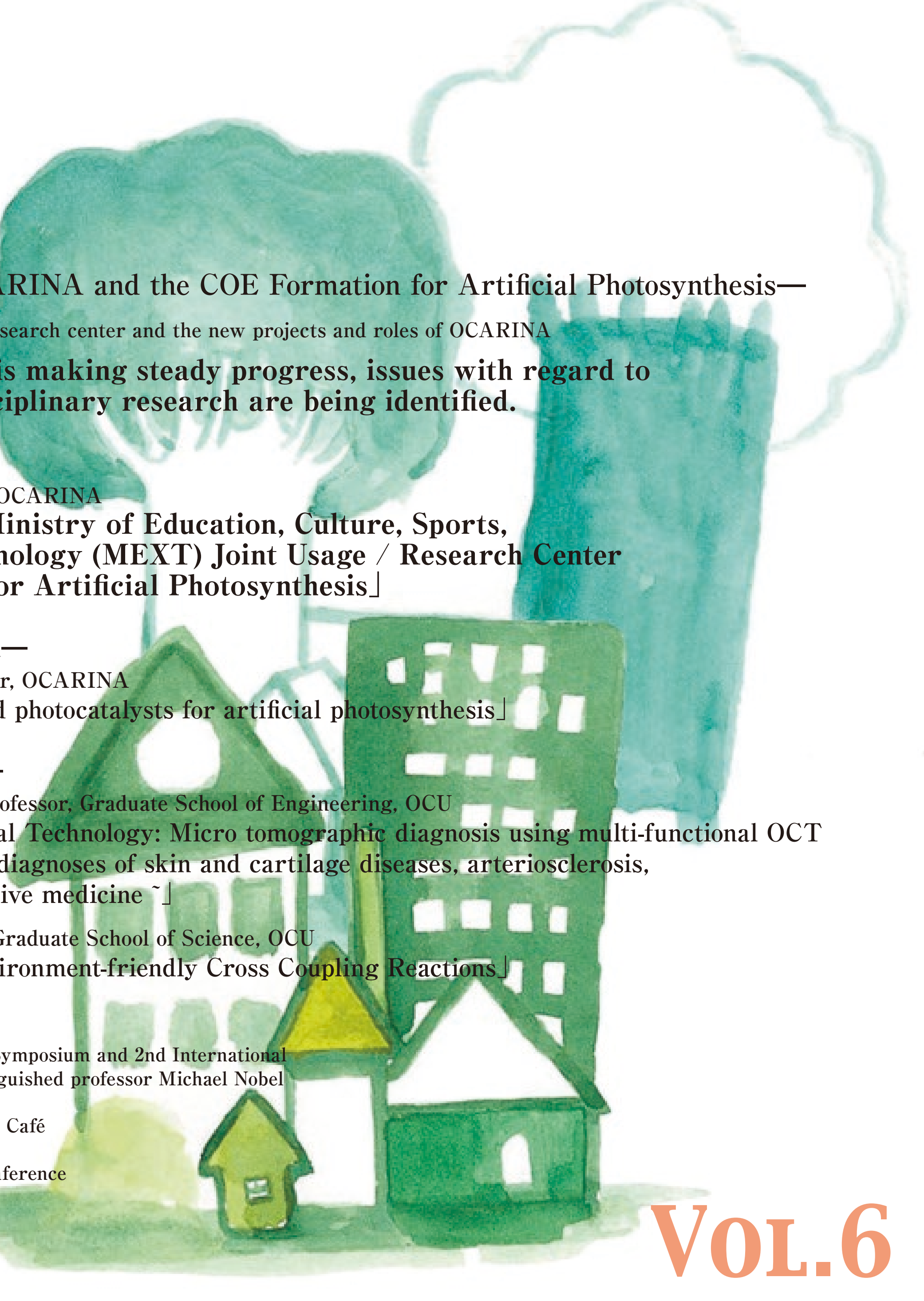
OCARINA通信

The OCU Advanced Research Institute for Natural Science and Technology



—Joint Project of OCARINA and the COE Formation for Artificial Photosynthesis—

Approval as a joint usage/research center and the new projects and roles of OCARINA

While each project is making steady progress, issues with regard to promoting multidisciplinary research are being identified.

—Special Project—

Yutaka Amao　Professor, OCARINA

「Authorized by Ministry of Education, Culture, Sports, Science and Technology (MEXT) Joint Usage / Research Center COE Formation for Artificial Photosynthesis」

—Research Introduction—

Tomoko Yoshida　Professor, OCARINA

「Development of solid photocatalysts for artificial photosynthesis」

—Project Introduction—

Soichi Saeki　Associate Professor, Graduate School of Engineering, OCU

「Advanced Biomedical Technology: Micro tomographic diagnosis using multi-functional OCT ˜ Application to the diagnoses of skin and cartilage diseases, arteriosclerosis, cancer and regenerative medicine ˜」

Tetsuya Satoh　Professor, Graduate School of Science, OCU

「Development of Environment-friendly Cross Coupling Reactions」

—Activity Report—

7th OCARINA International Symposium and 2nd International Symposium in honor of Distinguished professor Michael Nobel

Outreach Activities & Science Café

OCU Tenure Track Study Conference

OCARINA Seminars

木下 佑一氏
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VOL.6

■Joint Project of OCARINA and the COE Formation for Artificial

While each project is making steady progress, issues with regard to promoting multidisciplinary research are being identified.

Each project has been successful, and has received a good response this year. An example is the approval of the Research Center for Photosynthesis as a base for joint use and joint research. Meanwhile, one of the important issues is the training of young researchers. OCARINA is expected to become a place for the training of next-generation researchers and the generation of new ideas through exchanges in different fields of study.

We will take advantage of having been approved as a joint research base to promote our organization both in Japan and abroad.

Dr. Miyano／We were pleased to hear the news of the start of the COE Formation for Artificial Photosynthesis this year. Also, other new projects and sub-projects were launched. I would like to hear your opinions about the current condition and future perspective regarding these points.
First, Dr. Amao, please tell us about the start of the COE Formation for Artificial Photosynthesis.

Dr. Amao／This was our second attempt at obtaining approval, and fortunately we were approved. I think the most important reason for our approval was that we could promote the fact that we have hybrid professionals who specialize in both fields of photocatalysts and biology.
The funds provided by the approval were important for the startup, but the more important thing was the name "the artificial photosynthesis research base". We are now actively engaged in public relations and trying to publicize the fact that we exist.

Dr. Shigekawa／I think I came in 2011, around the same time as Dr. Amao. Since I study solar batteries, I was expecting the study fields of the organization to involve both science and engineering.

Dr. Amao／Yes. I received a lot of advice from you at the first stage. Based on that, I consulted Dr. Kamiya, and determined the current orientation of artificial photosynthesis plus solar power generation. Now, it is OCARINA's next direction.

Dr. Miyano／I think so. The main study topic of the Research Center for Photosynthesis was photosyntheses. A new topic was added and we are advancing in the direction we aimed for.

Dr. Kamiya／First, the Urban Research Plaza was acting in the field of liberal arts, and we started the study project, assuming the integration of arts and sciences. Now, we have the artificial photosynthesis research base as a base for science, and we have made another step toward our ideal image.
Now that we have a base for joint research, the way in which internal and external researchers use the organization to conduct research jointly is important. What do you think about this?

Photosynthesis

Approval as a joint usage/research center and the new projects and roles of OCARINA

profile
Assistant for President, OCU
Director, OCARINA
Michio Miyano

Completed the doctoral program of the Graduate School of Engineering, Tokyo Metropolitan University in March 1980 without obtaining a doctorate. Obtained a degree of Doctor of Engineering. Was a full-time lecturer, professor, Dean of the Graduate School of Human Life Science and the Faculty of Human Life Science of OCU, and became Vice President in 2010. His books include "Great East Japan Earthquake - Volunteering Activities and Temporary Housing" (Kenpakusha, 2014), "Long-period Ground Motion and Seismic Resistance of Buildings" (Architectural Institute of Japan, 2007), "Disaster Prevention Encyclopedia" (Tsukiji-shokan, 2002) and "Great Hanshin Earthquake - Short yet Long Five Years" (Gakugei Publishing, 2000).

profile
Vice Director, OCARINA
Nobuo Kamiya

Graduated from the School of Science and completed the doctoral course at the Graduate School of Science, Nagoya University. Doctor of science. Worked as the guest researcher at the High Energy Physics Research Institute, Photon Factory (PF), the researcher and research sub head at RIKEN and the director of the R&D office of RIKEN Harima Center (Spring-8). Became the professor of the Graduate School of Science, OCU in 2005 and took up his present post in 2010. Awarded the Asahi Prize in 2012.

