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SHIMADZU
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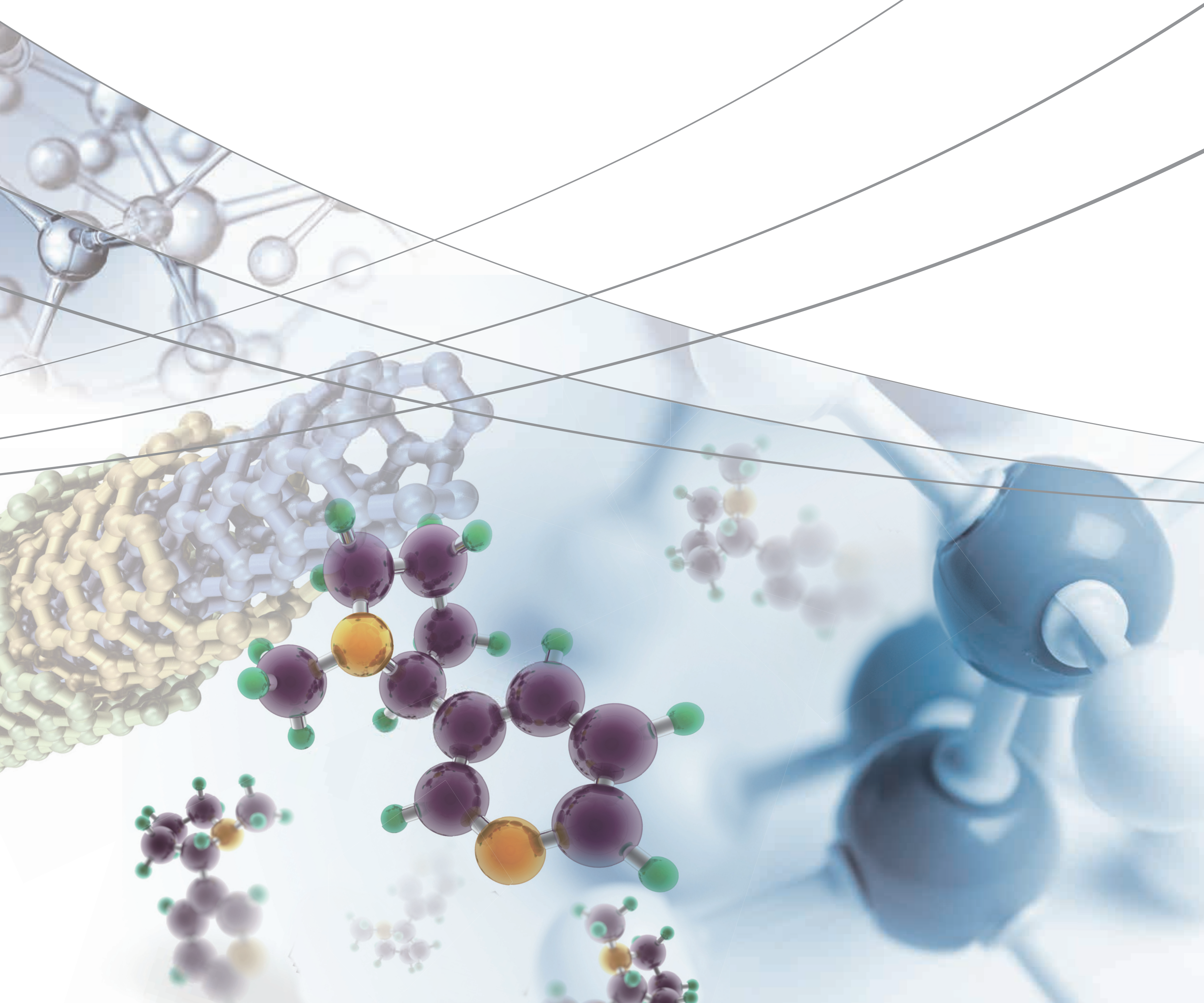
Material Science and more...



# Director's note

Dear Reader,

It is my sincere pleasure to deliver this year's first issue of Shimadzu Journal. As part of its core mission, Shimadzu has been actively promoting joint research and development with universities, research institutes, and companies with innovative technologies.

Based on this policy, adding to existing Innovation Centers in the U.S. and China, in Europe Shimadzu designated advanced universities and research institutes that conduct joint research and development with Shimadzu as innovation centers, and established a headquarters at its subsidiary, Shimadzu Europa GmbH, located in Duisburg, Germany. In addition, Shimadzu established an Innovation Centre in another overseas subsidiary, Shimadzu (Asia Pacific) Pte Ltd., to manage advanced joint research and development with local researchers. This Innovation Centre started operations on November 17.

