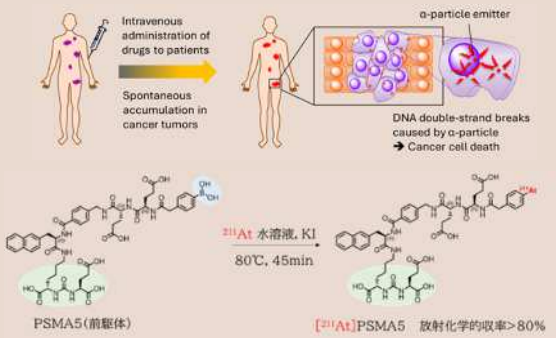

Figure: (Top) Nuclear medicine therapy using alpha radiation, one of the types of radiation. (Bottom) Developed cancer treatment drug (clinical trials started at Osaka University Hospital from June 2024).

Department of Chemistry

Laboratory for Radiation Chemical Biology

(Institute for Radiation Sciences)

Members Kazuya KABAYAMA (Professor)

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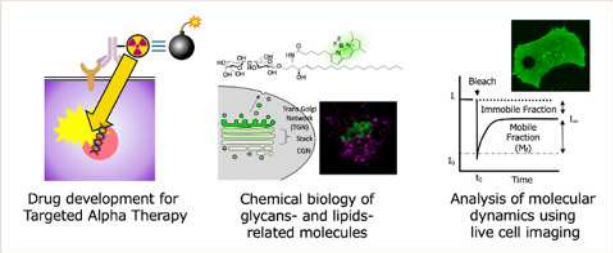
[Research Interests]

1) Drug development for Targeted Alpha Therapy (TAT)
2) Functional analysis of lipids-related molecules involved in innate immunity
3) Investigation of intermolecular interactions by glycans
4) Analysis of molecular dynamics using live cell imaging

Targeted Alpha Therapy (TAT) is a drug therapy that delivers high-energy α-emitting radionuclides to cancer cells to kill them, and is attracting attention as a novel treatment for refractory cancer. We have developed a drug candidate compound labeled with astatine-211 (^{211}At), a short-lived α-emitting radionuclides, and are conducting research in preparation for the First-in-Human (FIH) study, the first clinical trial in which the compound will be administered to humans. In collaboration with synthetic organic chemists, we are also developing fluorescently labeled bioactive molecules and analyzing the functions of sugar- and lipid-related molecules involved in pathological conditions, such as infectious diseases, cancer, and diabetes from a molecular chemistry perspective.



Department of Chemistry

Laboratory for Advanced Mass Spectrometry

Members Michisato TOYODA (Professor), Yoichi OTSUKA (Associate Professor), Yosuke KAWAI (Assistant Professor)

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[Research Interests]

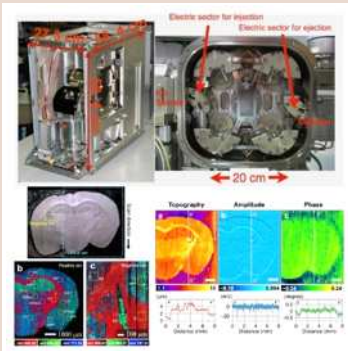
1) Development of advanced mass spectrometry techniques for molecular informatics.
2) Interdisciplinary and cross-disciplinary applied research based on mass spectrometry.
3) Molecular diversity of diseased tissues investigated by high-resolution mass spectrometry imaging techniques.

Mass spectrometry is widely used in various fields, including gas-phase chemical reactions, ultra-trace environmental pollutant analysis, and omics analysis in life sciences, due to its high-precision mass information measurements.

The laboratory's research focuses on the development of mass spectrometry for precise and sensitive measurements of gas-phase ions, as well as interdisciplinary research to evaluate and utilize these methods.

Current research includes the development of compact, high-performance mass spectrometers for on-site measurements, such as real-time analysis of molecules generated on farms.

Additionally, research on mass spectrometry imaging aims to elucidate disease mechanisms and improve medical diagnosis by measuring multidimensional chemical information of diseased tissues.



Development of the compact, high-performance mass spectrometer MULTUM.

Visualization of brain tissue by mass spectrometry imaging.