Dr. Amao／We felt the response was good when many joint researchers came to attend the lecture meeting last December. We made an announcement only on our website, but many researchers outside the university became interested and attended the meeting. The kick-off meeting was held in a room with a capacity of 100, but the room was not large enough, and some people were standing. I was surprised to see that.
We will publicize our organization by holding a large symposium and periodically inviting top researchers in relevant fields, while holding this kind of small-scale meetings on a regular basis.
We will also make an effort to increase the awareness of our organization worldwide. We are thinking of making cards with the URL and Facebook code of our organization, and distributing them at academic conferences to publicize globally.
In order to fan the flame of artificial photosynthesis, we would like more people to know about it, and take various new initiatives as a research base.

Dr. Miyano／It is very good that our university was approved, even though most approved joint research bases are national universities, and that the center has become our second approved organization, following the Urban Research Plaza. We are expecting a lot of development in the future.
Next, let' s talk about the new projects. Could you explain your project, Dr. Saeki?

What is necessary to popularize medical technologies in Japan

Dr. Saeki／Our Advanced Biomedical Engineering project involves the development of medical equipment for diagnosis through the use of light. Our diagnostic instrument can be applied to various parts of the body, so we are working in collaboration with various fields of medicine such as dermatology, orthopedics and digestive and circulatory organs.
At present, we are engaged in the project of making an instrument to evaluate regenerative tissues. Research has focused on tissue regeneration yet we have no evaluation standard for regenerative tissues. We are now developing an instrument that can follow the processes of evaluating, diagnosing and treating regenerative tissues when they are used on actual medical sites.
I' ve been involved in medical engineering for ten years, and I feel that it is not as popular in Japan as it is overseas. I think this is because the relevant companies have established ties with foreign organizations or moved their research bases overseas.

Dr. Satoh／At Japanese universities, the medical department and engineering department are separated physically. Is this another reason?

Dr. Saeki／A difficult aspect of medical engineering is that it requires cross-sectoral knowledge from science to engineering.
At Harvard Medical School, for example, engineers and medical doctors study in the same laboratory, and they have a close relationship. I spend one third of the week studying in a building of the medical department. It may be difficult if we do not have such a close relationship.

Dr. Shigekawa／We are trying to promote collaboration between medicine and engineering, but it is inadequate compared to Harvard. We may need some more time.

Dr. Saeki／At the university I used to work for, I taught students of the medical department in a major. It would be difficult if we do not have such circulation.

Dr. Kamiya／Medicine-engineering collaboration is one of the orientations we should take, and I hope OCARINA can provide support, although I' m afraid it won' t be very easy. It is, however, very significant that we have the Faculty of Medicine. We were already receiving requests for collaboration between medicine and engineering or science before you came, but it didn' t proceed smoothly during some periods. It has just started. I think what we should do from now on is to go by orthodox methods such as steady advertisement and promoting contacts and collaboration between the fields.

Dr. Saeki／Thank you very much. There are some problems to be solved, but anyway, I think it is important for me to continue doing what I should do.

Dr. Miyano／Do you have any expectation for OCARINA?

Joint Project of OCARINA and the COE Formation for Artificial

profile
Vice Director, OCARINA
Naoteru Shigekawa

Graduated from the Department of Physics, Faculty of Science, University of Tokyo in March 1984, and completed the master' s course at the Department of Physics, Graduate School of Science in March 1986. Studied chemical semiconductor hetero binding devices at NTT Atsugi Research Institute for Electrical Communication (present NTT Device Technology Laboratories) from April 1986 until Sep. 2011. Took up his present post in Oct. 2011. Doctor of science

profile
Professor, OCARINA
Yutaka Amao

Obtained a Doctorate in Engineering at the Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology in March 1997. Was a researcher at the Kanagawa Academy of Science and Technology Foundation and the National Aerospace Laboratory of Japan (present-day JAXA). In addition, he was a lecturer, an assistant professor, and then an associate professor at the Faculty of Engineering, Oita University. He became a professor of OCARINA in April 2013. He has also been acting as the Director of the Research Center for Artificial Photosynthesis since April 2015.

Dr. Saeki／At present, only our group is involved in the project of medical engineering. We need to establish an organization equipped with medical instruments that can meet the need for drug development during this time of integration of prefectural and municipal organizations. We are in a good environment to form a team and make it a reality. We will be glad if we can receive support for our project as a symbol of joint research from not only one faculty but from multiple faculties.

Dr. Miyano／It is important to grow the momentum in OCARINA in various respects, including through the integration of prefectural and municipal universities.

Research of organic materials has great potential for development through integration of multiple fields.

Dr. Satoh／I joined the project of advanced materials led by Dr. Shigekawa this year. In the project, my group is specialized in organic materials. We are developing catalytic reactions for the synthesis of π conjugate molecules.
For the synthesis of π conjugate molecules, cross coupling reactions are used widely; however, there are disadvantages such as waste emission and difficulty in getting materials. Our group is trying to find new coupling reactions, using homogeneous catalysts.
In short, we are trying to develop reactions for the synthesis of organic materials, using easy-to-get reagents.

Dr. Miyano／You have been selected as a highly cited researcher by Thomson Reuters for three consecutive years. I hear many people in different fields of study are citing your reports.

Dr. Satoh／Yes. I am developing reactions that bond commercially available reagents, which can be carried out by anyone. That' s why my reports are often cited.

Dr. Miyano／Then, is there a possibility of joint research with different fields of study?

Dr. Satoh／We are already conducting joint research with various companies using organic materials. This university is strong in natural material synthesis, in particular, in organic chemistry, and there are many researchers specialized in the field.
In our group, Dr. Usuki is studying natural material synthesis, and he sometimes uses reactions developed by us to produce molecules he needs.
We are also developing reactions according to the needs of the group of natural material synthesis, so people making natural things, medicine or agricultural chemicals are also interested in our research.

Dr. Miyano／Do you have relationships with the Faculty of Engineering?

Dr. Satoh／We are communicating with researchers of the Faculty of Engineering in order to develop functional molecules for liquid crystal, organic solar batteries and luminescence materials.
When I came to this university, I noticed there was no base organization for researchers of catalysts, so I made a proposal for this sub-project.

Dr. Miyano／I hope the relationships with different fields will increase as a result of this project.

Dr. Satoh／I agree. It is said that catalysts are used in 90% of production processes of commercial chemicals. If there were a place for researchers of catalysts to gather, it would create chances for joint research with various fields.
I expect OCARINA to be used as a gathering place by researchers of different fields with the same purpose of catalyst research.

Dr. Miyano／I think there are many things OCARINA can do to support you.
Now, let us talk about our future activities.

Opening up the future and promoting multiple perspectives through disciplinary integration

Dr. Miyano／Let' s move on to the issue of joint research, industry-academia collaboration and collaboration of universities. When I was listening to Dr. Saeki' s words, I thought that it may be necessary to cultivate human resources who have expertise in multiple fields.
There are some young specially-appointed researchers, but

Photosynthesis

profile
Associate Professor, Graduate School of Engineering, OCU
Soichi Saeki

Obtained a doctoral degree (Engineering) at the Department of System Quantum Engineering, Graduate School of Engineering, University of Tokyo in March 1999. He became a doctoral researcher at MIT in 1999, a lecturer of the Department of Mechanical Engineering, Graduate School of Engineering, Yamaguchi University in 2001, an associate professor of the Department of Applied Medical Engineering, Graduate School of Medicine, Yamaguchi University in 2004, a guest associate professor of the Department of Mechanical Engineering, MIT in 2008, and an associate professor of the Department of Mechanical and Physical Engineering, Graduate School of Engineering, OCT in 2013.

profile
Professor, Graduate School of Science, OCU
Tetsuya Satoh

Graduated from the Department of Applied Chemistry, Division of Engineering, Osaka University. Obtained a doctoral degree (Engineering) at the Department of Applied Chemistry, Graduate School of Engineering, Osaka University. After working as an assistant and an associate professor in the Division of Engineering, Osaka University, he became a professor at OCT in 2015. He also worked as a guest researcher at the University of Rochester (MEXT overseas researcher) (2000~2001) and a guest professor at Osaka University (2015~2017).

we have not established a training system for them. How should we train young researchers in the system, with a focus on researchers who are carrying out project research? What do you think about this issue?