The work performed at these Innovation Centers is key to developing relationships and introducing new solutions to the scientific community. One such solution, a Trace Moisture Analysis GC, was created in 2017. This system was developed at Shimadzu's U.S. Innovation Center. Developed in close collaboration with Dr. Daniel W. Armstrong, Robert A. Welch Distinguished Professor at the University of Texas at Arlington, and MilliporeSigma, the life science business of Merck KGaA, Darmstadt, Germany, this system consists of Shimadzu's Nexis GC-2030 equipped with our proprietary Barrier Ionization Discharge detector and MilliporeSigma's unique capillary column, which was originally developed by Dr. Armstrong. With this system, users can precisely analyze PPM levels of water in gas and some liquid samples.

We are very excited about the potential of the new trace moisture analysis GC, and eager to share more about it in a future issue of Shimadzu Journal. At the same time, we are proud to present this issue of Shimadzu Journal, which focuses on Material Science. For an insight from a customer, we interviewed Dr. Gunnar Merz, CEO and Chair of the Board of CFK Valley e.V., Germany, which is an internationally recognized competency network for carbon fiber reinforced plastic. Also, Associate Professor Kazuo Tanaka and Professor Yoshiki Chujo of Kyoto University shared with us their research concerning the development of Solid-State Emissive Materials based on Aggregation-Induced Emission-Inducible Organoboron "Element-Blocks".

Thank you for being a partner of Shimadzu. We hope this journal will be of great help to all of you. We welcome your feedback at any time.

Yours Sincerely,

**Shuzo Maruyama**

General Manager, Analytical & Measurement Instruments Division

# CONTENTS

## Featuring Material Science

# Interview with Dr. Gunnar Merz

We interviewed Dr. Gunnar Merz, CEO of CFK Valley e.V. in Germany. The CFK Valley e.V. is an established World-wide competence network for carbon fiber reinforced plastics (CFRP, German abbreviation is CFK). More than 100 international companies, research facilities and universities are organized in the non-profit association.

**Dr. Gunnar Merz, thank you very much for your time for this interview. At first, could you briefly introduce the CFK Valley? The purpose of establishment of this organization, when it was established what encouraged you to establish it, the role in the network, and so on.**

In 2004. seven members established CFK Valley e. V. in Stade. These included Airbus, CTC, Saertex, Hexcel Composites, German Aerospace Centre, Fraunhofer Institute for Manufacturing Technology and Advanced Materials, and the Hanseatic City of Stade. In the same year the CFK Valley Technology Centre Stade, is inaugurated. We have now become an internationally recognized competency network for CFRP. Around 120 national and international companies and research institutes are now part of the network and are promoting like this the fiber composite technology as industrial production technology. Various work groups have already been initiated along the value-addition chain and a technology roadmap is updated on a regular basis.

**Why CFRP? Could you explain to us about CFRP application and its potential usage for the future after briefly outlining what CFRP is?**

CFRP is a so-called composite material. Carbon fibers are embedded in a matrix, which consists of duroplastic epoxy resin or thermoplastic synthetic materials, and is brought into shape. This results in excellent mechanical properties, such as an extremely high tensile strength and stiffness in the compound. Apart from this, further convincing advantages are fatigue behavior, resistance to corrosion, low thermal expansion and a good damping capacity at low density (2/3 of aluminum, 1/5 of steel).

Considering these characteristics, CFRP is best suitable for the manufacture of products, which must be light, but at the same time should show a high stability. CFRP has the same strength as metals and is being used today in more and more innovative application areas, for example, in airplanes. Lighter-weight parts create faster vehicles, which can also create more energy-saving airplanes. Other than the airplanes, the applications expand to automobiles, ships, rotor blades for wind power plants, medical technology, or also in construction, where products made from CFRP are being used in roof construction right up to building complete houses.

### Was CFRP your research theme? If not, please let us know why you changed your direction from your original research theme to CFRP.

I was originally working as a chemist at Dow Chemical which is one of the CFK Valley member companies. I was involved as the representative of Dow Chemical, and had been conducting my projects at CFK Valley since 2008, and in 2014 I accepted the full-time CEO position at CFK Valley.

### What achievements have you made so far? What are you going to do next? Would you share your future vision with us?

Here are some examples of the successful projects. The first one is in the airplane industry. Following applies to airplanes: the lighter, the better. The largest aircraft part made from CFRP by Airbus is an upper wing shell with a length of 32 m and is installed in Airbus A350. Naturally, this was manufactured in Stade.

We also made achievements in construction area. When Dr. Amer Affan purchased a sailing ship with a CFRP mast, he was absolutely fascinated by the material and its possibilities for the construction sector. In 2010, Dr. Affan visited the CFK Valley booth at the JEC Paris and became a member of the association. Today, he is one of the international experts for innovative design solutions with CFRP.

Recycling and waste prevention are our challenges and achievements as well. For instance, the company Strehl produces new, high-quality orthoses from the carbon-fiber production wastes of Airbus. This example of a cross-sector cooperation shows how synergies provide for more sustainability.

