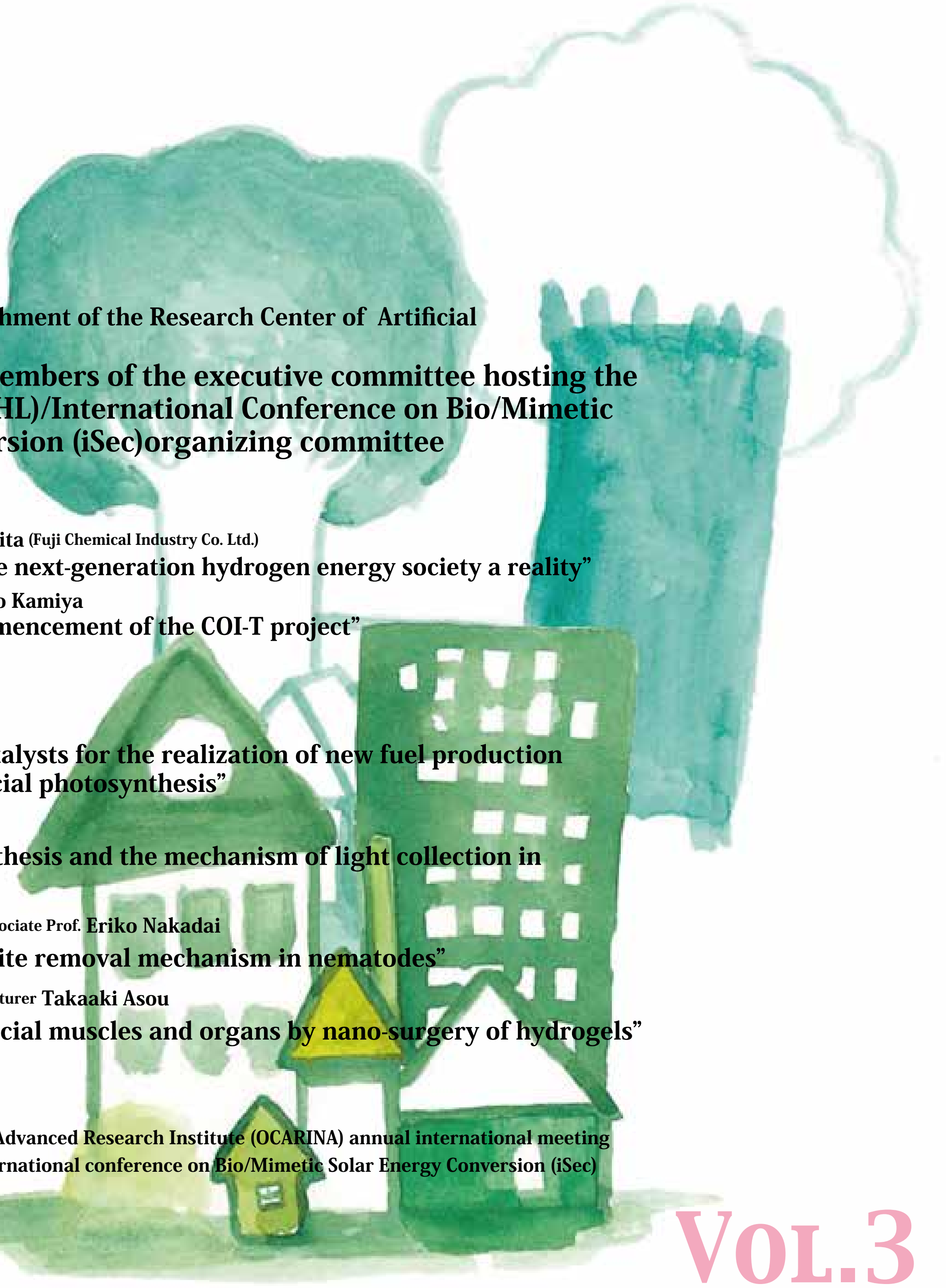
OCARINA通信

The OCU Advanced Research Institute for Natural Science and Technology



—Special Project—

Celebrating the establishment of the Research Center of Artificial Photosynthesis (ReCAP)

Discussion by the members of the executive committee hosting the Asia BioHyLink (ABHL)/International Conference on Bio/Mimetic Solar Energy Conversion (iSec)organizing committee

—Topics—

COI-T Project Leader Eiji Yamashita (Fuji Chemical Industry Co. Ltd.)

"Towards making the next-generation hydrogen energy society a reality"

COI-T Research Leader, Prof. Nobuo Kamiya

"Regarding the commencement of the COI-T project"

—Research Introductions—

Prof. Amao Yutaka

"The necessity of catalysts for the realization of new fuel production techniques in artificial photosynthesis"

Associate Prof. Ritsuko Fujii

"Artificial photosynthesis and the mechanism of light collection in photosynthesis"

Specially Appointed Tenure-track Associate Prof. Eriko Nakadai

"Discovery of a neurite removal mechanism in nematodes"

Specially Appointed Tenure-track Lecturer Takaaki Asou

"Fabrication of artificial muscles and organs by nano-surgery of hydrogels"

—Activity Information—

OCARINA Seminar

2013 Osaka City University Advanced Research Institute (OCARINA) annual international meeting

Asia BioHyLink (ABHL) /International conference on Bio/Mimetic Solar Energy Conversion (iSec)

Trends in external funding

木下 佑一氏
デザイン・イラスト

VOL.3

■ Special Project Celebrating the establishment of ReCAP

Discussion by the members of the executive committee hosting the Asia BioHyLink (ABHL)/International Conference on Bio/Mimetic Solar Energy Conversion (iSec)

Dr. KINOSHITA ／ Five months have passed since the Artificial Photosynthesis Research Center was opened on June 18, 2013. Before full activities begin, thanks to Dr. Miyake's contributions, we have been able to hold an international conference at OCU to celebrate the opening of the Artificial Photosynthesis Research Center. We are holding this discussion during the international conference, which is ongoing successfully. In this discussion, we would like to ask you to discuss the background that led to organizing this international conference and the future management of the Artificial Photosynthesis Research Center.

This discussion is being held with the main speaker and the director of the Artificial Photosynthesis Research Center, Dr. Kamiya. Welcome, Dr. Kamiya.

Dr. KAMIYA ／ As the parent organization of the Artificial Photosynthesis Research Center, the OCU Advanced Research Institute for Natural Science and Technology has studied photosynthesis and artificial photosynthesis for some time. The new research center will initiate applied research in photosynthesis as a part of a university–industry collaboration aimed at putting this science to practical use.

In cooperation with the conference of the Asia BioHyLink (ABHL), we are holding this meeting to introduce our activities. I've just started to study the field of biohydrogen because it is outside my area of expertise. From listening to the discussion of ecology from the viewpoint of a small community, it is my impression that biohydrogen is nearly ready for practical use.

Based on the work of many Asian presenters at the conference, I think that there is a high level of activity in this field, because Asia appears to be in a suitable environment to study photosynthesis. I hope that our discussion today makes the point that the realization of a hydrogen-based society is an immediate goal at each base.

Dr. MIYAKE ／ Thank you.

Dr. KAMIYA ／ Is this biohydrogen conference the tenth meeting?

Dr. MIYAKE ／ It is the eighth.

Dr. KAMIYA ／ Oh, it is the eighth. While listening, I thought that's quite an accomplishment.

Dr. MIYAKE ／ Thank you. As expected, the level of biomass production in Asia is exceptionally higher than that in other regions, so naturally, this topic is relevant to be dealt with here.

Dr. KINOSHITA ／ From listening to your stories today, I wonder that biomass production might compete with biohydrogen.

Dr. MIYAKE ／ Rather than competition, there is potential synergy. In other words, the issue is what kind of energy we use from biomass: biomass itself, hydrogen, or even methane, where there would be no distinction.

Hydrogen can be considered as an advanced chemical substance. I believe that future issues will be addressed with a system appropriate for the time.

Dr. KAMIYA ／ Recently, the term exit strategy has been mentioned frequently. Ultimately, can the exit strategy for a small biohydrogen community be some type of control center that is surrounded by various institutions emitting hydrogen from biomass or from waste?

When thinking about artificial photosynthesis, the desert is one of the targets. I understand that the exit strategy is moving

profile

Professor of OCARINA

Nobuo Kamiya

Visiting researcher at the High Energy Physics Laboratory/Synchrotron Radiation Experiment Institution, vice principal investigator at RIKEN, and chief of the Research Technique Development Section at RIKEN, Harima Branch (large-scale synchrotron radiation facility, SPring-8). In 2005, he became a professor at the Osaka City University Graduate School of Science. Since 2010, he has been a full-time professor at the Advanced Research Institute.

profile

Professor, Graduate School of Engineering Science,Osaka University

Jun Miyake

Completed Doctor's Course at Osaka University, School of Science in 1980
Doctor of Science. Having worked as chief researcher at the National Institute for Advanced Disciplinary Research, the Agency of Industrial Science and Technology, and the Ministry of International Trade and Industry, Doctor Miyake held successive positions as director of the Tissue Engineering Research Center and director of the Cell Engineering Research Division at the National Institute of Advanced Industrial Science and Technology (formerly, the Agency of Industrial Science and Technology). He took up his current post in April 2009. Since then, he has held additional posts including Visiting Professor at the School of Engineering, Tokyo University, Guest Professor at the Institute for Frontier Medical Sciences, Kyoto University, and Guest Professor for the Course of Advanced Medicine, School of Medicine, Osaka University.