Dr. Kamiya／I think that training of young researchers is really important. It will take 20 or 30 years for artificial photosynthesis to become popular in society. Therefore, it should be supported by students. Whether it is artificial photosynthesis or another project, every research field has its ups and downs. Research flourishes when it is attracting attention, but it loses its speed when it is not. Therefore, I think continuity is a key.

Dr. Miyano／You mean our organization should be a place to train next-generation researchers in addition to a place of advanced research.
Students who experience learning from multiple perspectives naturally tend to be able to integrate different fields of study. It would be great if such young people go into not only academia but also industry, and start up a business or play an active role.

Seeking innovative ideas produced by combining different fields

Dr. Saeki／This might be a digression, but when I was working for MIT, people from various fields such as science, chemistry, engineering, mathematics and material science gathered together. We were presented with a sponsored project and told to divide it into different fields to achieve the purpose.
I wonder if it might be possible to do the same thing at OCARINA. We have a system to support obtaining external funds, and it would be really beneficial to our research. For example, the research support department forms a team in collaboration with OCARINA, and the team supports fundraising and takes the initiative in supporting research.

Dr. Miyano／It would be difficult for OCARINA to do it alone. We should cooperate with the research support department and the coordinators of the URA center, which was established last year for providing support. But it's not impossible.

Dr. Saeki／At MIT, it did not seem that those researchers had had relationships before that. I did not know if there was some kind of database to determine the required researchers according to companies' needs or how those researchers were selected.

Dr. Shigekawa／Did you feel that the university was assuming leadership?

Dr. Saeki／Yes. It may not be popular in Japan yet, but I wish we could do that here. I usually work only with my colleagues within my field of study, but then, people studying in totally different fields from mine gathered together, and proceeded with the project, thinking about what was needed for the project's success. Seeing that, I learnt a lot. I wish we could do the same thing here at OCARINA.

Dr. Miyano／Such management should be conducted by the URA center, but it was established just last year and has not matured to that stage yet. However, I think they are considering a similar thing. OCARINA can provide such an occasion through support for other organizations.

Dr. Satoh／Individual researchers will be able to work easily if the goal is clear, even if the project is a little separate from their own field.

Dr. Miyano／The project groups are not interacting actively now. If OCARINA can deepen relationships between people of different specialties, disciplinary integration can be realized right here.
I will be very delighted if people who meet here form new groups which are not limited by boundaries between projects, to take on challenges for innovation.

Dr. Kamiya／I totally agree with you. At present, each project is moving in parallel with others. However, OCARINA's original concept is to provide a place for creating new projects through integration. First, we aim to realize one example of such a project.

■Special Project

Authorized by Ministry of Education, Culture, Sports, Science and Technology (MEXT) Joint Usage / Research Center COE Formation for Artificial Photosynthesis

profile
Professor, OCARINA
Yutaka Amao

Obtained a Doctorate in Engineering at the Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology in March 1997. Was a researcher at the Kanagawa Academy of Science and Technology Foundation and the National Aerospace Laboratory of Japan (present-day JAXA). In addition, he was a lecturer, an assistant professor, and then an associate professor at the Faculty of Engineering, Oita University. He became a professor of OCARINA in April 2013. He has also been acting as the Director of the Research Center for Artificial Photosynthesis since April 2015.

One of Osaka City University (OCU)' s priorities is researching solutions for urban and international environmental problems and new energy production. We have obtained high-level research results in the area of artificial photosynthesis for the production of fuel from solar energy. The Research Center for Artificial Photosynthesis (ReCAP) was established in June 2013 with the support of Osaka City as a base of industry-university-government cooperation. Joint research chairs and departments were organized by OCU instructors who have been engaged in advanced photosynthesis and artificial photosynthesis research, as well as companies involved with that research, to realize artificial photosynthesis, which was until now considered an impossible technology. This is the only facility in Japan for industry-university joint research that has facilities and equipment for artificial photosynthesis.

Artificial photosynthesis is a groundbreaking technology that produces hydrogen and methanol from water and carbon dioxide, using inexhaustible solar energy; it will solve the energy problem that the world will be faced with in the near future. Artificial photosynthesis technology not only contributes to solving environmental problems by decreasing carbon dioxide concentrations that have been increasing due to the use of fossil fuels such as gasoline, but also enables the creation of an ideal sustainable society in which carbon circulates, since low-carbon fuel produced by this technology will reconvert to carbon dioxide after consumption.

Our center is equipped with chemistry laboratories, biochemical laboratories and analysis instrument facilities for joint research chairs and departments. The analysis instrument facilities house state-of-the-art high-accuracy analyzing equipment such as a nuclear magnetic resonance spectrometer, a Fourier transform ion cyclotron resonance mass spectrometer, and an ultra-high luminance X-ray crystal diffractometer, which can also be used by outside researchers. In addition, the center endeavors to provide a better environment for researchers by providing, for example, a female researcher support facility.

In April 2016, ReCAP was authorized by MEXT as a Joint Usage/Research Center focusing on the research of artificial photosynthesis, making the best use of research results that have been achieved so far all over the world. The period of authorization is six years.The Kickoff Seminar on CEO formation for artificial photosynthesis was held on August 17, 2016. Tomoyuki Sakaba, Assistant Manager of Scientific Research Institutes Division, Research Promotion Bureau, MEXT explained MEXT activities for the "Joint Usage/Research Center" and "Project to Promote Characteristic COE — Start-up support," as well as the promotion of research centers for the planning of large-scale academic research projects. He also talked about expectations with regard to the center. Haruo Inoue, Specially-appointed Professor of Tokyo Metropolitan University, delivered a commemorative lecture entitled "The Current Situation and Vision with Regard to Artificial Photosynthesis". He talked about a clear target and the present conditions for the practical use of artificial photosynthesis in society, and explained the drastic measures that will be necessary in the future to bring about change.

Fig.1 COE Formation for Artificial Photosynthesis

Based on OCU' s photosynthesis and artificial photosynthesis research results, ReCAP started as a center of research activities to develop the technology of photosynthesis and artificial photosynthesis for the creation of next-generation energy and as a solution for environmental problems.

I would like to explain the features of COE formation for artificial photosynthesis, as well as future activities. This center is expected to expand the domestic and overseas communities of researchers and joint research networks related to photosynthesis and artificial photosynthesis, disseminate research results, and promote the industry and university collaboration system for practical application of research results. ReCAP is a core of excellence organized by many researchers in various fields to promote the research of artificial photosynthesis and the application of related technology.The situation is such that there is nowhere for researchers studying natural photosynthesis and artificial photosynthesis systems to discuss their research results in Japan or abroad. Now, an artificial photosynthesis system based on natural photosynthesis has been studied vigorously. We have been promoting the study of an innovative photosynthesis system, a hybrid system integrating biological organization and functional materials. The center is disseminating highly original study output focusing on "Photosynthesis and Artificial Photosynthesis," which other laboratories cannot follow. The center's state-of-the-art analytical instruments enable us to respond to joint research in various fields.

In order to advance the joint research at the Joint Usage/Research Center, we set the study period per research topic to three years, and select topics for the departments by advertising outside the university. We conduct joint research to explore new research topics, including the use of analyzing instruments and facilities, and contribute to the training of next-generation human resources. In order to carry out joint research, we reorganized ReCAP and established four departments related to the creation of next-generation energy, so that we can accept a wide range of topics from fundamental studies to application of research results in cooperation with companies. Many joint research projects focusing on artificial photosynthesis are expected to be carried out at this center to foster researcher communities and networks both inside and outside of Japan for practical use of the technology.

We advertised for joint research topics for FY2016 including the following: Analysis of photosynthetic protein mechanism and its application to artificial photosynthesis; Invention of polymer catalyst/biocatalyst for molecular conversion of carbon dioxide; Production of photo-hydrogen using semiconductor photocatalyst / carbon dioxide restoration system; Creation of artificial light collection system and its application to artificial photosynthesis; Solar cell / Energy carrier / Study of artificial photosynthesis to compose chemicals, and selected about 20 projects. We have great expectations for research results related to new photosynthesis and artificial photosynthesis.

In addition to joint research, we provide information related to the "Joint Usage/Research Center" via the website, the new ReCAP facebook page, and semiannual newsletters. In addition, we plan to hold lectures related to artificial photosynthesis on a regular basis, so please have high expectations for the COE Formation for Artificial Photosynthesis.