To develop these cross-sector cooperations, we are proceeding with our open innovation more aggressively. Together with its national and international partners, CFK Valley e. V. will become the world's leading and most innovative composites-meta-cluster.

One major challenge for CFRP is automation of the production process. When we establish automated mass production platform, the cost of the CFRP will decrease and more applications can be available. We believe open innovation and global networking can accelerate the research for those technical solutions.

### What do you think you need to realize your future vision?

I think we are on the way to our future vision, and to realize it, we need more resources and the right partners. CFK Valley e. V. looks for national and international suitable companies, institutions and networks, which, complementary to the experience and knowledge, infrastructure, technologies and trained specialists of the members of the CFK Valley network, bring in their know-how, in order to develop innovations for market-oriented customer solutions. We've already established our sites in Japan, Korea, China, and planning to open in India in the near future.

### Finally, could you tell us what you expect us to do as a vendor of analytical and measuring instruments? How can we help you?

When we proceed with the automation of mass production process, we need more scientific analysis and measurement to improve the process. Industry 4.0 is changing the manufacturing process dramatically, and everything is controlled by data. When I visited ICC, Innovative Composite Center, in Japan, I saw many Shimadzu analytical instruments and measuring equipment working in the lab. Currently they are mainly used for research and development area, but I expect those instruments to play the important role in the future process automation as well.

### It was significant to know what you think of us and our collaboration. We will strive to meet your request. Thank you very much.

# CFK-VALLEY STADE CONVENTION 2017/2018: WHEN VISIONS BECOME REALITY

CFK Valley hold their convention every year to exchange new ideas among the members, and welcome the new partners around the world. The convention 2018 will take place on June 12th - 13th in Stade, Germany.

The Main topic 2018 is: "Composite Innovations for Global Mobility" With the following sessions:

(1) Smart Cities and Countryside of the Future
The first part will give an outlook into the future: What are the requirements for the future in cities and on the countryside and what can (carbon) composites contribute.
(2) Newest Composites Innovations
In this session real outstanding innovations which will have a high impact on the global mobility will be presented.
(3) Global Mobility: The Human
The third session will start with mobility of the human, which means overcoming of handicaps by means of carbon composites and activities in our free time and sports where composites can play an important role.
(4) Global Mobility on Earth
Global mobility on earth covers the usage of composites in trains, trucks and automobiles.
(5) Global Mobility in the Air
In this session there will be a discussion about the future requirements of the aerospace industry, the contribution from our partner country China and a path how to realize.

CONVENTION 2017 was held in Stade, Germany on May 17th, 2017. More than 300 visitors from 20 nations visited the two-day 11th International CFK-Valley Stade Convention, which took place at the Stadeum in Stade. This year's winner of the Innovation Award is a project consortium headed by Fraunhofer IFAM, which automates the assembly of CFRP vertical tails for the first time. Already on the eve of the convention, a MOU regarding a CFK Valley Korea was signed with the City of Gumi.

After Korea was already the partner country of last years' convention and the city of Gumi became a member of CFK Valley some time ago, the city's mayor, Dr. Yoo-Chin Nam, visited the Hanseatic City of Stade and the CFK-Valley Stade Convention with a 20-person delegation of business and science people. And he brought a very special present with him: a Memorandum Of Understanding which contains the founding of a CFK Valley Korea at the City of Gumi and which was signed on Monday, on the eve of the convention, at the "Insel Restaurant" in Stade. The city with more than 400,000 inhabitants is known as the Silicon Valley of South Korea due to the establishment of companies such as Samsung and LG and has set itself the goal of becoming one of the top three carbon cities in the world. The next logical step for both parties is the partnership with CFK Valley e.V., which is not only the oldest competence network for CFRP in the world but also the best connected. "This is another important milestone in the implementation of our internationalization strategy," says Dr. Gunnar Merz, CEO of CFK Valley e.V. "After the branch offices in Belgium and Japan, this will be a next international location. This brings us a big step closer to our vision of becoming the world's leading and most innovative composites meta cluster in 2020".

CFK Valley is not only strengthening its international presence but also the local partners. This year's CFK-Valley Innovation Award, traditionally awarded during the evening event on the first day of the convention and endowed with € 7,500, went to the Flex- Mont project headed by the Fraunhofer IFAM. Also other, mainly local partners are involved in the project. The goal of the joint project "FlexMont", funded by the Lower Saxony Ministry of Economy, was to significantly reduce assembly time and costs for the vertical stabilizer's CFRP box on the A320 family of passenger planes. This includes the future-forward box design (VTP-NG – Vertical Tail Plane Next Generation), which assists the automation of the assembly process. Dr. Dirk Niermann, Head of Fraunhofer IFAM at the Research Center CFK Nord, received the prize as representative of the project consortium deeply moved from Prof. Dr.-Ing. Axel Herrmann as well as Stades economic promoter Thomas Friedrichs. The project partners Airbus Germany, CTC GmbH, FFT Production Systems, Mahr Metering Systems and QuISS were also very pleased to be honored for the jointly executed project work. After all, CFK Valley has already set a great goal when founding the association in 2004: Reducing the production costs for the CFRP component production by industrial automation. With the FlexMont project an important milestone could be reached.