Department of Chemistry

Laboratory for Radiation Biological Chemistry

Members Kazuko KANEDA-NAKASHIMA (Professor)

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Home Page https://www.chem.sci.osaka-u.ac.jp/lab/medsci/

[Research Interests]

1) Synthesis and isotope labeling of amino acid derivatives for nuclear medicine applications
2) Investigation of the quality of nuclear medicine drugs using short-lived radioisotopes
3) Assessment of Biological Effects of Ingestion of Radioisotopes
4) Functional analysis of cancer cell-type amino acid transporter

Our laboratory is engaged in the labeling of low molecular-weight compounds (sodium salts), middle molecular-weight compounds (amino acid derivatives, transporter inhibitors), and high molecular-weight compounds (antibodies, etc.) with short-lived radionuclides and their functional evaluation for application as nuclear medicine therapeutics. In addition to collaborations with laboratories in the Department of Chemistry, we are involved in the production and separation of nuclides, synthesis and labeling of compounds, and evaluation using living organisms (cells and experimental animals) in cooperation with the Graduate School of Medicine, Graduate School of Engineering, Institute for Radiation Sciences, and Research Center for Nuclear Physics. In addition to this, we are also conducting functional analysis of LAT1, an amino acid transporter that is specifically induced in cancer cells and is one of the molecular targets of nuclear medicine drugs, in an attempt to elucidate the significance of the expression of this molecule in cancer and to develop better therapeutic drugs.

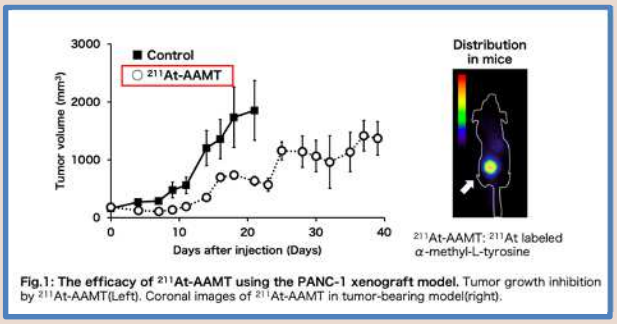

Fig.1: The efficacy of ^{211}At-AAMT using the PANC-1 xenograft model. Tumor growth inhibition by ^{211}At-AAMT(Left). Coronal images of ^{211}At-AAMT in tumor-bearing model(right).

Department of Chemistry

Laboratory for Bio-Nanotechnology

(SANKEN)

Members Masateru TANIGUCHI (Professor), Makusu TSUTSUI (Associate Professor), Hiroyuki TANAKA (Assistant Professor), Yuki KOMOTO(Assistant Professor)

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[Research Interests]

1) Development of a fifth-generation (5G) sequencer that determines DNA and RNA nucleotide sequences and amino acid sequences in peptides in a single molecule
2) Development of methods for the early diagnosis of cancer using a 5G sequencer
3) Development of a nanopore testing method for examining a single virus or bacteria
4) Measurement of chemical reactions at the single-molecule level

We are engaged in the field of single-molecule science, which involves the electrical investigation of single atoms, molecules, viruses, or bacteria through the integration of nanotechnology, quantum metrology, artificial intelligence, and biotechnology. Specifically, we are focused on developing 5G sequencers to directly analyze DNA and RNA sequences along with the amino acid sequences of peptides and proteins. Utilizing these sequencers, we aim to identify new cancer markers and develop methods for the early diagnosis of cancer. Although we have only developed testing methods so far, we will now extend our research to detecting minute amounts of antibodies and antigens in the body and developing drugs for cancer and other intractable diseases.

Additionally, we are exploring methods to measure single-molecule chemical reactions—phenomena previously unobserved. Our objective is to discover chemical reactions not documented in existing textbooks and to observe single-molecule transition states, thereby fulfilling a long-held dream of chemists.

Fig. Shematic of fifth-generation (5G) sequencer.

Department of Chemistry

Laboratory for Transcendental Materials Chemistry

Members Masanori SAKAMOTO (Professor), Keito SANO (Assistant Professor)
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[Research Interests]

1. Converting infrared light into an energy resource
2. Development of transparent solar cells that generate electricity using infrared light

Transcendental materials chemistry laboratory is conducting research to realize the use of infrared light, an untapped solar energy resource, as an energy resource. Approximately half of the sunlight that reaches the earth's surface is in the infrared region (infrared light). However, collecting infrared light and converting it into electrical and chemical has not been achieved. If a method for effectively utilizing sunlight in the infrared region is developed, it will lead to the development of new sustainable energy resources comparable to photosynthesis and solar power generation.

We are also conducting in developing transparent solar cells that take advantage of the fact that infrared light is invisible to the naked eye. Transparent solar cells that generate electricity from sunlight in the infrared region can be installed on existing windows such as residential windows.

This series of discoveries will lead to a breakthrough in the use of infrared light as an energy resource, and will develop into science and technology that will open up a new future that fully utilizes clean and sustainable solar energy.