Please access the following:

Organization of COE Formation for Artificial Photosynthesis

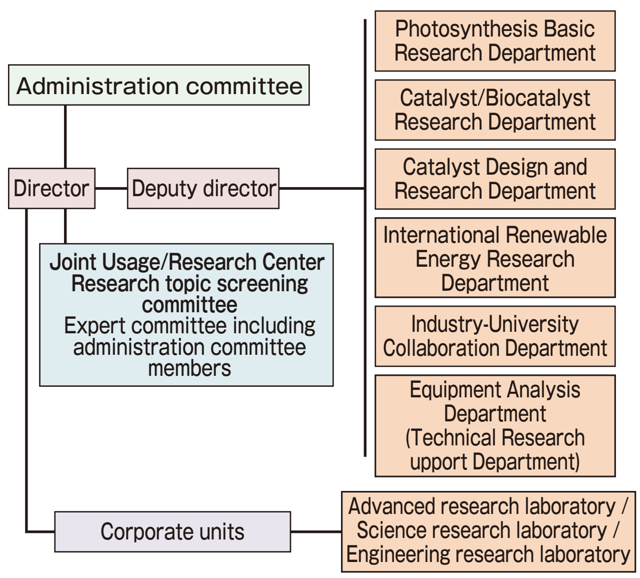


Fig.2: Organization of COE Formation for Artificial Photosynthesis

Website of COE Formation for Artificial Photosynthesis, OCU
http://recap.osaka-cu.ac.jp/ap-coe/index.html

Facebook page of COE Formation for Artificial Photosynthesis, OCU
https://www.facebook.com/RECAPOSAKACUACJP/

Research Introduction

profile
Professor, OCARINA
Tomoko Yoshida

Obtained a doctoral degree (Engineering) at Graduate School of Engineering, Kyoto University in 1996. Through a fellowship (PD) of the Japan Society for the Promotion of Science, she became an assistant of the Graduate School of Engineering, Nagoya University in June 1996. After working as an associate professor of the above graduate school and Eco Topia Science Institute of Nagoya University, she became a professor of OCARINA in April 2015.

Development of solid photocatalysts for artificial photosynthesis

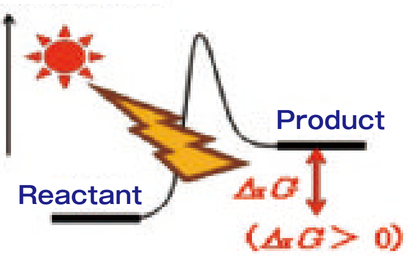
I moved from the Eco Topia Science Institute of Nagoya University to OCARINA on April 1, 2015. At Nagoya University, I studied solid materials that express functions when illuminated by radial rays with various energetic spectra (infrared rays to γ-rays).
For instance, when solid materials are illuminated by high-energy radial rays such as γ-rays and X-rays, many low-energy electrons are generated due to the Compton effect and photoelectric effect. Using these electrons, we succeeded in making harmful chemicals harmless as well as decomposing water and effectively producing hydrogen, a substance that has been attracting attention as a clean energy source.
We applied this method to the development of a power generation system (battery) that uses high-energy radial rays existing in space. At OCARINA, I have been studying solid photocatalysts that express functions by solar radiation.

In order to realize a sustainable society, we need technologies that enable an effective use of the ultimate recyclable energy of solar light and environment-friendly material circulation.
Photocatalysts allow for material transformation with energy accumulation, which is disadvantageous from a thermodynamic perspective; therefore, they are able to realize direct energy conversion from solar light to hydrogen and artificial photosynthesis (CO_2 reduction and generation of hydrogen from water). This is a significant technology that can solve environmental and energy problems.
I am involved in the synthesis and preparation of solid photocatalysts as well as the study of various environment-friendly chemical reactions by means of photocatalysts, in order to understand and improve the functions and performance of photocatalysts.

Meanwhile, in order to control photocatalytical reactions, it is indispensable to understand the atomic structures and electronic conditions of active sites, which continue to change during reactions. I am also engaged in research of advanced nano analysis technology that has integrated synchrotron spectroscopy (XAFS, XPS) and electron microscopy (TEM, STEM, EELS). I am using this technology to separate various atomic structures and chemical conditions in solid photocatalysts, and to clarify atomic structures and chemical conditions of active sites.
I am also studying the reactive mechanisms of active sites by mapping their positions in solid photocatalysts at a resolution of one nanometer and observing during reactions (OperandoIR, optical absorption and luminescence measurement). I believe these analytic technologies will enable rational design and development of new solid photocatalysts.

The following are the main two fields of my studies.

1) CO_2 reduction by semiconductor photocatalysis
This research group is engaged in the study of generating CO, hydrogen and oxygen from CO_2 and water using the gallium oxide photocatalyst with silver particles added.



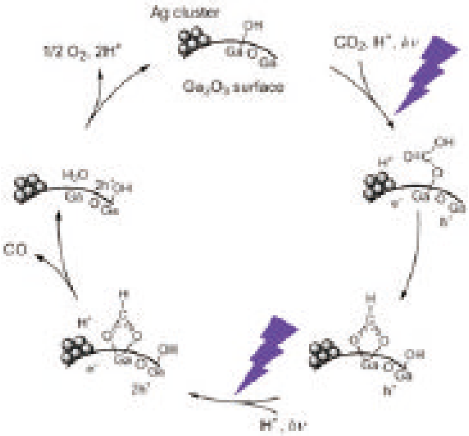


Fig.: CO_2 reduction mechanism by silver-additive gallium oxide (Ag/Ga_2O_3)

We examined the atomic structure and chemical condition of the silver-additive catalyst by various analytical technologies (TEM, HAADF-STEM, XAFS), and identified the dynamic behavior of CO_2 on the surface of the photocatalyst by in-situ FT-IR measurement. As a result, we discovered that the CO_2 generation mechanism changes according to the variance of silver particles in size on a nanometer scale. It was also confirmed that the generation of formate, a reaction intermediate of CO generation, was accelerated when it was close to silver particles of one nanometer in diameter on gallium oxide, and that CO was effectively generated.

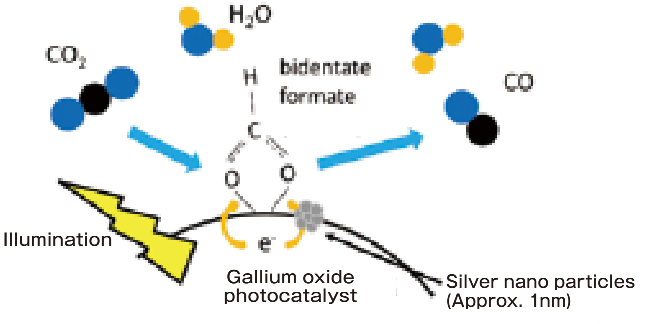


Fig.: CO_2 reduction on gallium oxide with silver nano particles added

2) Semiconductor photocatalyst's responsiveness to visible light

We are studying photocatalytic reaction that generates hydrogen from water and biomass with the aim of producing hydrogen not from fossil resources but from recyclable energy and resources. Most hydrogen generation by semiconductor photocatalysts proceeds only under ultraviolet rays. In order to use solar light effectively, it is important to develop photocatalysts that react under visible light.

One of the disadvantages of the main photocatalyst, titanium dioxide (TiO_2), is that it does not absorb light that has less energy than ultraviolet rays; however, it responds to visible light when the band gap is narrowed by adding nitrogen. We added nitrogen to TiO_2 by means of the ion implantation method, which can control concentration and depth of nitrogen introduction. As a result, we confirmed that the structure and chemical condition around the added nitrogen atoms depend on local nitrogen concentration. In concrete terms, we could present the atomic and electronic structure of a type of nitrogen that could express responsiveness to visible light by means of XAFS, EELS and TEM measurements and theoretical calculation. The figure below presents the difference in hetero structures of nitrogen with different chemical and electronic conditions, which were formed in TiO_2, and their special distribution visualized at a nano level resolution. The mechanism of responsiveness to visual light, about which there is still no consensus, is now being clarified by means of state-of-the-art analysis technology that combines the two methods of radiant light analysis and electro microscopy.

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[2] M. Yamamoto, T. Yoshida, N. Yamamoto, T. Nomoto, A. Yamamoto, H. Yoshida and S. Yagi, J. Phys: Conference Series, vol. 712 (2016) 012074

[3] T. Yoshida, S. Niimi, M. Yamamoto, T. Nomoto and S. Yagi, J. Colloid Interf. Science vol. 447 (2015) 278-281.

[4] M. Yamamoto, T. Yoshida, N. Yamamoto, T. Nomoto, Y. Yamamoto, S. Yagi and H. Yoshida, J. Mater. Chem. A, vol. 3 (2015) 16810-16816.