Research: Doctor Miyake has won many awards for his work in areas that include regenerative medicine using stem cells, medical/biofunction support robot technology, and bioenergy. These awards include the Director of the Science and Technology Agency's Award, the Minister of International Trade and Industry's Award, and the Akira Mitsui-Memorial Award presented by the International Association of Hydrogen Energy. From 2005 to 2010, he was the Operating Agent of Annex 21 of the International Energy Agency's Hydrogen Implementing Agreement. His interests include cycling and modern art.

in the opposite direction, against producing fuels in very large institutions in a very extensive area. Is it correct?

Dr. MIYAKE ／ -In fact, there are two entirely different approaches. As examples of the first approach, there are projects targeting the desert, as you've just said, and another project being conducted in Brazil to handle a large quantity of biomass to derive ethanol. The second approach is the strategy to use a small amount of biomass that is produced daily in small communities. It is interesting that these approaches are very different but coexist.

Basically, in photosynthesis, it is an effort to get an enthalpy-like gain. However, when it is scaled up, it will be too costly to collect biomass as a product. The use of biomass, which is spontaneously collected in daily life, leads to entropy control.

Dr. KAMIYA ／ Yes, I think so.

Dr. MIYAKE ／ Therefore, the goal of the small system is to establish a project inside a community-sized area where biomass is generated spontaneously. By focusing the technology on entropy instead of enthalpy, we expect that innovations will establish a new approach.

Dr. KINOSHITA ／ Dr. Okura, how do you think that our OCU can be involved in this biohydrogen scenario?

Dr. OKURA ／ I am also interested in biohydrogen production.
I've studied hydrogenase as a catalyst for hydrogen production. Hydrogenase is an enzyme that catalyzes the hydrogen production in water by electron transferring from a suitable donor to a proton. The enzyme can produce hydrogen if it has an electron source. For example, green plants split water producing oxygen during photosynthesis, which means they require reducing power and the produced electrons are transported to Calvin cycle via electron carriers.

If the electrons are donated to hydrogenase by the extraction from the electron carriers, hydrogen will be produced. Thereby complete splitting of water is accomplished. Water can be completely splitted when a hydrogenase system and photosynthesis are combined. However, the hydrogenase is deactivated if hydrogen and oxygen are produced concurrently.

Therefore, the systems should be separated in order for the process to function.

As the earth atmosphere is oxidative, containing a lot of oxygen, photosynthetic organisms requires a reducing power. By contrast, in earliest times when the earth was covered by reducing atmosphere, microorganisms required oxidizing power rather than reducing power. Such organisms contained hydrogenase to produce reducing agents such as hydrogen. Therefore, hydrogen can be produced by utilizing such a system. Complete splitting of water seems to be preferable, and it is much easier to produce hydrogen if we can use another electron donor.

We are interested not only in hydrogen but also in other biofuels such as methanol, producing from CO_2 or methane.

If hydrogen is available, methane bacterium can be used to produce methane by CO_2 reduction with hydrogen. When methane is produced, methane is converted to methanol catalyzed by methane monooxygenase, an enzyme contained by methanotrophs. Methanotrophs are microorganisms cultivated by methane as the only carbon source. When methanotrophs treated with cyclopropanol methanol production is observed because of the deactivation of alcohol dehydrogenase. Methane is easily converted to dimethyl ether which would be more suitable for practical use, because it can be mixed with gasoline.

Dr. KINOSHITA ／ We have good news for the OCU Advanced Research Institute for Natural Science and Technology this year, two professors have joined us since April. Dr. Amao researches on sustainable methanol production, and Dr. Fujii researches on various related projects. Dr. Amao and Dr. Fujii, could you please tell us your opinion on the theme?

Dr. AMAO ／ Originally, I studied the production of methanol from CO_2 using light energy because, as Mr. Okura mentioned, this field has not received much attention. I focus on producing methanol by reducing CO_2 with a hydrogen ion and an electron without using hydrogen gas. While dimethyl ether may be fine as the final product, I think that it is necessary to promote the potential of methanol as a fuel a little more.

For example, an American racing car has a speed potential

Special Project

profile

Specially-Appointed Professor, OCARINA

Ichiro Okura

After becoming a doctoral research fellow at Princeton University, Doctor Okura became an assistant at the Institute of Technology, Tokyo Institute of Technology in 1974. He then held the posts of assistant professor and professor at the same university in 1988. He founded the School of Bioscience and Biotechnology in 1990, and has served as a professor there. He has also served as a Councilor of the Tokyo Institute of Technology, Dean of the Graduate School of Bioscience and Technology, Dean of the School of Bioscience and Technology, and member of the Management Committee. Since 2007, he has served as Vice President for Planning. He became Professor Emeritus of the Tokyo Institute of Technology in 2011. He has served as Specially-Appointed Professor at Osaka City University since July 2013.

profile

Professor, OCARINA

Yutaka Amao

Completed a doctorate in Engineering at the Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology in March 1997. He was a researcher at the Kanagawa Academy of Science and Technology Foundation and the National Aerospace Laboratory of Japan (now JAXA). In addition, he was a lecturer, assistant professor, then became an associate professor at the Faculty of Engineering, Oita University, and is a professor at the Advanced Research Institute since April 2013. He is also a pioneering researcher at the Japan Science and Technology Agency since April 2010.

as high as that of a Formula 1 car if it uses fuel containing 90% or more methanol. Therefore, I believe we must continue to emphasize the importance of methanol as a product of artificial photosynthesis.

As shown in the road map for the Artificial Photosynthesis Research Center, we believe that artificial photosynthetic production of methanol fuel can become practical by 2030.

Currently, my technology is the only technology capable of producing methanol from carbon dioxide using light energy. I enthusiastically want to proceed with this study to identify practical applications.

I've also studied hydrogen production for a long time with Dr. Miyake. Regarding biohydrogen, to produce oxygen and hydrogen by splitting water is very attractive, but it is fraught with various difficulties associated with organic dye molecules that facilitate the use of light energy. However, if biomass such as starch and cellulose can be used as the reducing agent, hydrogen production might be accomplished without using organic dye molecules.

Dr. Miyake and I often talk about not only the production of hydrogen but also its utilization, such as using hydrogen directly in fuel cells to generate electricity.

Dr. FUJII ／ I've studied physical chemistry and used spectroscopy to study the mechanism by which antennae collect light in natural photosynthesis. Natural photosynthetic organisms drive photosynthesis by collecting sunlight with extremely low luminous flux density and channeling it to the photoreaction center. This mechanism to harvest light is highly ingenious and is not fully understood.

With the goal to understand how to link such a mechanism to artificial photosynthesis, I'm committed to the ABHL and the first International Conference on Bio/Mimetic Solar Energy Conversion (iSEC). Previously, I focused on fundamental research, and I felt that this had limited scope. Going forward, I intend to apply a broad vision to seek solutions to energy problems by examining the current situation and asking what energy "substitutes" exist and to what extent alternative energy can provide solutions. I initiated my research with the basic studies, with which I am familiar. I plan to search for paths to link my research results to societal needs, such as energy problems. Going forward, I'm committed to studying these issues. I'm looking forward to doing business with you.

Dr. KINOSHITA ／ Dr. Matsuoka, thank you for joining us today. In this international conference, we ask you not only to be a committee member but also to deliver an invited lecture. We would like to have your opinion on this theme.

Dr. MATSUOKA ／ Thank you. My name is Matsuoka. I work at Osaka Prefecture University. This is the first time I am participating in this conference. I have worked in cooperation with Professor Anpo to study solar energy conversion to chemical energy using inorganic oxide-based photocatalysts. The number of researchers, particularly in Asia, who study photocatalysis has been increasing. The use of light energy and photocatalysts to produce hydrogen from water is under active investigation. However, the mainstream method is still based on using powdered photocatalysts to split water to produce hydrogen and oxygen. In order to use hydrogen from such a reaction system, the method of separating the produced hydrogen and oxygen is important. When a photocatalyst such as titanium oxide is used, only ultraviolet radiation can be used. It is also important to develop photocatalysts that respond to visible light by using the band engineering technique.

In our laboratory, we produce titanium oxide thin film that can respond to visible light by modifying the oxidation state of titanium oxide with a sputtering technique. The material is incorporated into electrochemical reaction cells that enable the separate evolution of hydrogen and oxygen from water. The primary difficulty in our previous studies of water splitting was triggering an oxygen generation reaction involving the transfer of four electrons. If a natural enzyme or an oxidation catalyst used in photosynthesis can be used as co-catalyst for oxygen production from water splitting, studies might broaden in scope and activity might increase dramatically. I hope that our study will have such an effect.