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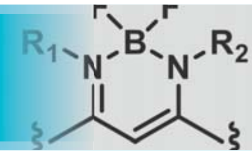
# Development of Solid-State Emissive Materials Based on Aggregation-Induced Emission-Inducible Organoboron "Element-Blocks"




Kazuo Tanaka and Yoshiki Chujo, Department of Polymer Chemistry, Graduate School of Engineering, Kyoto University

## Aggregation-Induced Emission as a Promising Solution for Overcoming Aggregation Caused Quenching

Emissive organic materials are versatile for the application to advanced organic devices such as paper displays, flexible photovoltaic cells, and printing electronic circuits. In particular, organoboron complexes including polymers have gathered much attention as a key building block for the next-generation of opto-electronic devices because of their opto-electronic functions.[1] Most of organoboron molecules are composed of four-coordinated boron and can show a variety of optical properties. Indeed, so far, various types of luminescent materials involving the four-coordinate boron have been prepared. As one of typical examples, boron dipyrromethene (BODIPY) derivatives, which possess superior optical properties such as large light absorption and emission ability, sharp spectra, and high photo-stability, are used for a wide variety of applications in material science as well as biotechnology. Thus, optically-functional materials such as solid-state emitters, light absorbers, light-harvesting antennae and white-light emitting materials can be produced with BODIPY derivatives. Furthermore, we recently reported the BODIPY derivative-containing conjugated polymers can work not only as efficient emitters in deep-red and near infrared regions but also as an efficient electron-carrier materials. It should be mentioned that higher electron-carrier ability from the film samples composed of the BODIPY derivative-containing conjugated polymers was obtained than those of Alq3 crystal which is commonly used as an electron-carrier material in the conventional optical devices. This result means that these polymers should be promised to be the key materials in modern organic opto-electronic devices with printing methods.

When organoboron luminescent dyes are actually utilized in the devices, we often have one critical problem to be overcome. In general, bright emission can be observed from the diluted solution state. On the other hand, most of emission properties are spoiled in the condensed state such in the film and powder. These behaviors are called as concentration quenching or aggregation-caused quenching (ACQ). To receive the highly-efficient emission from the devices, ACQ should be avoided. On the contrary, it has been reported that some of organic compounds presented stronger emission only in the aggregation states. Tang et al. firstly showed unique behaviors with tetraphenyl-substituted silole compounds in 2001.[2] Only when the compounds were aggregated in the poor solvent, the bright emission can be obtained. This phenomenon is called aggregation-induced emission (AIE). In order to overcome ACQ and to receive bright emission from the solid samples, the mechanism of AIE behaviors and AIE-active materials have been significantly focused. Therefore, many researchers devoted their effort to explore new AIE-active units for obtaining highly-efficient materials.

## "Element-Block Polymers", New Strategy for Material Design

We have recently proposed a new concept of "element-block" consisting of nanobuilding units or clusters of heteroatoms for the material design.[3] In this review, we describe recent advances on the development of AIE-inducible organoboron "element-blocks". Simply by introducing "element-blocks" composed of organoboron complexes in the conjugated system and connecting with other functional units, the series of functional emissive materials can be readily obtained. Additionally, by the combination with stimuli-responsivity of the materials, emissive chemical sensors can be constructed. Initially, the transformation of commodity fluorescent organoboron dyes to the AIE-active molecules is presented. Based on this result, the conjugated polymers with AIE properties were obtained. The optical properties of conjugated polymers involving boron element are illustrated. Moreover, the applications of these AIE-active polymers for the film-type sensors are mentioned. Next, as another instance of the AIE-inducible "element-block" composed of organoboron molecules, the AIE behaviors observed in the carborane materials are mentioned. The material design and unique solid-state emission of the carborane derivatives are demonstrated.

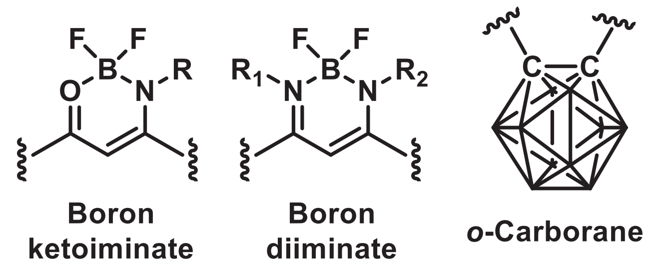



Fig. 1 Chemical structures of AIE-inducible organoboron "element-blocks".