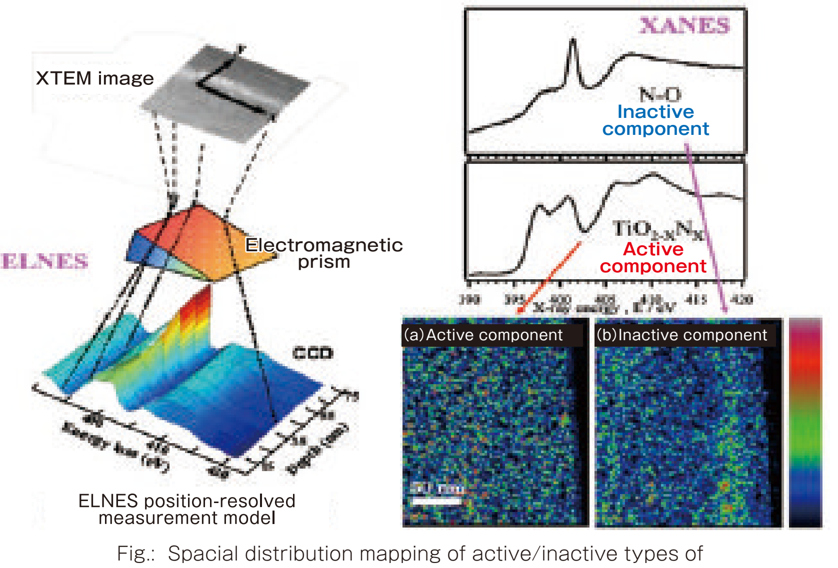

Fig.: Spacial distribution mapping of active/inactive types of nitrogen by means of XANES/ELNES

Project Introduction

profile

Associate Professor, Graduate School of Engineering, OCU

Soichi Saeki

Obtained a doctoral degree (Engineering) at the Department of System Quantum Engineering, Graduate School of Engineering, University of Tokyo in March 1999. He became a doctoral researcher at MIT in 1999, a lecturer of the Department of Mechanical Engineering, Graduate School of Engineering, Yamaguchi University in 2001, an associate professor of the Department of Applied Medical Engineering, Graduate School of Medicine, Yamaguchi University in 2004, a guest associate professor of the Department of Mechanical Engineering, MIT in 2008, and an associate professor of the Department of Mechanical and Physical Engineering, Graduate School of Engineering, OCT in 2013.

Advanced Biomedical Technology: Micro tomographic diagnosis using multi-functional OCT

~ Application to the diagnoses of skin and cartilage diseases, arteriosclerosis, cancer and regenerative medicine ~

Wrinkles and sagging of the skin, which are caused by aging and ultraviolet rays, are also related to a decrease in the metabolism of skin tissue; therefore, micro circulation system including exchanges of interstitial fluid from/to tissues and cells are regarded as an important evaluation index for skin care and anti-aging.The skin tissue consists of the three main layers of epidermis, dermis and hypodermis, and capillaries with a diameter of 10 μm to 20 μm run from the papillary layer under the epidermis to the subpapillary layer at the upper dermis, covering a depth of 500 microns from the skin surface.The properties of micro blood flow and diapedesis of interstitial fluid may change the viscosity and elasticity of the skin as well as metabolic functions. Hence, it is necessary to conduct non-invasive measurement of micro blood flow in order to clarify skin mechanisms such as the generation of wrinkles.

Also, in malignant tumors, which are the top cause of death, metastasis via neovascularization as well as the invasion depth of the tumor determine the cancer stage. Neovascularities grow around tumors, and they transmit more interstitial fluid and activate more exchanges of interstitial fluid compared with normal blood vessels; therefore, the risk of lymph node metastasis increases before that of blood metastasis. Accordingly, the blood dynamics of neovascularities is an important factor in determining treatment policies.The NBI endoscopic system, which is generally used for the diagnosis of cancer of digestive organs, only provides a surface image including overlapping mucosal layers that display the running status of blood vessels. Therefore, it is impossible to evaluate the invasion depth quantitatively or evaluate blood flow mechanisms, and the rate of correct diagnoses depends on doctors' skills.Optical coherence tomography (OCT) was developed recently [1], and it has enabled in vivo non-invasive visualization of morphological distribution of biological tissue. However, this system is based on the low-coherence interferometer; therefore, although it is possible to visualize biological tissue structures on a micro scale, it is impossible to evaluate the functional properties of biological tissue by visualizing blood flow dynamics.

We proposed the optical coherence Doppler velocigraphy (OCDV) system [2], which allows for precise detection of Doppler modulation frequencies in OCT interference signals. We are now developing an instrument for micro tomography that measures blood flow velocity distribution in the capillaries based on video signal rates.Our OCDV system is a low-coherence interferometer based on the fiber-type Michelson interference optical system, using the light source of a near-infrared band of 1,300nm. The reference arm optical system adopted the system that reflects light emitted from the diffracting grating on a curved mirror and conducts tomographic scanning by means of a resonant mirror. It realized high-speed optical path scanning and dispersion compensation.In addition, the adjoining self-correlation method has been introduced to detect phase changes in rear incoherence interference signals from biological tissues, and Doppler modulation generated by the dynamic changes of red blood cells, which indicate the blood flow dynamics, is examined by means of high-precision micro tomographic visualization.As shown in Fig. 1, a system using this technology was produced in cooperation with Takaoka Toko Co., Ltd. and is to be exhibited in Medical Japan 2017 in Osaka this February. It is scheduled to be on the market starting next year.

Figure. 2 shows examples of tomographic images produced by means of our OCDV. These are the images produced by means of micro tomography at 6cm from the wrist of a human forearm flexor for examining the morphological distribution in the skin surface layer and capillary blood flow distribution. Figures. 2 (a) and (b) show the normal condition and avascularization condition using tourniquet respectively.Since the diameter of red blood cells is about the same as the capillary diameter (10 micron), red blood cells flow very slowly (approx. 100 μm/s) and intermittently while deforming, and intermittent Doppler modulation signals are observed. This figure shows the images at the maximum blood flow speed in the data for about two seconds, which are projected on OCT tomographic images.It has been confirmed that the flow speed of blood that comes up from the upper dermis to the bottom of the epidermis is lower in the avascularization condition than in the normal condition. Also, in morphologic distribution of OCT tomographic images, Doppler modulation was detected in the low-brightness part, which was presumed to be blood vessels. Doppler modulation generated from red blood cells flowing in the capillaries was thought to be detected.Hence, this system was found to be effective in the quantitative evaluation of micro circulation mechanisms (metabolism) of skin tissues by visualizing in vivo blood flow speed. This result is expected to become an important evaluation index for skin mechanisms for anti-aging and smart aging. This research is expected to be important not only for medicine but also for the cosmetics industry, and we have been receiving inquiries from transdermal medicine companies and cosmetic companies.We are also studying the appropriateness of micro tomography for examining the blood flow speed distribution and neovascular network blood vessels in micro tumors by applying this method to the animal model of gallbladder cancer. We aim to diagnose the invasion depth of tumors, based on blood flow speed and 3D blood vessel images. This method is expected to be applied to the diagnosis of not only cancers of digestive organs, but also malignant neoplasms of skin cancer and brain tumors. It is also useful in the evaluation of medicine that prevents generation of neovascularization, and can be used for the monitoring of brain blood behavior in neurosurgery for brain infarctions, etc. We are now engaged in the application of this technology to neurosurgery and plastic surgery.

Meanwhile, the main factor leading to cardiac disease, which is one of the three main causes of death, is arteriosclerosis. In this regard, it is important to identify the changes in dynamic properties of biological tissue. Also, it is estimated that 40 million people in Japan suffer from osteoarthritis of the knee, and the understanding of viscosity and elasticity of cartilage is a key to early diagnosis; however, it has not been realized yet.We have developed a multi-functional OCT system, which contains our OCDV system [3] [4] [5], and we are developing a micro tomographic instrument for the diagnosis of dynamic properties of biological tissue (biomechanics, viscosity and elasticity). This can also be used to examine the skin in the fields of cosmetic skin care and plastic surgery and we are working jointly with a cosmetic company.In particular, evaluation of the dynamic quality of regenerative tissues is key to the realization of regenerative medicine and related business plans. We have already obtained the results of experiments using cultured skin models, and this method is expected to be effective for the evaluation of tissue quality.As stated above, we aim to realize a diagnosis system using micro tomography to visualize the functional properties of biological tissue such as blood flow speed, viscosity and elasticity, through collaboration of medicine, engineering and the private sector, and apply the accomplishments to the medical instrument industry, pharmaceutical industry and aesthetic and health industry, thus contributing to society through our support for the treatment of patients.