Furthermore, in the field of biohydrogen, the source of the reducing agent is important. However, the OCU has a plant factory. I think it would be a good idea to produce a hydrogen

profile

Associate professor, OCARINA

Ritsuko Fujii

Completed a doctorate in science at the Graduate School of Science, Kwansei Gakuin University in March 2001. She was a specially appointed researcher of the Japan Society for the Promotion of Science (PD) and held successive research positions at the Graduate School of Science and Technology, Kwansei Gakuin University, and the Osaka City University Research Center for Industry Innovation, before being specially appointed as associate professor to the Advanced Research Center. She has been working there since April 2013. She has also been a pioneering researcher of the Japan Science and Technology Agency since October 2011.

profile

Professor, Graduate School of Engineering, Osaka Prefectural University

Masaya Matsuoka

Doctor Matsuoka earned his doctorate in engineering after finishing his doctorate at the Graduate School of Engineering, Osaka Prefectural University in March 1997. After becoming a doctoral research fellow in chemistry at the University of Paris VI (Pierre-and-Marie-Curie University), he took up the position of research assistant at the Graduate School of Engineering, Osaka Prefectural University. He subsequently held the posts of lecturer and associate professor at the same university's Graduate School of Engineering; he has served in his current post since April 2010. His areas of expertise are catalytic chemistry, photochemistry, and physical chemistry.

using a photocatalyst from organic waste fluid derived from the plant factory as reducing power. This system produces CO_2, in addition to hydrogen, however, the system is completely CO_2-neutral. The photosynthetic efficiency of plants can also be improved by returning CO_2 to the plant factory. The issue of using hydrogen after its release has been mentioned already. With regard to this issue, we are studying about the construction of an electrode system, similar to a fuel cell, which can produce electricity by decomposing organic waste fluid using photocatalysts. I hope that we can collaborate with you on such a study.

Dr. MIYAKE ／ The problem of hydrogen as an industrial raw material is also important. As Dr. Okura explained clearly, some types of compounds required when organisms use light are very unstable energy sources. If the process is not photosynthesis, biomass is used. Biomass is stable because it is a reserve substance of energy. If it is converted into the more highly compatible substance hydrogen, it will have major value to the entire society as a chemical raw material.

Dr. KAMIYA ／ This will be our target in the future.

Dr. KINOSHITA ／ Just days ago, we were included in the COI trial. We have planned for starting Center of Innovation for the sustainable future. Actually, a part of the proposal has been accepted by JST, then we will start the trial version of COI. In fact, all of us who must manage this project are core members. Dr. Nango, I know it's sudden, but please comment on or discuss this project.

Dr. NANGO ／ I've conducted fundamental research on artificial photosynthesis antennae with an American group for approximately 35 years. The study on biohydrogen was initiated in the form of international collaborative research for the New Energy and Industrial Technology Development Organization (NEDO) project when Dr. Hashimoto was a professor living in Shizuoka University.

The members of this study included the researchers who conducted fundamental research on photosynthesis antennae in those days: Prof. Richard Cogedll (UK), Prof. Hugo Scheer (Germany), Prof. Paul Loach (US), and us. Dr. Yanagida（Osaka Univ.）, who studied organic solar batteries, and Dr. Okura, who studied hydrogen generation, were also involved in this study. In addition, a group at Toyota Central R&D Labs Inc. conducted fundamental research on hydrogen generation. Dr. Okura had knowledge of hydrogenase, which was already mentioned some time ago.

He participated in the study as an observer and presented at a conference of the society in the UK. This was the starting point 15 years ago. When this project was initiated, the term "artificial photosynthesis" had not even been coined. Therefore, although artificial photosynthesis and biohydrogen were associated, little was known about biohydrogen.

As you know, Dr. Miyake was involved in a hydorogen evolution project in the Ministry of Economy, Trade and Industry, in which he produced hydrogen actively. The concept of a hydrogen society had already been suggested.

At that time, Prof. J. Barber in the UK, whose specialization was same as Dr. Kamiya's, presented the X-ray structural analysis of photosystem II (PSII). He also proposed the English term "artificial photosynthesis."

At that time, studies on an organic solar battery based on photosynthesis had not spread sufficiently. Dr. Miyake presented a rapid photoelectric conversion effect from light to electricity using photosynthesis materials. Since then, we have studied "Solar energy to Fuel" in more advanced forms along with Dr. Amao sitting next to me.

Our study developed the so-called level of "solar energy to fuel" using photosynthesis materials. Currently, it is an extension of the study, as mentioned earlier. I stand here to represent the study. At last, we've just started to find the contact point between artificial photosynthesis with biohydrogen.

The surprising thing about the COI trial is the topic aiming at a hydrogen society and the topic about a small town that will be important to society in 20 years, as mentioned earlier. Of course, what Dr. Miyake previously proposed as a form of a hydrogen community has been fulfilled in unchanged form. An overview of the result of the fulfillment is provided in a video by the Ministry of Economy, Trade and Industry. The recognition is entirely

■ Special Project

profile

Specially-Appointed Professor, OCARINA

Mamoru Nango

In 1974, Doctor Nango took up the post of assistant professor at the Graduate School of Engineering, Osaka City University. After working as a research fellow at Northwestern University's Department of Chemistry and Biology in 1976, he was appointed assistant professor at the Graduate School of Engineering, Nagoya Institute of Technology. Having served (concurrently) as associate professor at the Center for Interdisciplinary Research, Tohoku University, he became Professor at the Graduate School of Engineering, Nagoya Institute of Technology in 2000. In March 2010, he became Professor Emeritus of Nagoya University.

profile

Director, OCARINA

Isamu Kinoshita

Doctor Kinoshita graduated from the Department of Chemistry, School of Science, Tohoku University. He completed a research course at the Graduate School of Science, Nagoya University. He is a Doctor of Science. Having held posts as an assistant, lecturer, and assistant professor at the Osaka City University Graduate School of Science, he was appointed to his current position, which he has held since 2003.

different from the past.

In the present situation, because the contact point between fundamental research and applied research was achieved, we plan to perform the fundamental research in our university to fulfill similar contact points in the future. Based on the suggestion by Dr. Miyake, the base has to be placed at OCU because artificial photosynthesis has not been studied sufficiently in other universities. Thus, we intend to present and manage this field well. Coincidentally, it was the year when the international conference for hydrogen would be held in Japan, so Dr. Miyake said, "Let's conduct it in combination with the establishment of the Artificial Photosynthesis Center." We discussed it for about two year and actually held the conference.

It is expected that primarily Dr. Kamiya and other scientists will proactively conduct such studies, and OCU will provide the Artificial Photosynthesis Center as a base and lead this country in this field in the future. It will not only be a core of excellence base in Japan but also the core in the world.

Dr. MIYAKE ／ I hope that OCU will lead the world, by all means.

Dr. NANGO ／ That topic was about the beginning of the study. First, for the purpose of this study, we have to firmly and properly strengthen our foundation, including in East Asia, with regard to educational environment and future students. In fact, we've done it with the purpose.

Sorry that I spoke longer than you expected.

Dr. KINOSHITA ／ Thank you very much. These background discussions led to the current COI trial. The project leader should become from industry, Mr. Yamashita, belonging to Fuji Chemical Industry Co. Ltd., acts as the project leader. Instead, I would like to have the last comment from Dr. Kamiya as the research leader who actually manages this project from academic part.

Dr. KAMIYA ／ Initially, we began to apply the COI by strongly promoting artificial photosynthesis. This time, considering artificial photosynthesis, it was the trial and adoption in terms of the realization of a hydrogen society.

While listening to the discussion of the topic of biohydrogen involved in ecology, it appears that the hydrogen society is nearing reality. For those of us who aim at the realization of artificial photosynthesis, we think that the targets in the two years of the trial are as follows: to find the balance between artificial photosynthesis and the system that uses the organisms, to develop an artificial system for the balance, to improve it, and to contribute to the realization of a hydrogen society.

In the discussion, the topic of an oxygen-evolving system of PSII, which is my work, was mentioned. Natural photosynthesis is a water-splitting and oxygen-evolving system. If the natural system can be adequately incorporated into artificial photosynthesis system, it would be perfect. Such a system is still partly like a castle in the air, so we want to accelerate development of a hydrogen-evolving system while continually trying various electron sources.

I think that Dr. Amao, Dr. Fujii, and other members will play key roles. By having participated in this conference, I strongly feel that the important thing is communication and information exchange with communities in the forefront of biohydrogen. Thanks in advance for your help.

Dr. KINOSHITA ／ We are halfway through the international conference. It has already achieved great success, and we are excited to continue with the latter half and pray that it ends in success. The meeting is adjourned.

Thank you very much for taking the time to attend this conference.

Presentation of Dr. Masaaki Takabatake (Manager of the department of the local economy of the Kansai Bereau of Economy, Trade and Industry) at ABHL/iSec

■ Topics

Towards making the next-generation hydrogen energy society a reality

profile

COI-T unit project leader Fuji Chemical Industry Co., Ltd. (Group Company) AstraReal Co. Ltd., retail corporate headquarters scientific supervising director and manager of overseas sales.