Department of Chemistry

Laboratory for Regulatory Bioorganic Chemistry

(The Institute of Scientific and Industrial Research)

Members Kazuhiko NAKATANI (Professor), Chikara DOHNO (Associate Professor)
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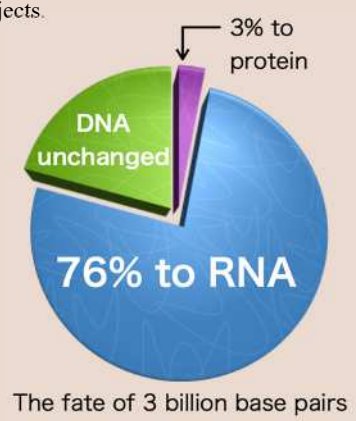
[Research Interests]

1) Chemical Biology of trinucleotide repeats
2) Regulation of gene expression by synthetic small molecule
3) Development of small molecule targeting functional RNAs
4) Development of really useful method for genetic diagnosis

With the technique of accurate synthetic organic chemistry and the knowledge and sense for treating nucleic acids as organic molecules, we focused our research attention on small molecules targeting DNA and RNA that regulates biological functions. Most part of human genome (76%) is transcribed into RNA that does not encode any protein. These non-coding but functional RNAs are important targets for small molecules to regulate biological function. With these studies, we may achieve to develop new technology for human society and to open a new ear in genome science. Toward this end, we have set very challenging research themes. Two approaches, one is from synthetic chemistry and the other is from molecular biology were effectively combined to launch creative studies on these projects.



The fate of 3 billion base pairs in human genome

Department of Chemistry

Laboratory for Complex Molecular Chemistry

(The Institute of Scientific and Industrial Research)

Members Takayoshi SUZUKI (Professor), Yukihiro ITOH (Associate Professor), Yasunobu YAMASHITA (Assistant Professor), Yuri TAKADA (Assistant Professor)

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[Research Interests]

1) Development of epigenetic inhibitors and their applications
2) Target-guided synthesis of enzyme inhibitors
3) Chemical biology and medicinal chemistry for refractory diseases
4) Medicinal chemistry using artificial intelligence

Aiming to develop therapeutic agents and chemical probes, medicinal chemistry and chemical biology studies are conducted in our group. The focused fields of computational molecular design, synthetic reactions, and biological action mechanisms of bio-functional molecules are studied on the basis of organic chemistry. For example, we are working on the development of epigenetic inhibitors and their applications. Epigenetic mechanisms including DNA methylation and histone modifications are regulated by enzymes. The epigenetic proteins form complexes by protein-protein interactions and protein-lncRNA interactions, which regulates epigenetic gene expression. We are trying to identify small molecules that inhibit the function of the complexes and to apply the small molecules to chemical biology studies and drug discovery.

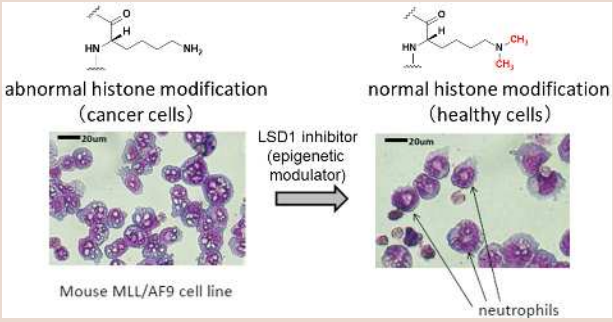

Fig. Cancer therapy by epigenetic modulators.

Department of Chemistry

Laboratory for Synthetic Chemistry for Molecular Systems

(The Institute of Scientific and Industrial Research)

Members Satoshi YAMAGUCHI (Professor), Shinobu TAKIZAWA (Associate Professor), Shinya YAMAHIRA (Assistant Professor)

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[Research Interests]

1) Surfaces for enabling photocontrol of any cell anchoring
2) Methods for converting any biomolecule or cell into the desired stimulus-responsive ones
3) Tools for selectively visualizing molecules and cells within a biological system
4) Workflows for sorting cells based on single-cell images and analyzing their genetic information

With the advancement of data science, vast amounts of information are utilized in life sciences, healthcare, and industry. In such a background, our laboratory is conducting studies with the aim of creating new molecular systems using organic synthetic chemistry to obtain previously unattainable unknown biological data. We focus on the development of synthetic molecules with desired functionalities, engaging in research to efficiently produce, control, and visualize targeted biomolecules and cells. The molecular systems serve as a platform technology addressing a wide range of challenges, from medical fields (Fig. 1) to issues in the food and environmental sectors.