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[4] S. Saeki, Y. Nakamichi: "Application of the functional OCT using two wavebands to DDS (multi-functional OCT)", Hikari Alliance, 2015
[5] Souichi Saeki, "In vivo and in situ Tomographic Micro-Diagnosis using Functional OCT", Japanese Society of Mechanical Engineering, 26th Bioengineering Conference, Korea and Japan Symposium, 2014, (on CDrom).

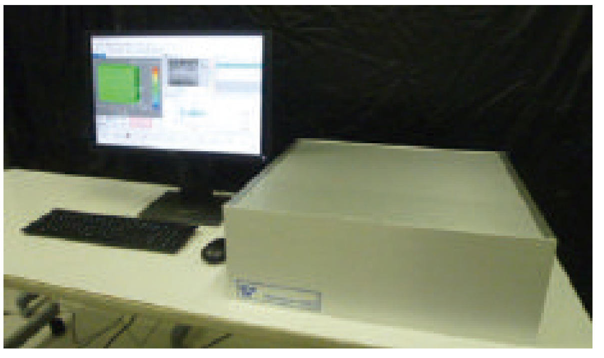

Fig. 1: Smart aging skin diagnosis instrument (OCDV system)
The system based on the accomplishment of this project was produced in cooperation with Takaoka Toko Co., Ltd. and is to be exhibited in Medical Japan 2017 in Osaka this February.

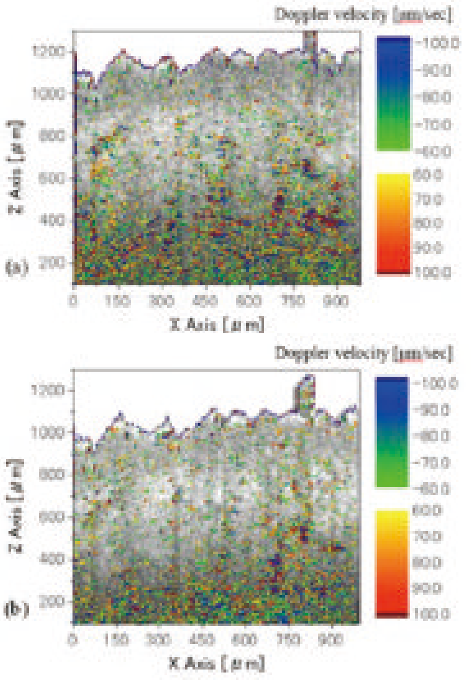

Fig. 2: Micro tomography of tissue morphological distribution and capillary blood flow velocity distribution on the wrist side of a human forearm flexor
The blood flow velocity is lower in avascularization condition using tourniquet (b) than in normal condition (a).

Project Introduction

profile
Professor, Graduate School of Science, OCU
Tetsuya Satoh

Graduated from the Department of Applied Chemistry, Division of Engineering, Osaka University. Obtained a doctoral degree (Engineering) at the Department of Applied Chemistry, Graduate School of Engineering, Osaka University. After working as an assistant and an associate professor in the Division of Engineering, Osaka University, he became a professor at OCT in 2015. He also worked as a guest researcher at the University of Rochester (MEXT overseas researcher) (2000~2001) and a guest professor at Osaka University (2015~2017).

Development of Environment-friendly Cross Coupling Reaction

Biaryl and phenylenevinylene skeletons are widely observed in functional aromatic molecules of medicines, agricultural chemicals and organic electronical materials, and effective production methods have been actively developed. At present, one of the effective methods is the coupling of aromatic halides with arylmetal reagents or alkene, using transition metal catalysts such as palladium, i.e., cross coupling.
This reaction has become famous since Dr. Suzuki, Dr. Negishi and Dr. Heck were awarded the Nobel Prize in Chemistry in 2010. In this reaction, it is possible to induce aryl-aryl bonding or aryl-vinyl bonding regioselectively under mild conditions in a simple manner; therefore, it is widely used in the synthesis of functional molecules not only in laboratories but also in industry. Fig 1(a) shows a representative example of palladium-catalyzed biaryl synthesis reaction.
This conventional cross coupling reaction, however, produces a large amount of waste including metal salt (MX in Fig. 1(a)) in the coupling process, which is a serious issue in synthesis on a large scale. Also, it is difficult to prepare starting materials such as aromatic halides and arylmetal reagents, and their processing can be multi-stage in some cases.

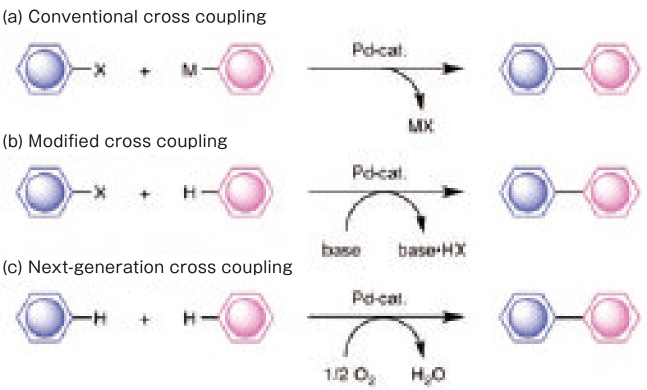

Fig.1: Evolving cross coupling reactions

Accordingly, modified cross coupling reactions have been developed in recent years by replacing one of the pairing materials with aromatic hydrocarbon involving the carbon-hydrogen bond cleavage. (Fig. 1(b)). In 1997, our research group reported the first modified cross coupling reaction in the world, the palladium-catalyzed cross coupling of iodobenzene with 2-phenylphenol. (Fig. 2) [1] Since this reaction does not use an aryl metal reagent, the waste amount was reduced (HX in Fig. 1

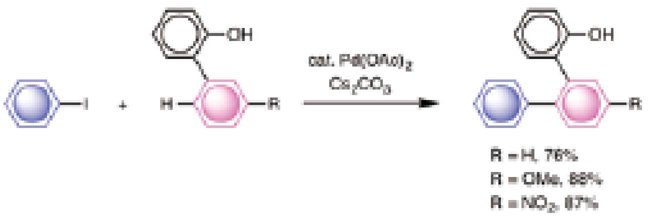

Fig.2: Coupling of iodobenzene with 2-phenylphenol [1]

(b)), and the total number of reaction steps decreased.
After that, next-generation cross coupling, which replaces both of the paring materials with aromatic hydrocarbon, began attracting attention. (Fig. 1(c)) This new cross coupling involves the cleavages of two sets of carbon-hydrogen bonding, and can be implemented in the presence of an oxidant. In particular, when molecular oxygen is used as an oxidant, the waste is only water; therefore, this is an environmentally friendly, clean reaction.
First, palladium was used as a catalyst in the same manner as in conventional cross coupling, and the stoichiometric amount of copper salt was used as an oxidant. (Fig. 3) [2] Palladium catalyst, however, is easy to deactivate under the condition of using molecular oxygen as an oxidant, and it was difficult to realize clean coupling. Therefore, we used rhodium as a catalyst instead of palladium. Under rhodium catalysis, tritylamine underwent intramolecular oxidative aryl-aryl coupling smoothly. (Fig.4) [3] We found out that this reaction can proceed efficiently under the condition of using air as an oxidant. [4] This is the next-generation of aryl-aryl coupling, which produces only water as waste. At present, we are studying how to develop

intermolecular oxidative cross coupling between two aromatic hydrocarbons using this rhodium catalyst.

Oxidative coupling had been studied using palladium catalysts, and there were few studies conducted using rhodium catalysts. We, therefore, studied the oxidative coupling of aromatic substrates with unsaturated compounds such as alkene and alkine.