Eiji Yamashita

Master degree in Pharmaceutical Sciences from Kyoto Pharmaceutical University Graduate School in March 1990; joined Itano Refrigeration Co. Ltd.
Research student at Tokushima University (1993–1998), researcher at School of Medicine, Texas University, San Antonio, USA (1995–1997), obtained doctorate in pharmacy in July 1998 (Tokushima University). Joined Fuji Chemical Industry Co., Ltd. in 2001. Fuji Health Science, Inc. Transfers (California, USA, 2003–2005). Transferred to AstraReal Co., Ltd. in 2012 (current position). Councilor of the International Carotenoid Society (secretary-general) 2011–2014. Qualified pharmacist and doctor of pharmacy. Visiting professor of Osaka City University, Advanced Research Institute, since November 2013. Specialty: Natural products chemistry. Research topics: research on the physiological function and biological activity of astaxanthin and elucidation of its mechanisms, as well as its formulation and product development.

Recently, the Ministry of Education, Culture, Sports, Science, and Technology has adopted a "Next-Generation Hydrogen Energy Society Realization" unit as part of their COI STREAM project, COI-T (trial). This unit places photosynthesis/artificial photosynthesis research at the core, with the driving force behind this research being based mainly at Osaka City University, with links to the University of Osaka Prefecture and the University of Hyogo as a satellite institute. Companies such as Fuji Chemical Industry Co., Ltd., Daiwa House Industry Co., Ltd., Sharp Co., Ltd., Espec Corp., and Glory Ltd. will contribute. The aim is to establish hydrogen production and storage techniques that are clean and safe and to reassure circulating energy by taking advantage of these research results.

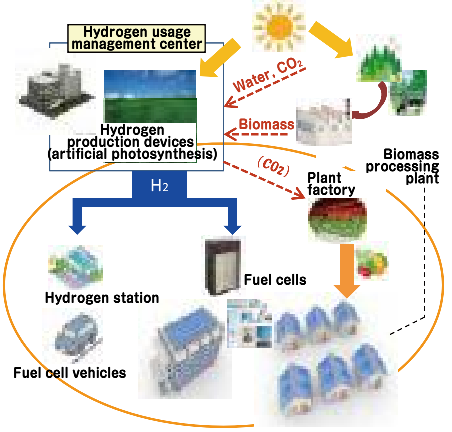
To achieve this, the Osaka City University Center for Health Science Innovation (opened this spring at the conveniently situated Osaka Umeda Kita Yard's Grand Front Osaka institute) has been established as a collaborative research organization. In addition to facilitating face-to-face communication with researchers related to the unit, it will engage in the execution of projects on the basis of careful coordination, with future plans to make use of ICT to establish systems to share information regarding the development status of projects internally and with associated organizations.

COI-T (trial) was recently adopted as a future COI unit candidate. As project leader, in order to verify concepts and the component technology towards achieving this vision, rather than setting a target to verify all application content over a short period of 2 years, I would like to verify core techniques and clarify/define exit strategies towards accomplishing this vision, as well as preserve the organisation unit, among other things, through industry-university collaborations.

Fuji Chemical Industry Co., Ltd. aims for the development and powdering of mesoporous materials that incorporate pigments that are essential for the integration of artificial photosynthesis into devices, by exploiting powder techniques refined over the past 60 years. We will send our researchers into the Artificial Photosynthesis Research Center completed by Osaka City University last year. In addition, astaxanthin, which has recently become an exceptionally popular subject in health food and cosmetics, has been produced by large-scale cultivation of an alga called Haematococcus. Furthermore, in response to the demand, we decided to invest 3 billion yen in the U.S last year, and to extend more facilities, and the second facility will be completed in this May in Washington. Application of this method includes the large-scale cultivation of algae with pigments and photosynthesis proteins useful for hybrid artificial photosynthesis. In addition, the establishment of purification/extraction methods falls within this scope.

For me personally, if the society that fits into the "shape of the future we should aim for" is realized, I would certainly like to put the people first.

<Shape of the future we should aim for>



Outline

Facilities for the production of hydrogen from water and biomass by sunlight are established in the regional community. Fuel cells and hydrogen station facilities are used as electric power and car fuel by households and public services within the community. Compared to hydrogen previously obtained from splitting water (and because it becomes water again after use), the fuel cycle does not burden the environment. CO_2 generated during the production of hydrogen from biomass will be captured together with CO_2 released by factories in the region in a plant factory and used in the high-efficiency production of, for instance, vegetables.

With the exception of persons requiring qualifications, these facilities will be managed by the residents of the region and will be set up in such a way that the elderly and disabled can also work there. In addition, because energy, vegetables, and foodstuffs can be self-sustaining for a certain period, the facilities will be an indispensable foundation to meet the basic needs of residents during disasters.

【Implementation system】

Core institution: Osaka City University; Collaborating institution: The University of Osaka Prefecture
Satellite institution: University of Hyogo
Participating companies: Fuji Chemical Industry Co., Ltd., Daiwa House Industry Co., Ltd., Sharp Co., Ltd., Espec Corp., and Glory Ltd.

■ Topics

Regarding the commencement of the COI-T project

profile

Professor of the OCARINA

Nobuo Kamiya

Visiting researcher at the High Energy Physics Laboratory/Synchrotron Radiation Experiment Institution, vice principal investigator at RIKEN, and chief of the Research Technique Development Section at RIKEN, Harima Branch (large-scale synchrotron radiation facility, SPring-8). In 2005, he became a professor at the Osaka City University Graduate School of Science. Since 2010, he has been a full-time professor at the Advanced Research Institute.

"From the shape of a society as it should be, guided by the currently dormant demands of a future society, a way of life (a vision) is established. With this vision as a foundation, liberal research and development subjects that deal with the limitations of existing fields and organizations and look into the future 10 years from now are specified. Such liberal innovation cannot be realized by industry alone but may be realized through collaboration with academia." With this aim, the liberal innovation inventing program (COI STREAM) was created (http://www.mext.go.jp/a_menu/kagaku/coi/index.htm). Project leader Eiji Yamashita (Fuji Chemical Industry Co., Ltd.) and research leader Nobuo Kamiya (Osaka City University) were proposed and selected for the COI-T (T for "trial") project "Next-Generation Hydrogen Energy Society Realization," centered at Osaka City University. Their activities began in November 2012, through an industry-academia collaboration between 5 companies(Fuji Chemical Industry Co., Ltd.; Daiwa House Industry Co., Ltd.; Sharp Co., Ltd.; Espec Corp.; and Glory Ltd.) and 3 academic institutions (Osaka City University, University of Osaka Prefecture, and University of Hyogo). The COI vision of this project is to accomplish a hydrogen energy society in the near future. Liberal research subjects necessary to work towards this vision include the realization of high-efficiency electrodes required by next generation fuel cells through the application of microsurface fabrication techniques and the development of next-generation hydrogen production equipment. This would rapidly increase the efficiency of hydrogen production by exploiting artificial photosynthesis techniques that use cyclable biomass and water as raw materials. These devices comprise circulating life support systems. As exit strategy of this project, it is planned to verify the utility of the aforementioned life support system, as well as to increase the amount of artificially photosynthesized hydrogen for the next-generation hydrogen energy society, through links with the disaster-orientated "Life Lab" program. This program takes a denomination of elementary school districts, which contain approximately 10,000 people. In the event of a great disaster, "Life Lab" aims to support people sheltering in elementary schools (estimated at 1,000 of 10,000 people) for a week, even if the supply of materials and energy is obstructed, by using secure emergency stores and life support systems implemented at elementary schools. Furthermore, this life support system includes a plant factory that makes effective use of the carbon dioxide produced during artificial photosynthesis of hydrogen from biomass, and can contribute to food supply in a time of crisis. The current COI-T project is a trial (implemented over 1.5 years), aiming towards a larger scale COI application. To further the application of this project, it is necessary to confirm whether the volume of artificially photosynthesized hydrogen in the future is sufficient to meet the demands of hydrogen of the "Life Lab," while developing the target subject of each unit.

Research and development themes key to this realization

◆**Development of a sunlight-driven polysaccharide biomass-hydrogen energy exchange system**
Develop a biohydrogen production system using sunlight energy and photosynthetic bacteria with unused biomass as raw material (and a target sunlight energy exchange efficiency of 10%).

◆**Development of molecular catalysts for hydrogen production**
Construction of a light hydrogen production system by integrating photosensitizers to models of hydrogenase function, which is based on complexing with iron (with a target yield of 15%)

◆**Development of a high-efficiency hydrogen production system using a hydrofluoric acid (HF) etching, visible light-responsive titanium oxide membrane photocatalyst**
Super activation of catalysts by chemical etching surface treatment with optimization of sputtering conditions, HF, etc. (target yield of 15-20% using visible light radiation with a wavelength of 400 nm).

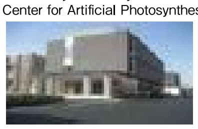
◆**Development of light-driven hydrogen producing catalyst systems to evolve the production of hydrogen from water using biomass.**
Investigation into the separate production of hydrogen and CO_2 from biomass compounds in aqueous solution using visible light-responsive titanium oxide membrane photocatalysts with high activity (with target values as above).

