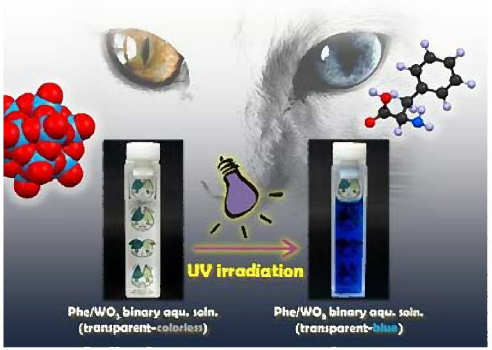
Colloidal Nanostructures and Nanomaterials for Novel Analytical and Measuring Technologies

Surfaces are ubiquitous in nature. Essentially, of everything we see around us, we observe the exposed surface. Surfaces define the boundary with the surrounding environment and influence interactions with that environment, and so it is no surprise that surfaces and interfaces have been intensely studied. Nobel Laureate Wolfgang Pauli once said, God made the bulk; the surface was invented by the devil. We are confronted with interfaces almost every day through phenomena like corrosion, tarnishing of metals, friction, lubrication of moving parts, adhesives, surface tension in liquids and a variety of heterogeneous chemistries in atmospheric (e.g. aerosol chemistry), geological (e.g. mineral oxide–water interfaces) and biological processes.

Nowadays, our research covers areas ranging from the optical and spectroscopic properties of organic/inorganic hybrid nanoparticles and clusters, to the design, assembly and use of nanoparticle-tagged biomolecules as analytical tools for novel sensing, imaging and diagnostics.



Surface-Enhanced Photochromic Phenomena by L-Phenylalanine Adsorbed on Tungsten(VI) Oxide Nanoparticles in Aqueous

About Researcher

ADACHI Kenta, Ph.D.

Ph.D., 2006, Osaka University

WEB ≫ http://researchmap.jp/k-adachi/?lang=english

Fabrication of Novel Functional Semiconductor Materials Using Plasma and Electrochemical Technologies

Our group has conducted research relating to the combination of plasma and electrochemical technologies. Synthetic methods for novel amorphous semiconductor materials (amorphous carbon semiconductors) and their electronic and electrochemical applications are under development. By combining nano-sized template materials (alumina) fabricated by electrochemical oxidation and plasma synthesis, synthetic methods for nano-structured surfaces of semiconductor materials are being established. New electronic and electrochemical applications that utilize the superior characteristics of nano-sized spaces using plasma-synthesized semiconductors have been explored.

Hydrogen plasma for fabrication of B-doped diamond

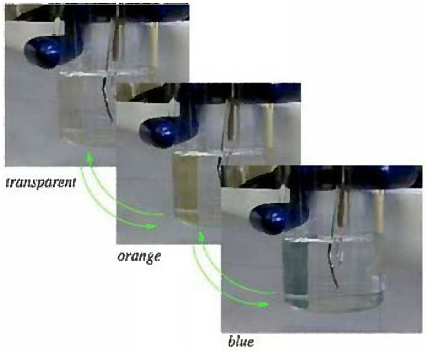
About Researcher

HONDA Kensuke, Ph.D.

Ph.D., 2001, The University of Tokyo

Development of Novel Functional Molecules Based on Physical Organic Chemistry

Based on mechanistic studies of organic reaction chemistry, new functional molecules and devices utilizing unique features of reactive intermediates and specific mechanisms of electronically activated reactions are explored. Organic photochemical reactions and electrochemical or light-induced electron-transfer reactions frequently involve electronically excited states or open-shell species exhibiting quite unusual physical properties, which may be employed as key components of novel functional materials. Our research covers: 1) design of organic reactions using photochemically or electrochemically generated intermediates such as radicals, carbenes, nitrenes and radical ions toward new molecular electronic or photoactive devices, 2) application of electron donors, acceptors and stable radical species for externally controlled molecular conducting, magnetic, light-emitting, energy, electron and information storage materials, 3) preparation of photochromic or other switching molecules showing logical circuit-like responses and 4) construction of ordered structures such as multilayers or amorphous materials with concentration gradients to realize novel functionality.