## Transformation of Conventional Fluorescent Dyes to AIE-Active Molecules

Boron diketonates are one of simple and stable organoboron complexes, and so far, various optical materials have been developed based on boron diketonates.[4] Therefore, boron diketonates are regarded as versatile "element-blocks" for constructing functional emissive materials. However, emission efficiencies were often crucially lowered in the solid state because of ACQ. Particularly, organoboron conjugated polymers suffered from ACQ when these materials have been used as an emissive unit in the optical devices. In order to overcome ACQ and to realize AIE-active materials, we designed and synthesized the new ligands based on boron diketonate.[5]

It was presumed that by replacing oxygen to nitrogen, the flexibility of the complex should be enhanced. As a result, excitation energy can be consumed in the solution state, resulting in annihilation. In the solid state, molecular tumbling should be restricted. Moreover, the distortion around nitrogen could contribute to disturbing undesired intermolecular interaction. Therefore, we expected strong emission can be observed from the solid sample. To confirm the validity of this idea, boron ketoiminates and diiminates were synthesized, and their optical properties were examined. In summary, significant AIE behaviors were observed from these complexes. For instance, in THF, emission was hardly observed from boron ketoiminate. In contrast, bright emission was observed from the samples in the mixed solvent system of THF / $H_2O$ (1/9 (v/v), $\Phi$agg = 0.30–0.76). Furthermore, in the crystalline state of boron diiminate, further enhancement to emission intensity was observed by the phase transition from amorphous to crystalline states. These data meant that new boron complexes have crystallization-induced emission enhancement (CIEE) as well as AIE properties.[6] Based on these solid-state emission properties, various types of luminescent chromism were observed such as vapochromism6 and mechanoflurochromism[7].

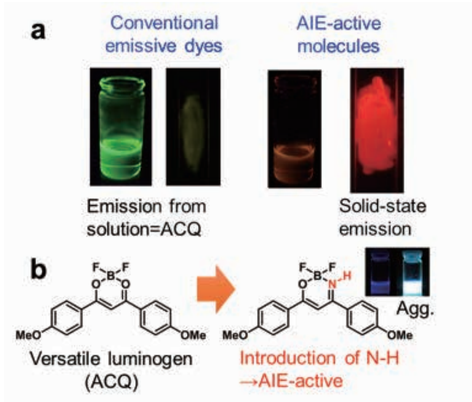



Fig. 2 (a) Typical luminescent behavior of conventional emissive dyes and AIE-active molecules in the solution and solid states. (b) Schematic model of transformation of ACQ luminogen to AIE-active molecule by chemical modification. Reprinted with permission from ref 5. Copyright 2013 Wiley-VCH Verlag GmbH & Co. KGaA.

## Film-Type Sensors Based on Oxidation-Induced Emission Properties

To extend the application of the stimuli-responsive AIE-active materials to the film-type chemical sensors, conjugated polymers composed of boron diiminate were designed. The thin films with the AIE-active copolymers composed of fluorene comonomers and the sulfide-substituted boron diiminates were synthesized, and the changes in the optical properties by the oxidation were monitored.[8]
Slight emission was observed from the film sample before the oxidation by $H_2O_2$ which can transform sulfide to sulfoxide. By soaking the film sample of the polymer in the solution containing $H_2O_2$, the increase of the yellow color emission of the film was detected. From the quantitative analyses for quantum yields, the emission intensity was finally elevated 3-times larger than that of the pristine film. By the oxidation, the electron-acceptability of boron diiminate should be enhanced. As a result, it was proposed that the intramolecular charge transfer should be also encouraged, leading to the emission enhancement from the charge transfer state through the polymer main-chain. In other words, oxidation-induced AIE can be realized with the sulfide-modified organoboron polymers. It can be expected that the AIE-active polymeric materials should be a versatile platform as a biosensor for longitudinal monitoring of the bio-related reactions. Especially, $H_2O_2$ is known to be one of reactive oxygen species and is endogenously produced in energy metabolism. Therefore, our materials could be valid for sensing generation of reactive oxygen species and oxidative stresses caused by these reactive molecules.

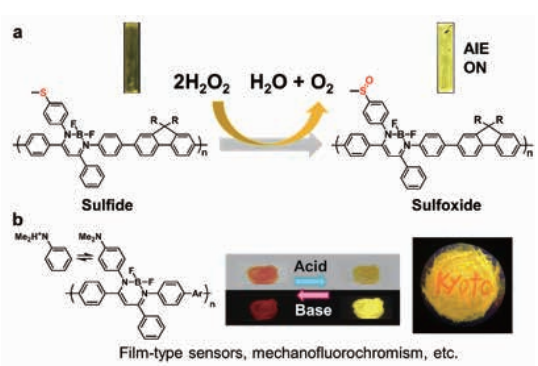



Fig. 3 (a) Schematic illustration of film-type sensors for $H_2O_2$ based on sulfide-substituted boron diiminate conjugated polymers with oxidation-induced AIE properties. (b) Other applications of boron ketoiminates and diiminates as luminescent chromism materials. Reprinted with permission from ref. 6. Copyright 2014 American Chemical Society.