◆**Planning of cycling communities in collaboration with "Life Lab"**
Verification of a prototype energy provision system for disaster prevention using next-generation hydrogen production devices and fuel cells for introduction into elementary schools (or junior high schools), in collaboration with the disaster prevention educational base ("Life Lab")

◆**Development and powderization of pigment-augmented mesoporous materials**
Establishment of methods for extracting pigments from large-scale cultivations of algae with efficient photosynthesis systems.

◆**Development of techniques related to next-generation hydrogen catalysts**
1) Towards the application of hydrogenase enzymes with superior catalytic activity as bio-electrodes.
2) Development of metallic hydrogen production catalysts with an ultra-high specific surface area using ultrafine manufacturing techniques.
3) Verification of techniques for the development of metal/inorganic-enzyme hybrid catalysts

Osaka City University Research Center for Artificial Photosynthesis



University of Hyogo Next Generation Hydrogen Catalyst Collaborative Research Center

Osaka Prefecture University Plant Factory Research Center

Introduction to research

The necessity of catalysts for the realization of new fuel production techniques in "artificial photosynthesis"

profile
Professor of OCARINA
Yutaka Amao

Completed a doctorate in Engineering at the Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology in March 1997. He was a researcher at the Kanagawa Academy of Science and Technology and the National Aerospace Laboratory of Japan (now JAXA). In addition, he was a lecturer and then became an associate professor at the Faculty of Engineering, Oita University, and is a professor at the Advanced Research Institute since April 2013. He is also a Precursory Research for Embryonic Science and Technology (PRESTO) researcher at the Japan Science and Technology Agency since April 2010.

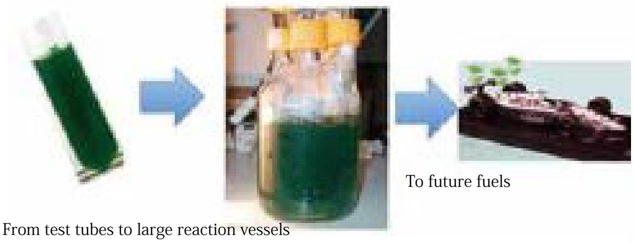
Having been appointed for over 12 years at the Department of the Applied Chemistry of the Faculty of Engineering at Oita University, I relocated to the Osaka City University Advanced Research Institute on April 1st, 2013. While appointed at Oita University, I pursued the use of organic, inorganic, and biological approaches in hybrid-artificial photosynthesis. At first, while enrolled in a doctoral program at the Tokyo Institute of Technology, I had been pursuing research on the photosynthesis reaction using chlorophyll, silver microparticles, and enzymes with visible light energy. In my second year of appointment at Oita University, I took an interest in reaction processes related to the recycling of carbon dioxide in photosynthesis, and we asked whether it is possible to construct a simple system using visible light energy and perform a molecular transformation on carbon dioxide. We then produced research on a reaction system of chlorophyll and similar molecules with formate dehydrogenase, which catalyzes the reaction of formic acid to carbon dioxide. Later, we discovered that if an aldehyde/alcohol dehydrogenase was included in the system, carbon dioxide was converted into methanol by visible light energy.

That was 10 years ago. However, at that time, hardly anybody paid attention to "artificial photosynthesis" as a keyword, and I remember that the photoreduction of carbon dioxide was surprisingly overlooked. However, a turning point was reached in 2009. In September 2009, the administration changed and the prime minister announced at the UN climate change summit that the greenhouse gas emissions would be reduced by 25% by the year 2020, compared to levels of 1990. Thinking back, the number of requests for lectures and reviews both from Japan and abroad about results of research on the photoreduction of carbon dioxide started to increase, which I recall mass media also seized upon. Thus, with the establishment of an artificial photosynthesis research center at Osaka City University and the target of utilizing light energy by 2030, I am aiming for the realization of systems to convert water and carbon dioxide into methanol. Photosynthesis utilizes visible light energy to create sugars and enzymes from water and carbon dioxide. Therefore, it is a model for the realization of artificial systems to convert carbon dioxide into a low-carbon fuel. Naturally, it is necessary to use those biomolecules that participate in photosynthesis appropriately; however, development cannot occur with those biomolecules alone. Catalysts that participate in the decomposition of water into oxygen and electrons, catalysts that participate in reactions that reduce hydrogen ions and carbon dioxide, and catalysts that participate in the transfer of energy and electrons and the efficient collection of light are needed. Consequently, the development of hybrid catalysts that utilize organic, inorganic, and biological agents has become an important subject.

It goes without saying that catalysts are the key players in the realization of artificial photosynthesis (however, understanding just how important they are requires an equal amount of effort). I believe in the necessity of an appropriate assembly of photocatalysts, molecular catalysts, solid catalysts, and my specialty, biocatalysts, in leaving artificial photosynthesis techniques for low-carbon fuel production in the near future not just a dream, but making it a reality, and I will contribute with my humble skills in this area.

One final word: To the question "Why Methanol?" I think you will understand the potential of the new fuel if I say, "methanol fuel can move an F1 scale racing car at more than 300 km/h."

Towards the realization of artificial photosynthesis



To future fuels

From test tubes to large reaction vessels

■ Introduction to research

Artificial photosynthesis and the mechanism of light collection in photosynthesis

profile
Associate professor, OCARINA
Ritsuko Fujii

Completed a doctorate in science at the Graduate School of Science, Kwansei Gakuin University in March 2001. She was a specially appointed researcher of the Japan Society for the Promotion of Science (PD) and held successive research positions at the Graduate School of Science and Technology, Kwansei Gakuin University, and the Osaka City University Research Center for Industry Innovation, before being specially appointed as associate professor to the Advanced Research Institute for Natural Science and Technology (OCARINA). She has been working there since April 2013. She has also been a pioneering researcher of the Japan Science and Technology Agency since October 2011.

The sun is the outside force with the greatest impact on the planet. Therefore, it is clear that if we can efficiently exploit the sun, humanity will gain an inexhaustible supply of energy. However, if we look at the sun as a light source, the density of photons is exceptionally low. Moreover, the influence of not just day and night but also clouds and the atmosphere make the amount of light considerably unstable and the efficiency for stimulating photoreactions for interactions between molecules and photons is poor. The light collecting mechanisms of photosynthetic organisms have overcome this problem. The answer is an "in times of excess, thin out; in times of scarcity, collect"-mechanism, which could be called a light management mechanism. The essential components of this interplay of light energy are photosynthetic pigments bound to proteins. Much of the molecular mechanisms and their true nature are still unclear, and active fundamental research is still carried out in this field. By focusing on the light gathering mechanism demonstrated by photosynthetic pigments bound to proteins, I would like to carry out research to modify artificial photosynthesis in an applicable fashion through the elucidation of natural photosynthetic systems.

In April of 2013, I became an associate professor of OCARINA. I will take this opportunity to introduce my research with a short outline. When I was an undergraduate with vague ambitions of doing photosynthesis research, I learned about photosynthetic membranes, where photovoltaics were obtained in a lipid membrane, and had rough ideas, e.g., how great it would be if we could attach photovoltaic membranes to the windows. I was thinking about those kinds of things when I started working in a laboratory. Seeing the colorful photosynthetic bacteria being cultured and realizing that photosynthetic organisms are not just green made a big impression on me. The substances conferring these varied colors were photosynthetic pigments called carotenoids. Carotenoids supply absorbed photoexcitation energy to chlorophyll, which carries out the photoelectric conversion. In addition to their role as light antenna, their antioxidative effects have a photoprotection role; all photosynthetic organisms have carotenoids.

Thus, I am carrying out a spectroscopic approach, focusing on qualities of the excited state and the structure of carotenoids bound to photosynthetic proteins. We cultivate large amounts of photosynthetic bacteria and prepare large volumes of pigments and proteins, employing Raman, absorption, and fluorescence spectroscopic methods, along with methods such as vibrational calculations. Through research on structural changes immediately following photoexcitation, we have gained new knowledge about the fact that structural information of pigments as they exist in proteins is indispensable in the elucidation of details on photosynthetic functions.

Having married, I took the opportunity to move to Osaka City University, where we performed X-ray crystallographic structure analysis of complexes of proteins with photosynthetic pigments and attempted time-resolved spectral diffraction of these complexes in the photoexcited crystal state. Then, we carried out research for which we constructed artificial photosynthetic membranes by insertion of photosynthetic proteins into lipid membranes, observed the protein arrangement by electron microscopy, and investigated the transmission of energy by fluorescence spectra [1].

Returning to work after having a child and with assistance from a project where large-scale cultivation of marine macroalgae according to the requirements of the particular species was possible, I was able to take on a research project about the structure and function of a photosynthetic pigment that binds to a new photosynthesis antenna protein [2,3]. From biochemistry to analysis, we are in a situation where we are making progress, with experiments covering a wide field, including the purification of proteins and determination of amino acid sequences, as well as the determination of the structure and composition of the pigment. Nonetheless, I would like to accumulate definitive data and establish parameters around which the mechanism of the photosynthetic antenna can be discussed.

It has been 10 years since I came to Osaka City University; however, I am still a novice member of the teaching staff and I will continue to reach out to everyone for their cooperation.