Three-color electrochromism of poly(tetraarylbenzidine) film

About Researcher

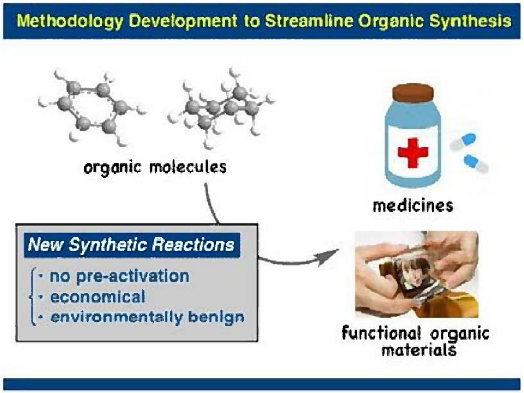
ISHIGURO Katsuya, Ph.D.

Ph.D., 1988, Nagoya University

Methodology Development to Streamline Organic Synthesis

Research Topics
1. Methodology development to streamline organic synthesis
(a) direct functionalization of C-H bonds
(b) two-directional functionalization of C–C multiple bonds
2. Design and synthesis of new medicines and functional organic materials

Direct functionalization of organic molecules is an ideal chemical transformation, because it avoids prior manipulations for the preparation of a pre-activated precursor and thus greatly shortens the synthetic sequences. Among such reactions, we are focusing on methodology development to enable direct functionalization of C-H and C-C multiple bonds that can streamline the design and synthesis of new medicines and functional organic materials.



About Researcher

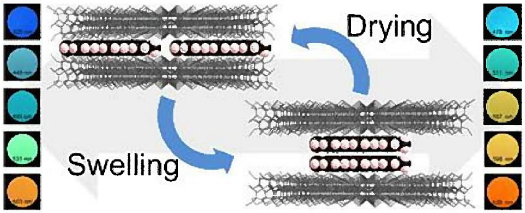
KAMIJO Shin, Ph.D.

Ph.D., 2002, Tohoku University

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~hannou/kjlab/Top.html

Environmentally Sensitive Fluorescent Organic Materials

Our research interests are in the development of organic compounds exhibiting prominent photo- and optical-functionalities. In particular, our recent work is focused on fluorescent compounds that are sensitive to the surrounding environment. Organic compounds confined in the interlayer spaces of nanosheets exhibit specific optoelectronic functionalities that are not observed in the solution, polymer dispersed or pure crystalline states. When a nanosheet that can be swollen is used as the host, the microenvironments of the confined organic compounds, and thus their optical responses, can be switched by swelling and drying. By utilizing this mechanism, chromic materials sensitive to external stimuli, such as humidity and temperature, have been developed. This knowhow has also been utilized to make sensors out of living cells or tissues. We developed fluorescent sensors for determining the activity of mitochondria. The compounds will be utilized as a future therapy for diseases related to mitochondria.



Fluorescent Color Changes of Nanosheet–Organic Compound Hybrid Materials Accompanied by Swelling and Drying

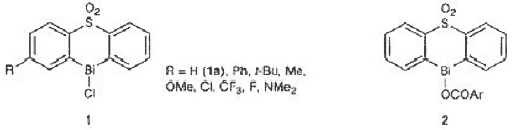
About Researcher

KAWAMATA Jun, Ph.D.

Ph. D. ,1997, Hokkaido University

Synthesis, Structure and Antifungal Activities of Hypervalent Organobismuth Compounds

The biological activity of bismuth compounds has attracted considerable interest due to its medicinal utility. In this regard, inorganic bismuth complexes have been extensively investigated and their history of medicinal applications is very long, whereas organobismuth compounds, containing at least one bismuth–carbon bond, have rarely been studied. We are interested in the structure–activity relationship of organobismuth compounds, and have found that hypervalent organobismuth(III) halides show antifungal activity against the yeast Saccharomyces cerevisiae. The Lewis acidic bismuth center is an active site in organobismuth compounds, and heterocyclic bismuth chloride 1a derived from diphenyl sulfone exhibits high inhibition activity. The inhibition activity of 1 depends on the substituent R, and there is a clear structure–activity relationship between the size of the inhibition zone and the value of ClogP; the antifungal activity decreases as the lipophilicity increases. On the other hand, replacement of the chloro group attached to the active bismuth center with an alternative electron-withdrawing carboxylate group (2) provides important information about the mechanism of action for these organobismuth compounds.