## o-Carborane-Based AIE-Inducible "Element-Blocks" and Extremely-Efficient Solid-State Emissive Materials

As the next example of the AIE-inducible "element-block", unique optical properties of organoboron clusters called as o-carboranes are introduced. o-Carboranes are icosahedral clusters consisting of 10 boron and 2 carbon atoms with three-center two-electron bonds. Since the three-dimensional electron delocalization in the carborane cage contributes to improving thermal and chemical stabilities, o-carborane derivatives have been used for heat-resistant materials. In addition, owing to the intrinsic reactivity of boron under radiation irradiation, o-carborane derivatives have been applied as the positron sources in positron electron tomography treatments. In 2009, we firstly found that o-carborane can work as a key unit for presenting AIE.[9] The alternating polymers were prepared with o-carborane and p-phenyleneethynylene sequences, and their optical characteristics were examined. In summary, the typical AIE behaviors were observed from the o-carborane-containing main chain-type polymers. Significant emission was hardly observed from the THF solution of the polymers having electron-donating $\pi$-conjugated linkers. On the other hand, by adding the water content in the solution for the formation of aggregation, emission intensity was enhanced. Finally, similarly to the previous example having AIE properties, in the mixed solvent of THF/$H_2O$ = 1/99, bright emission was obtained. From these experiments, it was proposed that the o-carborane polymers can work as an AIE-active material.
To comprehend the AIE mechanism in the o-carborane-containing polymers, the series of mechanistic studies with o-carboranes were performed. Accordingly, it was clarified that the intramolecular charge transfer should occur by the photo-irradiation because of strong electron-accepting properties of o-carborane and electron-rich linkers. In the excited state, the electrons should be delocalized involving the C–C bond in the o-carborane unit. By the structural vibration at the o-carborane moiety, excitation energy was consumed, leading to the quenching of the emission. In the solid state, most of molecular motions should be suppressed, resulting in the strong emissions. Thus, AIE behaviors should be obtained from the polymers. Based on this mechanism, we aimed to modulate AIE properties by altering environmental factors.

## Stimuli-Responsive AIE Regulation with o-Carborane Materials

The modulation of emissive properties of the o-carborane-containing polymeric materials by environmental alteration was accomplished based on hydrogel matrices.[10] The cross-linking reagent composed of o-carborane was synthesized (Fig. 4a). By using this cross-linker, the translucent hydrogels consisting of poly($\gamma$-glutamic acid) were prepared. By the gel-shrinkage from the change of ionic strength, it was found that the luminescence intensity from the modified hydrogels was drastically changed. Weak emission was obtained in the swollen state. The bright emission was observed by drying the hydrogel. Moreover, these changes in the emission intensity were reversibly repeated many times between the swollen and dried states. According to the AIE mechanism of the o-carborane unit, these behaviors can be explained by the fact that the molecular motion at the o-carborane cross-linkers should be suppressed in the dried state. Then, the significant emission can be observed from the material. In the swollen state, the molecular motion should be recovered, leading to the annihilation of the emission.
We also prepared the o-carborane derivative and found multi-chromism behaviors (Fig. 4b).[11] For example, we synthesized di-o-carborane-substituted oligoacenes, and their structures as well as emission behaviors were investigated in detail. Accordingly, from recrystallization in $CH_2Cl_2$, $C_6H_6$, and $CHCl_3$, solvent-incorporated crystals were afforded. Each crystal exhibited different emission colors (yellowish-orange, orange, and red, respectively). Additionally, the emission colors can be tuned by heating, vapor fuming and external mechanical stimuli. In summary, we can expect the o-carborane "element-block" should be not only AIE-inducible unit but also a functional unit with multi-chromism behaviors.