【References】
[1] Fujii et al. Photosyn. Res. 95 (2008) 327.
[2] Fujii et al., Photosynth. Res., 111(2012)157.
[3] Fujii et al. Photosynth. Res. 111(2012)165.
[4] Nakagawa, Fujii, et al., J. Phys. Chem B 112(2008)9467.

Figure: Photosynthesis antenna proteins to which carotenoids with different numbers of conjugated double bonds (n) bind (photo above) and the chemical structure of those carotenoids (below) [from reference 4]

Discovery of a neurite removal mechanism in nematodes

profile
Specially appointed tenure-track associate professor of OCARINA

Eriko Nakadai ((Kage)

March 1999: Graduated from the School of Pharmaceutical Sciences, Kyushu University.
March 2001: Completed a masters at the School of Pharmaceutical Sciences, Kyushu University.
March 2004: Completed a doctorate in Pharmaceutical Science at the Graduate School of Pharmaceutical Sciences, University of Tokyo.
April 2004: Researcher at Sankyo, ltd. (now Daiichi Sankyo, ltd.)
April 2007: Assistant teacher, 2nd Physiology Laboratory, Tokyo Women's Medical University
April 2012: Lecturer 2nd Physiology Laboratory, Tokyo Women's Medical University
February 2014: Current position.

I will introduce my research up until now. I performed research on bees under Prof. Takeo Kubo of the Graduate School of Pharmaceutical Sciences (now at the School of Science), Tokyo University. In the process, I participated in the cloning of the transcription factor Mblk-1, which is selectively expressed in the memory center of the bee brain. To estimate the gene function, we started research using the model animal Caenorhabditis elegans (C. elegans). Such research has many advantages, because nematodes have clear bodies and, in addition to having a simple nervous system (comprised of a mere 302 neurons), it is easy to perform gene manipulation on them. We identified the nematode homologue gene of Mblk-1, mbr-1, and by expression analysis, we found that it is expressed in multiple interneurons, including a neuron pair called AIM. Mbr-1 deletion mutants were constructed, and phenotype analysis results showed abnormalities in the plasticity of olfactory behavior. In addition, visualization of neurons of mbr-1 deletion mutants using green fluorescent protein and analysis of the shape of neurons revealed that the left and right AIM neurons were connected by neurites not seen in the wild type strain (Figure 1).

In fact, these neurites are commonly seen in early larvae of the wild type strain, and it has been found they are removed later during development. Similar to the finding that the transcription factor MBR-1 is necessary for the removal of neurites accompanying development, the present research was the first report of neurite removal in nematodes and, therefore, the research results were published in Current Biology (reference 1). Dr. Yu Hayashi (then a graduate student of the School of Science, Tokyo University, now a young research fellow at the International Institute for Integrative Sleep Medicine, University of Tsukuba), who worked with us in this research, later discovered that the Wnt signal has an inhibitory effect on neurite removal by MBR-1, and the results were presented in Nature Neuroscience (reference 2).

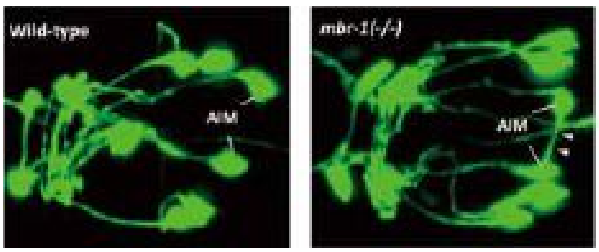


Figure 1: Removal of neurites between AIM neurons (left and right) did not occur in mbr-1 mutants

Mechanism of the body surface barrier of nematodes

Having spent 3 years in drug development research in pharmaceutical companies, Prof. Shohei Mitani of the Department of Physiology, Tokyo Women's Medical University, started research on the barrier mechanism used by nematodes to regulate the permeability of the body surface (skin). We found that a very-long-chain fatty acid CoA synthetase (with fatty acids containing >24 carbons) carries out important roles in the body surface barrier mechanism. More specifically, it was discovered that mutations in *acs-20*, the gene coding a very-long-chain fatty acid CoA synthetase in nematodes, caused various low-molecular-weight compounds that, in general, not easily pass through the normal body surface to be taken up into the body. It was also found that abnormalities in the body surface due to mutation in *acs-20* could be negated by insertion of the human homologue gene, Fatp4 (reference 3). Until now, compound screening of individual nematodes had a limitation in that compounds are not easily taken up into the body because of the body surface (cuticle) barrier of nematodes; however, it is hoped that it will be possible to construct a highly sensitive screening system using mutations in *acs-20* (figure 2).

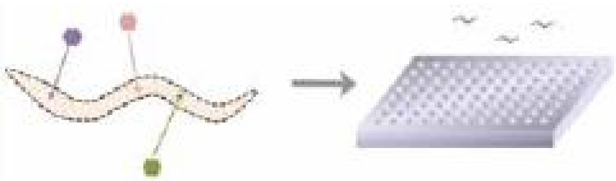


Figure 2: Drug screening on an acs-20 mutant with increased permeability to compounds

In addition, the body surface barrier plays an important role in the prevention of infection. Nematodes continue to accumulate interest as host model for various pathogenic microbes. Given its role as a host model, I would like to engage in the elucidation of the molecular mechanism of the bodily defense system of the nematode in the future.

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3. Kage-Nakadai E, Kobuna H, Kimura M, Gengyo-Ando K, Inoue T, Arai H, Mitani S. Two very long chain fatty acid acyl- CoA synthetase genes, acs-20 and acs-22, have roles in the cuticle surface barrier in Caenorhabditis elegans. PLoS One 5, e8857. 2010

Introduction to research

Fabrication of artificial muscles and organs by nano-surgery of hydrogels

profile
Ph.D., Department of Applied Chemistry, Graduate School of Engineering, Osaka University

Takaaki ASOH

April 2009 to February 2013
Assistant Professor, Tokyo University of Science
March 2013 to the present
Tenure-track Specially appointed Lecturer, OCARINA

Hydrogels are similar to the macromolecular-based components in the body, therefore, hydrogels have found numerous applications in tissue engineering and drug delivery systems. Hydrogels with a large amount of water have attracted much attention as substitute material of conventional plastics, artificial muscles and organs.

Adhesion of soft materials including hydrogels has therefore attracted attention because it is one of the most important processes for building functional soft constructs. To develop functional and microstructure-regulated devices using hydrogels, the "adhesion" of hydrogels is required. However, it is difficult to adhere hydrogel each other, because when any glue is applied to adhere two hydrogels, the motion of the adhesive coated surfaces or mass transfer between the two hydrogels will be encumbered by the presence of solidified glue.

Recently, we successfully adhered oppositely charged hydrogel by "electrophoretic adhesion(Fig.1)[1-4]". During electrophoresis, cationic and anionic polymers move to the cathode and anode, respectively. Then, polyions were diffused inside of the gels and adhesion was achieved through the formation of a polyion complex at the interface of the two hydrogels. The adhered hydrogels were quite stable in water, and detachment of the adhered hydrogels was also possible by simply applying the inverse voltage.

We already reported about preparation of hydrogel actuator by adhesion of stimuli-responsive hydrogels and non-stimuli-responsive hydrogels each other. In other words, the electrophoretic adhesion of hydrogels is nano surgery, which the hydrogel interface is stitched together using water-soluble polymers. At OCARINA, I develop micro-structure regulated "artificial muscles" and "artificial organs" by "nano surgery" of synthetic and natural occurring polymer gels, protein, and cells. Tailor Made 3-D materials are build up by electrophoretic adhesion of desired hydrogel parts with regulation of shape, gradient, porosity, and pattern for fabrication of artificial muscles and organs.

【References】

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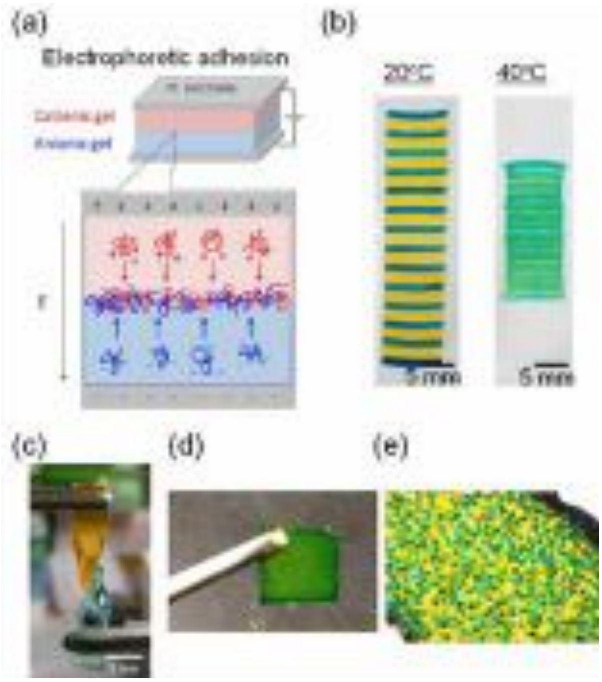


Figure 1 (a) Illustration of electrophoretic adhesion of hydrogels and (b-e) adhered hydrogels.