As a result, we confirmed that this rhodium catalyst

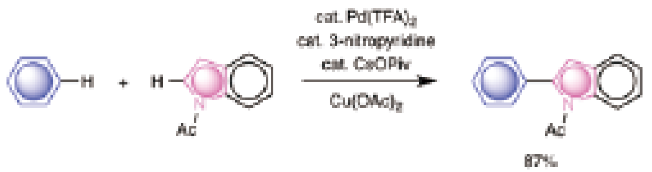

Fig.3: Coupling of benzene with N-acetylindole [2]

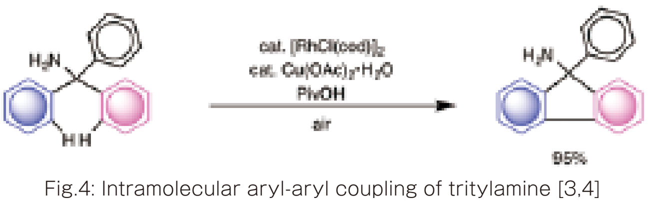

Fig.4: Intramolecular aryl-aryl coupling of tritylamine [3,4]

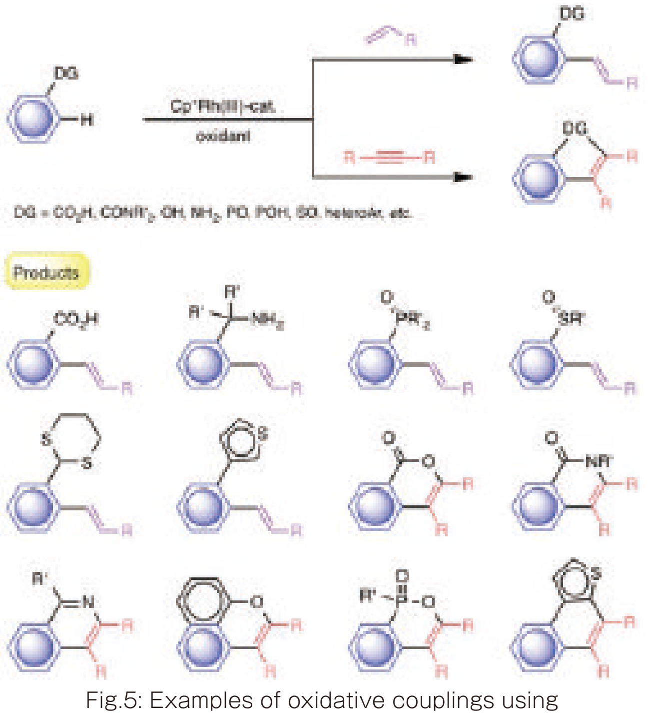

Fig.5: Examples of oxidative couplings using rhodium catalysts [5]

can be applied to a variety of aromatic substrates and shows a very high activity in each reaction. (Fig.5) [5] This oxidative coupling can easily synthesize vinyl arene and condensed hetero aromatic compounds with various structures in one step.

Now many studies have been carried out in the world using similar rhodium catalysts, and various reactions have been developed. We succeeded in the development of other catalysts such as ruthenium and iridium in addition to rhodium, and discovered a number of oxidative coupling reactions specific to these catalysts. In particular, we recently confirmed that cross coupling reactions are possible not only between carbons, but also between carbon and oxygen [6] or nitrogen [7].

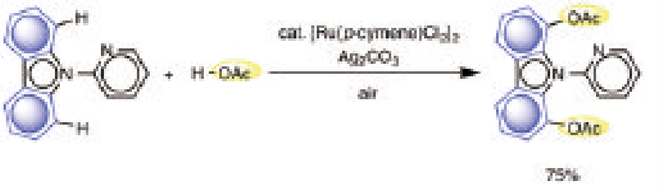

Fig.6: Carbon-oxygen oxidative coupling [6]

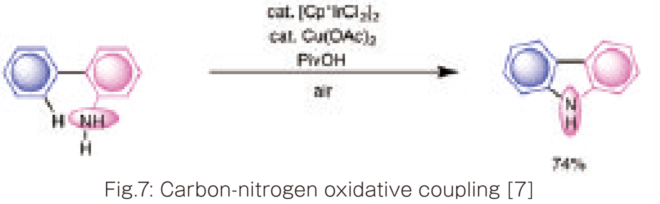

Fig.7: Carbon-nitrogen oxidative coupling [7]

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[3] (a) Morimoto, K.; Itoh, M.; Hirano, K.; Satoh, T.; Shibata, Y.; Tanaka, K.; Miura, M. *Angew. Chem., Int. Ed.* 2012, *51*, 5359. (b) Itoh, M.; Hirano, K.; Satoh, T.; Shibata, Y.; Tanaka, K.; Miura, M. J. *Org. Chem.* 2013, *78*, 1365.
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[5] For the first example, see: (a) Ueura, K.; Satoh, T.; Miura, M. *Org. Lett.* 2007, *9*, 1407. See also reviews: (b) Satoh, T.; Miura, M. *Chem. Eur.* J. 2010, *16*, 11212. (c) Miura, M.; Satoh, T.; Hirano, K. *Bull. Chem. Soc. Jpn.* 2014, *87*, 751.
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[7] Suzuki, C.; Hirano, K.; Satoh, T.; Miura, M. *Org. Lett.* 2015, *17*, 1597.

Activity Report

7th OCARINA International Symposium and 2nd International Symposium in honor of Distinguished professor Michael Nobel

Special Lecture

Dr. Michael Nobel (Distinguished professor, Osaka City University / Chairman, Nobel Sustainability Trust Foundation (NSTF)

Keynote Lecture

Kazunari Domen (Professor, Graduate School of Engineering, University of Tokyo)

Invited Speckers

Dr. Dror Noy (Principal Investigator, Migal-Galilee Research Institute, Israel)
Dr. R.N. Frese (Assistant Professor, VU University Amsterdam, the Netherland)
Dr. Z.-Y. Wang-Otomo (Professor, College of Science, Ibaraki University)
Dr. Chunhong Yang (Professor, Chinese Academy of Sciences, China)
Shuji Nakanishi (Research Center for Solar Energy Chemistry, Osaka University)
Yusuke Yamada (Professor, Graduate School of Engineering, OCU)
Kenji Iwasaki (Associate professor, Institute of Protein Research, Osaka University)
Hideki Kandori (Professor, Graduate School of Engineering, Nagoya Institute of Technology)
Yasuhisa Nakaso (Kansai Electric Power Co., Inc.)
Tomoyasu Noji (Specially-appointed Lecturer, OCARINA)
Ryo Nagao (Specially-appointed Assistant Professor, Graduate School of Engineering, Nagoya University)
Yasufumi Umena (Specially-appointed Associate Professor, Graduate School of Natural Science and Technology, Okayama University)
Keisuke Saito (Lecturer, Graduate School of Engineering, University of Tokyo)
Akihito Ishizaki (Specially-appointed Associate Professor, Institute for Molecular Science, National Institute of Natural Sciences)

Project-team Presenters

Naoteru Shigekawa (Professor, Electric and Information Engineering, Graduate School of Engineering, OCU)
Seiya Kobatake (Professor, Applied Chemistry and Bioengineering, Graduate School of Engineering, OCU)
Masatoshi Kozaki (Professor, Molecular Materials Science, Graduate School of Science, OCU)
Kazunobu Sato (Professor, Molecular Materials Science, Graduate School of Science, OCU)
Makoto Miyata (Professor, Biology & Geosciences, Graduate School of Science, OCU)
Akihisa Terakita (Professor, Biology & Geosciences, Graduate School of Science, OCU)
Muneki Mitamura (Professor, Biology & Geosciences, Graduate School of Science, OCU)
Masatoshi Nishioka (Professor, Urban Design & Engineering, Graduate School of Engineering, OCU)

International Symposiums were held in the OCU Media Center (10F: Large conference room) on March 17 and 18, 2016. The 7th OCARINA International Symposium (in the morning of the 17th and afternoon of the 18th) was held in conjunction with the 2nd International Symposium in honor of Dr. Michael Nobel (in the afternoon of the 17th and morning of the 18th). Eight world-class researchers were invited to each of the two symposiums.

At the OCARINA International Symposium, 16 researchers including OCARINA project team members made presentations in four sessions with the following themes; 1) Studies on photosynthesis, 2) Advanced materials, 3) Advanced biology, 4) Urban energy / Aquifer heat storage research. A lively discussion was held. In addition, presentations on 44 topics were given in the poster session. Poster prizes were awarded to two presenters selected from among 25 topics through a vote held among the symposium participants. (right-hand photos)

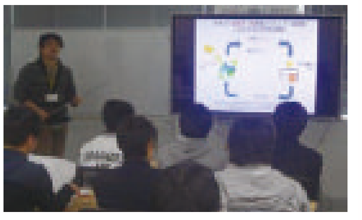
At the Dr. Michael Nobel International Symposium, Dr. Nobel delivered a presentation on advantages and problems with regard to fuel-cell vehicles and electric vehicles from the economical viewpoint, and gave his opinions based on a comparison with hybrid ships developed by a research group in OCARINA. An animated discussion ensued. (bottom photo)

Meanwhile, Dr. Kazunari Domen, a leading photocatalyst researcher (Graduate School of Engineering, University of Tokyo) gave a keynote lecture, and Yusuke Yamada, (Professor, Graduate School of Engineering, OCU) gave a lecture on a related theme in the session. In the session on the use of photosynthesis and photo energy, domestic and overseas young leading researchers including Dr. Dror Noy (Migal-Galilee Res. Inst., Israel), Dr. R.N. Frese (VU, Amsterdam, Netherlands), Dr. Chunhong Yang (Chinese Acad. Sci., China), Prof. Seiu Otomo, (Professor, College of Science, Ibaraki University) and Shuji Nakanishi (Research Center for Solar Energy Chemistry, Osaka University) gave presentations. There was lively discussion throughout the session, and the symposium was very successful.