Structure of Our Antifungal Organobismuth Compounds

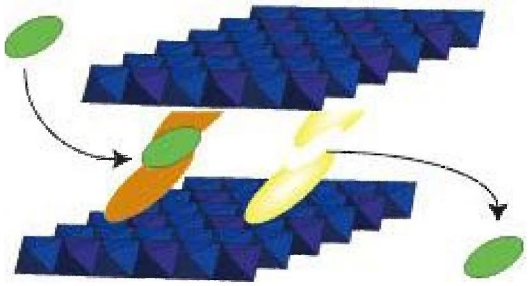
About Researcher

MURAFUJI Toshihiro, Ph.D.

Ph.D., 1993, Kyoto University

Separation and Determination of Toxic Substances Using Materials having Large Surface and Restricted Space.

Our research interests lie in the field of analytical and separation chemistry of toxic substances and metal ions by using unique materials with a large surface and restricted space, such as mesoporous silica and layered double hydroxides (LDH). Modification of the interlayers of LDH or the pores of mesoporous silica with various organic molecules causes the formation of a new unique phase. Fluorescence from the organic substance aids the detection of toxic substances. Therefore, we modify the surface of LDH or mesoporous silica with fluorescent organic molecules having O, N or S atoms. After the modification, metal cations adsorb on the modified solid from aqueous solution. Moreover, confinement effects control the reaction rate and dispersion of the molecules. Unique properties, such as the enhancement of fluorescence, catalytic properties and increment of product selectivity, can be obtained. We aim to develop analytical devices using these materials with mobile, safe and reusable properties.



The change of fluorescence intensity in an LDH interlayer caused by metal ions.

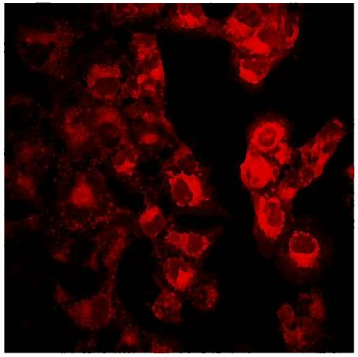
About Researcher

MURAKAMI Yoshiko, D.Sc.

D.Sc., 2009, Yamaguchi University

Development of a Functional Luminescence Bio-Probe

Living organisms are maintained by a concerted mechanism of nano-scale functions of single cells. The relationship between the nano-scale functions of single cells and the vital activity of living organisms has still not been fully clarified due to its complexity. Recently, it has been pointed out that understanding the concerted mechanism of cell clusters is important for the development of medical drugs and medical treatments. To clarify these mechanisms, our research group is studying the technology of non-invasive three-dimensional imaging of single cells and cell clusters. In particular, we are developing molecular probes that indicate biological functions and enable molecular-level visualization of the whole single cell in cell clusters.



Example of an animal cell stained with our luminescence molecular probe.

About Researcher

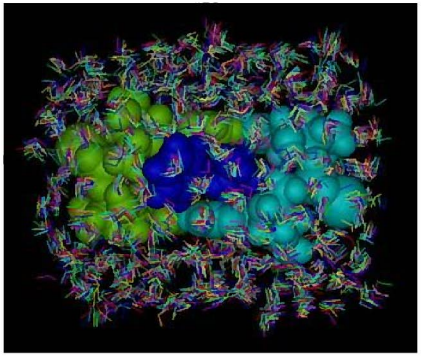
SUZUKI Yasutaka,Ph.D.