Introduction to Facilities

MALDI-TOF/TOF mass spectrometer

Makoto Miyata

"Life phenomena" appear chaotic without any regularity; however, that chaos actually follows its own kind of laws based on the properties of biomolecules, evolution, and energy. Biology is a subject that attempts to apply these kinds of laws to the ultimate chaos that is the life phenomena, and of the various "outlets" of chaos, proteins were the first to be discovered. The fundamental elements of proteins, i.e., amino acids, form a polymerized structure with infinite degrees of freedom. Until around 15 years ago, identifying a protein that is key to a given phenomenon and resolving its amino acid sequence required at least several years.

With more than 5 years of graduate school, if one could determine the amino acid sequence of an unknown protein, it would be his/her great start of a life as researcher. However, today, the determination of the amino acid sequence of a protein has been reduced to "work" that can be completed in 3 days by a 4th-year student, having just started working in a laboratory. It is like the return of Xuanzang to China on a cloud from India. It makes one think, "What was the reason for the limitations of our previous efforts?" The origin of the current, "happier," situation is the Human Genome Project, which most molecular biologists criticized harshly.

The amino acid sequences of all proteins are encoded in a 4-letter code in DNA (deoxyribonucleic acid) in genes, stored in a place called the nucleus in cells of organisms. The extraction of DNA and the reading of its code are very simple. In the Human Genome Project, as much of this code as possible was read and deposited into a database. The Human Genome Project has progressed substantially, and because many of the world's DNA codes have been added to the database, amino acid sequences of proteins can, in general, be determined by reference to sequences deposited in the database. Yet, how does one find the DNA code that corresponds to the amino acid sequence of a protein of interest? One uses a mass spectrometer, the working of which I have explained below. The device partially fragments the protein and accurately measures the mass of those fragments, which allows the identification of the protein's amino acid sequence from a database. Furthermore, in recent years, the device has been used not only in the determination of the amino acid sequence of novel proteins, but is also being used in all aspects of biology, as a method of specifying a protein and its fragments.

The Bruker Autoflex Speed TOF/TOF mass spectrometer (matrix-assisted laser desorption/ionization–tandem time-of-flight; MALDI-TOF/TOF), which exceeds the capabilities of other types of laser matrixassisted mass spectrometers currently on the market in sensitivity, precision, speed, ease of use, and maintainability, was introduced at the Osaka City University in the new research field of "harmonized supramolecular motility machinery and its diversity"(representative: Makoto Miyata of the Graduate School of Science). In addition, even when compared to mass spectrometers other than laser matrix-assisted ones, this device is superior with regard to its overall performance in the specification of proteins. It would certainly be no exaggeration to call this a "godly machine."

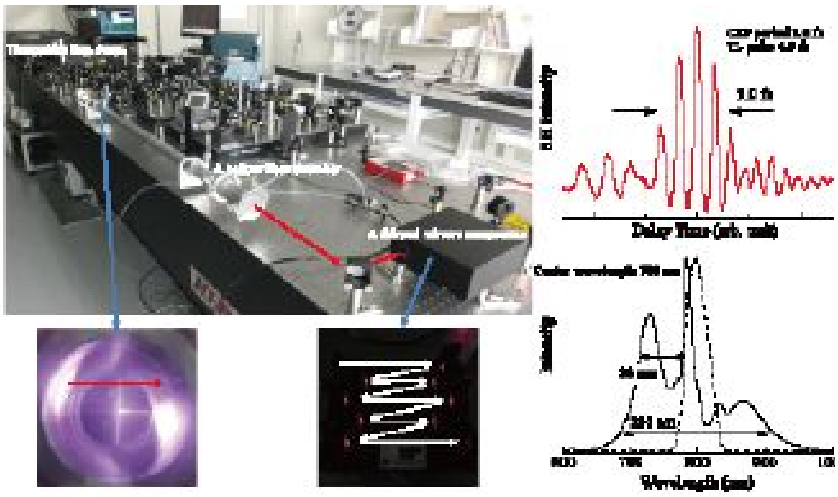
(Photo:graduate students pray to the "godly machine")

Ultrashort pulse generation

Daisuke Kosumi

Recent developments of an ultrashort laser technology realized a generation of high intensity and extremely short pulses with a pulse duration of sub-5 fs (10^{-15} s), which corresponds to a quasi-monocycle electronic field in the visible region. Such laser pulses have been utilized to attosecond (10^{-18} s) or THz (10^{12} Hz) science. Further, a sub-5 fs timescale is shorter than vibrational periods of atomic nuclei consisting condensed matters. Therefore, ultrafast spectroscopy utilizing sub-5 fs pulses can visualize real-time motions of atomic nuclei. We now introduce the hollow fiber pulse compressor: **Kaleidoscope** seeded with a femtosecond regenerative amplifier to obtain sub-5 fs pulses.

Ti:sapphire regenerative amplifier (Legend Elite-USP, Coherent) Output pulses of a regenerative amplifier has a center wavelength: 800 nm, average power: 4.5 W, a pulse duration: 30 fs, and a repetition rate: 5 kHz. Output pulse power stabilizes within 0.2% (rms) over time (>10 h).



Hollow fiber pulse compressor (Kaleidoscope, FemtoLasers)

Kaleidoscope is consisted of a hollow fiber chamber filled with a noble gas and an ultra-broadband chirped mirrors compressor. Optical pulses with high peak intensity are efficiently spectrally broadened by nonlinear optical effects during propagation in a hollow fiber (diameter: 250 μm). Output pulses from Kaleidoscope are compensated by a chirped mirrors compressor. Compensated pulses have a spectral band width of 230 nm, a pulse duration of 5.0 fs, and average power of 1.5 W. In the future, we will utilize 5 fs pulses to ultrafast optical spectroscopies to elucidate a primary process of photosynthesis.

Reports on Activities

The Advanced Research Institute invites leading scientists from Japan and abroad to its occasional OCARINA seminars. The OCARINA seminars include the "DISCO Party* major seminar," which is willingly organized by the group of doctoral students. At this fiscal year, OCARINA also held the international conference on biohydrogen and artificial photosynthesis (refer to the special interview).

* DISCO Party (Doctor Course students' Incorporated Scientific Communication Party): A group of doctoral students affiliated with OCARINA. The Party organized weekly closed seminars just for students to serve as an opportunity to exchange opinions and to understand their mutual interests. In addition to the seminars, the Party held the large seminars, called "DISCO Party major seminar", several times per year,.which invites guests from Japan and abroad, provide a common place for people with various occupations, including teaching staff, to discuss student research.

☆ OCARINA Seminars ☆

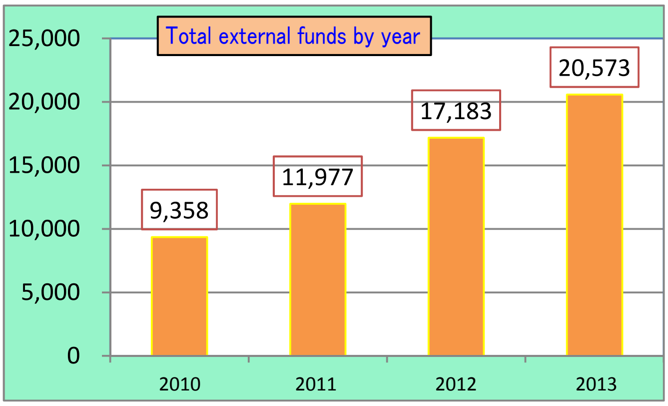
For more details, please see the website.

12th	Date	15th May 2013	Venue	Building 2, 220A
	Guest	Akitaka Ito (Assistant Teacher, OCU, Physical Chemistry)		
	Theme	"Excited state dynamics: photochemical qualities and photo-induced reactions in rigid media"		
	Guest	Masahiro Mikuriya (Professor, Kwansei Gakuin University,Inorganic/Complex Chemistry)		
	Theme	"Magnetic metal complexes using copper oxide as a motif"		
	DISCO Party major seminar no. 5	Student: Ayu Karimata (Physical Organic Chemistry Laboratory D2)		
13th	Date	10th June 2013	Venue	Building 2, 220A
	Guest	Daniel Gryko (Professor, The Polish Academy of Sciences, Organic Chemistry)		
	Theme	"Meso-substituted corroles and expanded porphyrins from synthesis and spectroscopy to photophysics"		
	DISCO Party major seminar no. 6	Student: Ayaka Tanaka (Molecular Physics Laboratory D2)		
14th	Date	25th July 2013	Venue	Building 2, 220A
	Guest	Shin-Ichiro Ozawa (Postdoctoral researcher, Institut de Biologie Physico-Chimique)		
	Theme	"Molecular association of the chloroplast ATP synthase CFO site in the green algae *Chlamydomonas reinhardtii*"		
15th	Date	5th August 2013	Venue	Building 2, 220A
	Guest	Kiyohito Kihira (Japan Aerospace Exploration Agency: JAXA)		
	Theme	"Increasing the quality of protein crystals on the international space station"		
16th	Date	9th September 2013	Venue	Building 2, 220A
	Guest	Yutaka Nagasawa (Associate Professor, School of Engineering Science Osaka University, JST researcher in the field of "light energy and conversion")		
	Theme	"A strange story about water A solvent dynamics viewpoint"		

☆ Trends in external funding (2010 -2013) ☆

The figure on the right shows the trend in total funding obtained from external sources (research grants, joint research funds, grants-in-aid of scientific research, subsidiary aid, and donations, etc.) over 4 years by the Advanced Research Institute, having commenced full scale activity from 2010 to 2013.