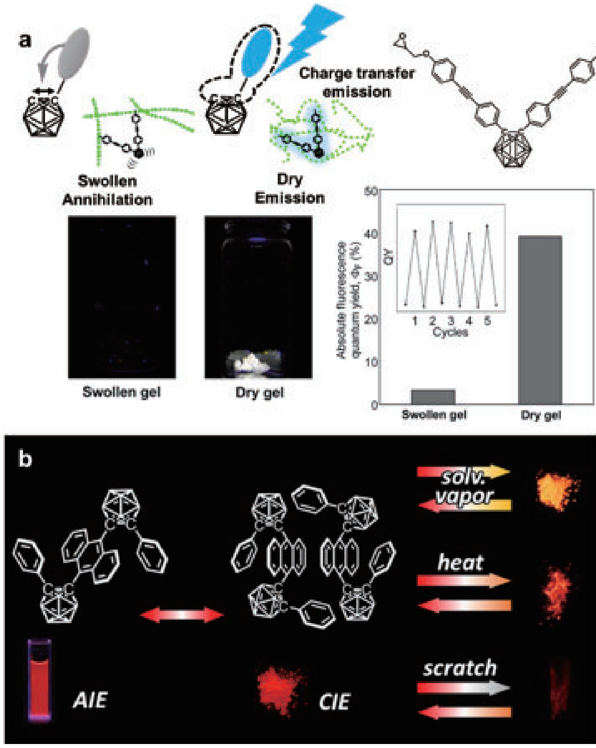



Fig. 4 (a) Schematic model of stimuli-responsive emissive hydrogels containing o-carborane cross-linker. Reprinted with permission from ref. 9. Copyright 2010 American Chemical Society. (b) Stimuli-responsive multi-luminescent chromism of o-carborane derivative. Reprinted with permission from ref 11. Copyright 2015 Wiley-VCH Verlag GmbH & Co. KGaA.

## Concluding Remarks

In this mini review, the recent progress for the development of the AIE-inducible organoboron complexes and the resulting AIE-active molecules including polymers are introduced. AIE-active materials can be readily prepared by introducing AIE-inducible organoboron "element-blocks" in the conjugation systems including polymers. As a result, various types of solid-state emissive materials with unique optical properties were observed. Finally, based on these emissive materials, the series of AIE-active conjugated polymers, film-type chemical sensors, and bright solid-state emissive materials can be obtained. The design strategies for the functional materials based on "element-blocks" are promised to be a versatile concept not only for improving the efficiencies of the conventional devices but also for generating novel organic devices.

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# Detection of Inclusions in Metal Materials Using an Ultrasonic Fatigue Testing System

Fumiaki Yano and Takuo Ono, Shimadzu Corporation

Generally it is known that with most structural metal materials the fatigue strength lowers until a load is applied $10^6$ times, and from $10^7$ times onward the fatigue limit is reached at which no fatigue fracture will occur. However, it is also revealed that with high-strength metal materials that are hardened or surface treated, internal inclusions become an origin of a fatigue fracture and cause a fracture even at $10^8$ to $10^9$ cycles. When a fracture occurs from the inside, it is considered that the fatigue strength depends on the size and kind of internal inclusions. Consequently, to evaluate the fatigue strength of high-strength metal materials, it is important to know the size and kind of inclusions present in the metal materials. There are some methods for inclusion detection, such as mirror polishing and observing the surface of the specimen; however, no one can tell whether a fatigue fracture starts from the detected inclusion. Therefore, to detect inclusions which lead to an internal fracture, it is best to actually carry out a fatigue test[*1]. However, a fatigue test exceeding $10^9$ loading cycles at 10 Hz will take approx. 3.2 years. The ultrasonic fatigue testing system used for this experiment enables testing at a frequency of 20 kHz, achieving a test with $10^9$ cycles in about 14 hours. Such a system is very effective to detect internal inclusions through actual fatigue testing. In this experiment, we performed the detection of inclusions in an SNCM439 specimen using the ultrasonic fatigue testing system, USF-2000A, and observed the inclusions using the electron probe micro analyzer, EPMA, to identify their elements.

## Inclusion Detection by Ultrasonic Fatigue Testing

Fig. 1 shows the testing system configuration. Table 1 gives the testing equipment used and Table 2 gives the test conditions. The stress amplitude that could cause an internal fracture was assumed to be 900 MPa based on the previous report[*2]. The testing results are listed in Table 3.

The number of cycles to failure was in the range of $2.91 \times 10^7$ to $6.27 \times 10^8$, indicating a difference of more than tenfold at the maximum. All fractures were originated from internal inclusions. For reference, a photo (optical microscope image) of the fractured surface of specimen #3 is shown in Fig. 2. In the case of a fracture originating from an inclusion, a condition referred to as a "fish eye"[*3] is observed on the fractured surface, which indicates the progression of fracture in a circular pattern with the inclusion at the center.

Table 1 Testing System

| | | |
|---|---|---|
| Testing system | : | Ultrasonic Fatigue Testing System USF-2000A |
| Thermometer | : | Radiation thermometer |
| Displacement meter | : | Eddy current displacement sensor |

Table 2 Test Conditions

| Specimen | Stress amplitude [MPa] | Number of cycles to failure |
|---|---|---|
| 1 | 900 | $6.27 \times 10^8$ |
| 2 | 900 | $1.06 \times 10^8$ |
| 3 | 900 | $2.91 \times 10^7$ |

Table 3 Test Results

| | | |
|---|---|---|
| Specimen | : | SNCM439 |
| Stress amplitude | : | 900 MPa |
| Maximum cycles | : | $1 \times 10^{10}$ |
| Number of specimens | : | n = 3 |
| Stress ratio | : | −1 |
| Frequency | : | 20 kHz |
| Intermittent operation | : | Oscillation time: 300 ms, non-oscillation time: 200 ms |