Ph.D. , 2011, Yamaguchi University

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~kawalab/index.html

Chemical Reactions and Optical Properties of Molecules in Various Environments Studied by Computational Chemistry

Our research interest lies in the chemical reactions and optical properties of molecules in various environments, such as in solvents, in nanospaces and at liquid–solid interfaces. Research now underway in our laboratory is focused on the following four fields; 1) three-dimensional structure and electronic structure of biomolecules in water, studied by computational chemistry, 2) Gibbs energy analysis of the chemical reactions of biomolecules in water, 3) photodegradation of photosensitive organic dyes at liquid–solid interfaces and 4) molecular dynamics simulations and optical properties of organic molecules and their applications. The thermodynamic properties of an oligopeptide in helix and expanded forms, and Gibbs energy analysis of the intercalation process of a fluorescence probe, ethidium, into successive two base pairs of a double-helical nucleic acid, have been investigated by quantum chemical calculations. Accurate prediction of the thermodynamic stability of biomolecules in water allows us to understand the biological processes more deeply and to develop new anti-cancer drugs. To develop new optical functional organic–inorganic hybrid materials, investigations of the molecular dynamics of organic dyes between two layers of clay minerals are in progress.



Superimposed snapshots containing twenty hydration shells, drawn by simple lines, from a molecular dynamics simulation

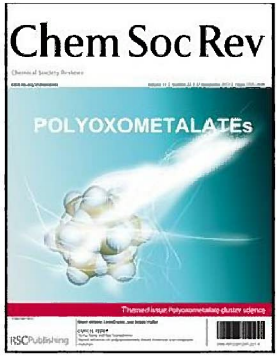
About Researcher

TANI Seiji, Ph.D.

Ph. D. ,1996, Hiroshima University

Development of Functional Molecular-Based Materials

Our research is focused on developing electronically active molecules, such as organic π-molecules and inorganic metal complexes, for their potential applications in future electric devices/materials. Details can be found in recent reviews; Chem. Soc. Rev., 2012, 41, 7384 and Angew. Chem. Int. Ed., 2010, 49, 1736.



Our research is focused on developing electronically active molecules, such as organic π-molecules and inorganic metal complexes, for their potential applications in future electric devices/materials. Details can be found in recent reviews; Chem. Soc. Rev., 2012, 41, 7384 and Angew. Chem. Int. Ed., 2010, 49, 1736.

About Researcher

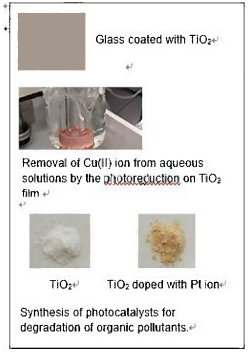
TSUNASHIMA Ryo, Ph.D.

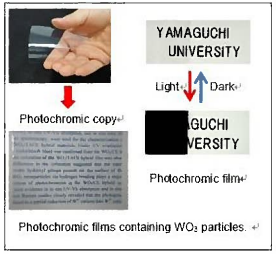
Ph.D., 2007, Hokkaido University

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~ryotsuna/tsuna_en/

Synthesis of Photo-Functional Materials to Solve Environmental Problems

We focus our interest on photochemical reactions aimed at solar energy conversion and degradation of environmental pollutants. We synthesize photo-functional materials by a sol-gel method and clarify the reaction mechanism by kinetic studies. Understanding the surface reactions is essential to improve the performance of these materials. To date, we have developed, for example, glass coated with photocatalytic materials used to trap and recover heavy-metal ions, photocatalytic membranes that require no support structure because they are hardened by low-temperature firing, composite photocatalysts that use two or more semiconductor photocatalysts, and photocatalysts capable of being operated by visible light. We have also succeeded in developing a transparent photochromic film that was colored by near-ultraviolet irradiation and discolored upon cessation of irradiation in air. This film is colored blue, even under sunlight. When colored, the film absorbs infrared light so it can be placed on the surface of a glass window to cut out the infrared light entering a room. We have found that changing the types of dispersants added during film production can control the color retention time.





About Researcher

YAMAZAKI Suzuko, Ph.D.

Ph.D., 1988, Nara Women's University