In 2013, the Advanced Research Institute obtained more than twice the total external funding acquired when it started full operations in 2010.



☆ International Conference ☆

2013 Osaka City University Advanced Research Institute (OCARINA) annual international meeting --- Establishment of the Research Center of Artificial Photosynthesis (ReCAP) ---

◆ Dates: Monday 4th - Wednesday 6th March 2013 ◆ Venue: Osaka City University Media Center

☆ Invited speakers ☆

1. Prof. Dr. **Leroy Cronin** (University of Glasgow, UK)
2. Prof. Dr. **Wolfgang Lubitz** (Max Plank Institute for Chemical Energy Conversion, DE)
3. Prof. Dr. **Bruno Robert** (CEA Saclay, FR)
4. Prof. Dr. **Tim Storr** (Simon Fraser University, CA)
5. Dr. **Rudi Berera** (Vrije Universiteit Amsterdam, NL)
6. **Osamu Ishitani** (Professor, Tokyo Institute of Technology Graduate School of Engineering)
7. **Jun Miyake** (Professor, Osaka University Graduate School of Engineering Science)
8. **Ryu Abe** (Professor, Graduate School of Engineering, Kyoto University)
9. **Yutaka Amao** (Assistant Professor, Applied Chemistry Department, Faculty of Engineering, Oita University)
10. **Jian-Ren Shen** (Professor, Graduate School of Natural Science and Technology, Okayama University)
11. **Masakazu Anpo** (Osaka Prefecture University, Director, Vice President and Head of the Regional Research Collaboration Institute)
12. **Masako Kato** (Professor, Faculty of Science, Hokkaido University)
13. **Masahiro Sadakane** (Assistant Professor, Hiroshima University Institute of Engineering)
14. **Sachiko Matsushita** (Assistant Professor, Tokyo Institute of Technology Graduate School of Engineering)
15. **Shigeyuki Masaoka** (Assistant Professor, National Institutes for Natural Sciences, Institute for Molecular Science)
16. **Yuji Furutani** (Assistant Professor, National Institutes for Natural Sciences, Institute for Molecular Science)
17. **Hiroshi Ishikita** (Specially Appointed Assistant Teacher, Career-Path Promotion Unit for Young Life Scientists, Kyoto University)
18. **Masayuki Yagi** (Professor, Faculty of Engineering, Nagoya University)
19. **Toshio Asada** (Assistant Professor, School of Science, Osaka Prefecture University)
20. **Miwa Sugirua** (Assistant Professor, Cell-Free Science and Technology Research Center, Ehime University)
21. **Kentaro Ifuku** (Assistant Teacher, Graduate School of Biostudies, Kyoto University)
22. **Mitsuo Shouji** (Assistant Teacher, Center for Computational Sciences, Tsukuba University)
23. **Kenji Kano** (Professor, Graduate school of agriculture, Kyoto University)

☆ In-house speakers ☆

1. **Nobuo Kamiya** (Professor, Osaka City University Advanced Research Institute/ Graduate School of Science, Osaka University)
2. **Masakazu Hirotsu** (Assistant Professor, Graduate School of Science, Osaka City University)
3. **Ritsuko Fujii** (Specially Appointed Assistant Professor, Osaka City University Advanced Research Institute)
4. **Daisuke Kosumi** (Specially Appointed Professor, Osaka City University Advanced Research Institute)
5. **Yoshimasa Fukushima** (Specially Appointed Professor, Osaka City University Advanced Research Institute)

Asia BioHyLink (ABHL)/International Conference on Bio/Mimetic Solar Energy Conversion (iSec)

◆ Dates: Friday 22nd - Sunday 24th November 2013 ◆ Venue: Osaka City University Media Center

☆ Main speakers of the ABHL/iSEC (Plenary Lecture) ☆

- ○ **Mitsuyoshi Ueda** (Professor, Graduate school of agriculture, Kyoto University)
- ○ **Mika Goto** (Senior researcher, Socio-economic Research Center, Central Research Institute of Electric Power Industry)
- ○ **Michael Seibert** (National Renewable Energy Laboratory)
- ○ **Ken-ichiro Ota** (Researcher/specially appointed professor, Faculty of engineering, Yokohama National University)
- ○ **Pieternal Claassen** (Wageningen UR Food & Biobased Research)
- ○ **Akihiko Kondo** (Professor, Graduate School of Engineering, Kobe University)
- ○ **Masahiro Nishio** (Principal researcher, National Institute of Advanced Industrial Science and Technology)
- ○ **Masanobu Kitanaka**
- ○ **Eiichi Tamiya** (Professor, Graduate School of Engineering, Osaka University)
- ○ **Yukio Okada** (Sapporo Breweries Limited Institute for Value Creation frontier Research)
- ○ **Takashi Hayashi** (Professor, Osaka University Graduate School of Engineering Science)
- ○ **Masayuki Hara** (Professor, Osaka Prefecture University Graduate School of Science)
- ○ **Hiroshi Ishikita** (Professor, Graduate School of Science, Osaka University)
- ○ **Ryu Abe** (Professor, Graduate School of Engineering, Kyoto University)
- ○ **Masaya Matsuoka** (Professor, Graduate School of Engineering, Osaka Prefecture University)

☆ Special Address and Remarks ☆

- ○ **Masaaki Takabatake** (Head of Regional Economy Division, Kansai Bureau of Economy, Trade and Industry)
- ○ **Kazue Taguchi** (Head of Industry-Academia Collaboration, Kansai Bureau of Economy, Trade and Industry)

Ms. Kazue Taguchi (above) spoke not only at the conference, but also at the social gathering.

From November 22nd to 24th, 2013, the International Conference on Bio/Mimetic Solar Energy Conversion (iSec) was held at Osaka City University (Sugimoto Campus) Media Center. This time, the 8th Asia BioHyLink (ABHL) shared the venue, congratulating the completion of Research Center of Artificial Photosynthesis (ReCAP), which opened its doors to participants, mainly from various Asian countries.

A total of 142 researchers attended the conference, with 91 participants from 13 overseas countries (of which 35 were students), and 51 participants from Japan (of which 16 were students). A total of 70 researchers, 36 from overseas countries and 34 from Japan, gave oral presentations on the latest research results in sun energy exchange, including photosynthesis and biohydrogen production, using bio-related content. Of particular interest, the student session, which was completely organized (from planning to management) by student members including OCARINA DISCO Party, was overflowing with lively discussions. At the student poster presentation, DISCO Party members Mr. Furuike (Graduate School of Science D2) and Ms. Tanaka (Graduate School of Science D2) were awarded the iSEC poster prize. (Picture on the right)

History of the Osaka City University Advanced Research Institute

March 2008 (H20) Founding Anniversary International Symposium held(#0)
April 2008 (H20) The OCU strategic key research project (H20-H23) started
December 2008 (H20) International Workshop held on the efficient use of sunlight energy
April 2009 (H21) Enforcement of official regulations (start of activities as an official bureau)
January 2010 (H22) 1st International symposium held (#1)
March 2010 (H22) 2nd International symposium held (#2)
October 2010 (H22) building 2 renovated for research floors of OCARINA
November 2010 (H22) Opening symposium for building 2 of OCARINA held
March 2011 (H23) 3rd International symposium, "Kakuno memorial," held (#3)
March 2012 (H24) Annual meeting and the OCU strategic key research project (H20-H23) debriefing held (#4)
April 2012 (H24) The OCU strategic key research project (H24-H26) started
July 2012 (H24) School of Science Building C completed, partial occupation
March 2013 (H25) 4th International symposium held (#5)
April 2013 (H25) 2 new full-time staff members appointed
June 2013 (H25) Research Center of Artificial Photosynthesis opened
February 2014 (H26) Partial occupation for the new School of Science Building
February 2014 (H26) 1 new full-time tenure track staff member appointed
March 2014 (H26) 1 new full-time tenure track staff member appointed
March 2014 (H26) 5th International symposium held (#6)

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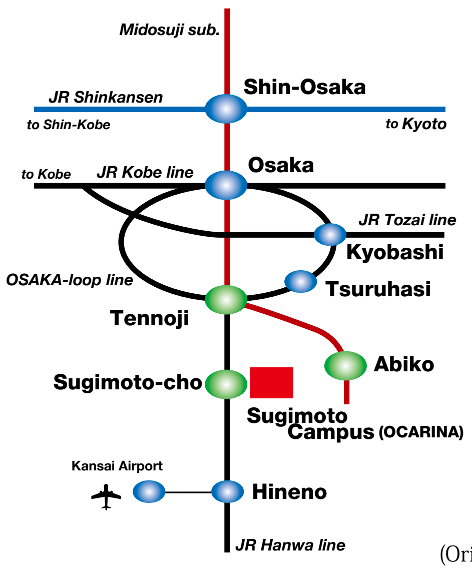

(Original Japanese Version Published March 2014)