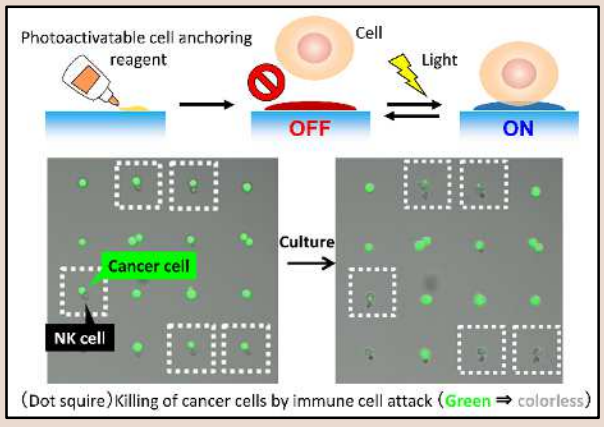

Fig. 1 Single-cell analysis of cancer immunology (*JACS* **2022**)

Department of Chemistry

Laboratory for Protein Organic Chemistry
(Institute for Protein Research)

Members Hironobu HOJO (Professor), Toshiki TAKEI (Assistant Professor)
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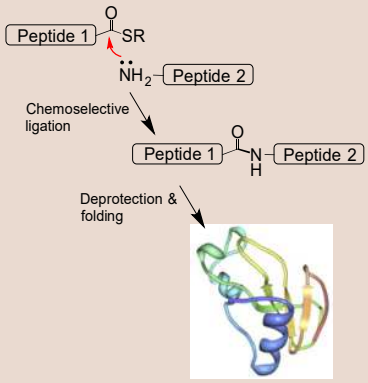
[Research Interests]

1. General studies on a chemical protein synthesis
2. Development of methods for ligation
3. Synthesis, structural and functional studies of membrane proteins
4. Synthetic studies of post-translationally modified proteins

Chemical methods enable the synthesis of proteins, which can not be prepared by the recombinant method, such as site-specifically labeled, glycosylated and phosphorylated proteins. Laboratory of Protein Organic Chemistry is aiming to promote new protein researches using these synthetic proteins. Thus, our laboratory is developing facile methods for protein synthesis based on ligation chemistries. In addition, the synthetic method is applied for the synthesis of membrane proteins and their partial sequences to elucidate the signal transduction mechanism by solid state NMR and IR. Modified histones and their partial sequences, glycosylated proteins are also being synthesized for the functional analyses.



General procedure for chemical protein synthesis.

Department of Chemistry

Laboratory for Computational Biology
(Institute for Protein Research)

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[Research Interests]

1) Data integration for relating molecular-level events to higher-order biological systems.
2) Understanding and predicting molecular interactions involving proteins, modelling biological responses.
3) Transcriptome analysis of early human embryos.
4) In silico prediction of pharmacokinetic parameters.

We aim to increase our understanding of biological systems and diseases by combining computer science and computational chemistry approaches, with applications to drug discovery and other research areas. Artificial Intelligence (AI) is expected to play major roles in many domains. Recognizing that the availability of a large amount of data in a computer-friendly format is key to the successful development of AI models, our research is focused on integrating a wide array of data, including genes, proteins, chemical compounds and diseases. We also develop methods for predicting protein structure, function and interaction, and apply them to specific biological problems.

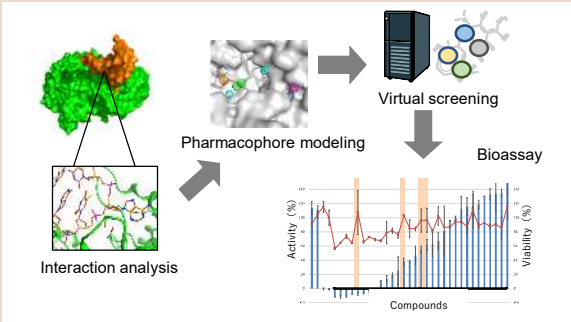

Fig. 1 Structure-based drug design procedure

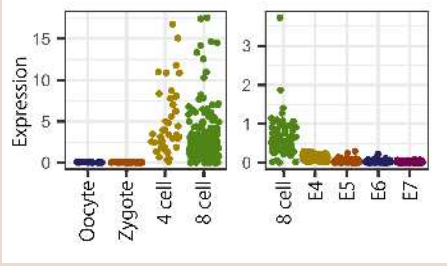

Fig. 2 Expression of LTRs

Department of Chemistry

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