*An article about this symposium appeared in the Japanese magazine "Seibutsu Butsuri" (Vol.56 No.6) (Serial vol. 328) published by the Biophysical Society of Japan.

Poster prize winners and instructors
(top) Natsuho Terahara (M1, Laboratory of Functional Biosciences, Graduate School of Science, OCU) (right), Makoto Miyata (Professor, OCU) (left) "Novel Chemotactic System Induced by Anaerobic Conditions for Spiroplasma Swimming, Unknown Energy-Conversion Mechanism"
(bottom) Nami Yamano (M2, Laboratory of Biological Structural Chemistry, Graduate School of Science, OCU)(right), Ritsuko Fujii, Associate professor (left) "Structure and Function of the Light-Harvesting Complex II Binding Heterologous Carbonyl-Carotenoids"

Science Café "Color changes!, "Color illuminates!" Let's observe the reaction of photosynthesis - From photosynthesis to artificial photosynthesis"



The Science Café was held in an undergraduate chemistry laboratory in the Science Faculties General Experiment building on January 21 (Sat), 2017. It was held in commemoration of Kodansha's publication of the Blue Backs Series "Dreamy new energy: what is artificial photosynthesis?" This book was given to the participants by OCARINA instructors (Professor Nobuo Kamiya and Associate professor Ritsuko Fujii). At the Science Café, Ritsuko Fujii gave a brief introduction of the Research Center for Artificial Photosynthesis, and Tomoyasu Noji, specially-appointed lecturer, gave a lecture. An experiment was explained briefly, and then conducted. Students who had appeared sleepy during the lecture perked up for picking up the leaves from living plants, and for starting experiment with them. The students asked many questions, and some added a new twist to the experiment; they evidently found it very interesting.

On July 16 (Sat), 2016, a similar seminar entitled "Easy Science and Technology Seminar" was held by Japan Prize Foundation in the same venue. Twenty-two junior high school students participated in the seminar. On November 4 (Fri), 2016, a similar seminar was held in English. Nine international high school students and teachers from Taiwan and Singapore who participated in the 13th High School Chemistry Grand Contest organized by OCU were invited. Both seminars were well received; we realized that people are very interested in the topic, and that it is disseminated widely in Japan and overseas.

Lastly, we would like to express our deep gratitude to everyone for this opportunity, and to the students for their support and cooperation. (Written by the coordinators, Ritsuko Fujii and Tomoyasu Noji)

OCU Tenure Track Study Conference

OCU Tenure Track Study Conference was held at the OCU Media Center on December 9 (Fri), 2016. The conference, which had the sub-theme of "The Future of Science, Technology and Society," was organized and administered by tenure-track instructors. After the opening speech by Takashi Uchida, Professor of Graduate School of Engineering, OCU, Tetsuo Arakawa, President of OCU, delivered a lecture. The audience listened intently to him talking about interesting topics such as the samurai spirit of Tomoatsu Godai, and the most important issues with regard to the city of Osaka.

Five tenure-track instructors gave presentations, and Hideaki Takeuchi, Associate professor of Okayama University and Michio Murakami, Associate professor of Fukushima Medical University, gave lectures. They explained high-level research themes in a way that was easy to understand. Many participants, including students and our instructors, asked questions, and a lively discussion ensued. The conference ended with a closing speech by Hiroyuki Sakuragi, Vice-President of OCU, who thanked the guest speakers and encouraged the tenure-track instructors with regard to their future activities. The conference was highly successful.

OCARINA Seminars

OCARINA seminars are held to provide opportunities for the members of OCARINA to talk with other researchers and give presentations on their research results. In addition to seminars inviting leading scientists from inside and outside of the country, a wide variety of activities such as study tours and PR activities are also held.

29th	Date:	2016年2月29日	Venue:	Faculty of Science No.7 Lecture Room
	Guest:	Tam Mignot (CNRS-Aix Marseille University- Marseille France)		
	Theme:	The Myxococcus Xanthus motility complex: moving parts and fixed anchor points"		
30th	Date:	June 29, 2016	Venue:	Faculty of Science No.6 Lecture Room
	Guest:	Masahiko Hibi (Professor, Bioscience and Biotechnology Center, Nagoya University)		
	Theme:	Analysis of the Mechanism of Axis Formation and Neural Circuit Formation Using Zebrafish		
31th	Date:	Aug 1, 2016	Venue:	Faculty of Science No.6 Lecture Room
	Guest:	Takashi Maoka (Research Institute for Production Development)		
	Theme:	"Distribution and Functions of Natural Carotenoid"		
	Guest:	Kentaro Ifuku (Laboratory of Molecular & Cellular Biology of Topipotency, Graduate School of Biostudies, Kyoto University)		
	Theme:	Crystal Structure of Photosystem II of Higher Plants— Configuration and Functions of Extrinsic Proteins		
	Guest:	Norihiko Misawa (Research Institute for Bioresources and Biotechnology, Ishikawa Prefectural University)		
	Theme:	"Production of Functional Isoprenoid by Means of Pathway Engineering"		
32th	Date:	Aug. 26, 2016	Venue:	Faculty of Science No.6 Lecture Room
	Guest:	Shuichi Nakamura (Tohoku University)		
	Theme:	Motility Mechanism of Bacteria that Uses Stickiness		
33th	Date:	Sep. 2, 2016	Venue:	Faculty of Science No.1 Lecture Room
	Guest:	Mitsuo Shoji (Center for Computational Sciences, University of Tsukuba)		
	Theme:	Theoretical Study on the Reaction Mechanisms of Oxygen-evolving Complex of Photosystem II		

What is OCARINA?

The mission of OCARINA (OCU Advanced Research Institute for Natural Science and Technology) is to find solutions for global-level energy and environmental issues and complex and advanced research subjects, and contribute to the establishment of a sustainable society. As an urban-type university that promotes multidisciplinary research, we set up research projects across the graduate schools.

Since its foundation in 2010, OCARINA has been carrying out large-scale projects with competitive research funds, while promoting globalization, integration of different fields, training of young researchers, and recruitment of female researchers.
Currently, we have five big projects at the four OCU research departments of Graduate School of Science, Graduate School of Engineering, Graduate School of Life Science and Graduate School of Medicine. The most distinguishing feature of OCARINA is the integration of different fields, which is conducted by a small number of selected researchers. With the major city of Osaka as our base, we will continue to promote original research, including collaborative research related to medicine.

History of the Osaka City University Advanced Research Institute for Natural Science and Tehnology

2008	March	Founding Anniversary International Symposium held
	April	The OCU strategic key research project (2008-2011) started
	December	International Workshop held on the efficient use of sunlight energy
2010	March	1st International symposium held
	March	Enforcement of official regulations(start of activities as an official bureau)
	October	Building 2 renovated for research floors of OCARINA
	November	Opening symposium for building 2 of OCARINA held
	December	2nd International symposium held
2011	March	3rd International symposium, “Kakuno memorial,” held
2012	March	Annual meeting and the OCU strategic key research project (2008-2011) debriefing held
	April	The OCU strategic key research project (2012-2014) started
	July	School of Science Building C completed, partial occupation
2013	March	4th International symposium held
	April	2 new full-time staff members appointed
	June	**Research Center of Artificial Photosynthesis opened**
2014	February	Partial occupation for the new School of Science Building
	February	One new full-time tenure track staff member appointed
	March	One new full-time tenure track staff member appointed
	March	5th International symposium held
	April	One new full-time tenure track staff member appointed
	April	The OCU strategic key research project (2014-2015) started
2015	March	6th International Symposium held
	April	One new full-time staff member appointed
	April	New project started
2016	March	7th International Symposium held
	April	The OCU strategic key research project (2016-2017) started
	April	ReCAP authorized as a Joint Usage/Research Center by Ministry of Education, Culture, Sports, Science and Technology (MEXT)
	April	One new project started

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