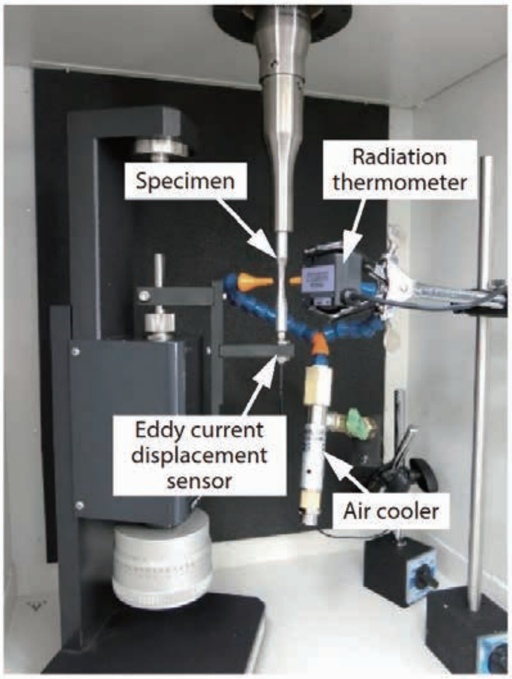



Fig. 1 Picture of the Test

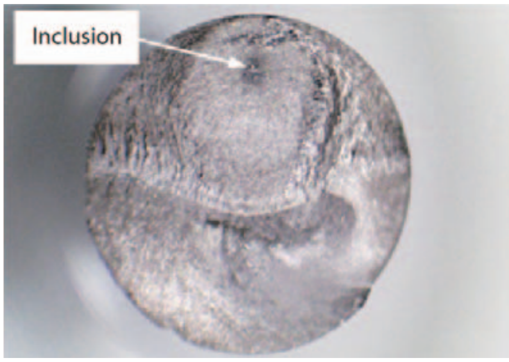



Fig. 2 Photo of the Fractured Surface (Optical Microscope)

## Observation and Analysis of Inclusions with an Electron Probe Micro Analyzer

To examine the fractured surface condition as well as the size and kind of inclusions in metal materials after a fatigue test, we used the electron probe micro analyzer, EPMA-8050G. Fig. 3, Fig. 4 and Fig. 5 show respective observation images (secondary electron images) of the fractured surfaces and inclusions on specimens #1, #2 and #3. On all specimens, the fracture was developed from an internal inclusion, indicating that inclusions are the origin of fatigue fractures. The size (major diameter) of the inclusion obtained from the images is listed in Table 4. Table 3 and Table 4 together indicate that the larger the inclusion size is, the smaller the number of cycles to failure, suggesting that fatigue strength is affected by the size of the inclusion. Following the above observation, we performed a mapping analysis to determine the constituent elements of inclusions on the specimens. The mapping analysis results of the inclusion of specimen #1 are shown in Fig. 6. Image (a) in Fig. 6 shows the secondary electron image which is suitable for grasping the profile of the inclusion. Image (b) helps to understand the relative composition of constituent elements. In this backscattered electron image, the smaller the mean atomic number the darker it appears and the larger the brighter. Images (c) to (f) show the distribution images of O, Al, S, and Mn and indicate that these elements are contained in inclusions at high concentrations. From these results, the inclusions proved to be alumina ($Al_2O_3$) and manganese sulfide ($M^nS$). Inclusions in specimens #2 and #3 were also found to be mainly alumina and manganese sulfide.

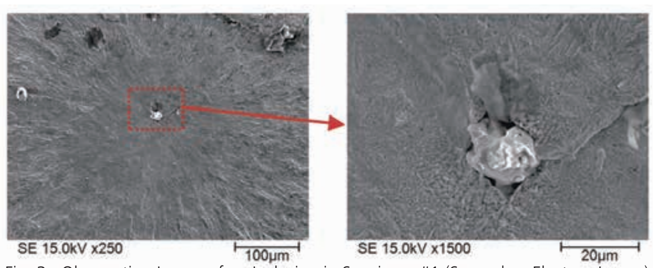


Fig. 3 Observation Image of an Inclusion in Specimen #1 (Secondary Electron Image)

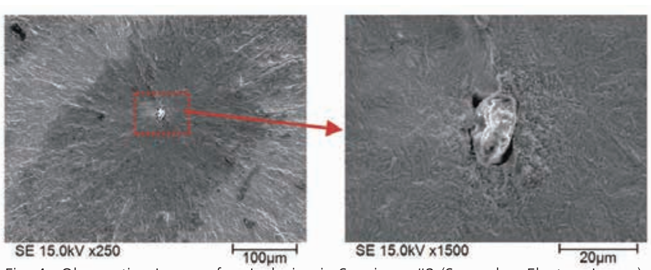


Fig. 4 Observation Image of an Inclusion in Specimen #2 (Secondary Electron Image)

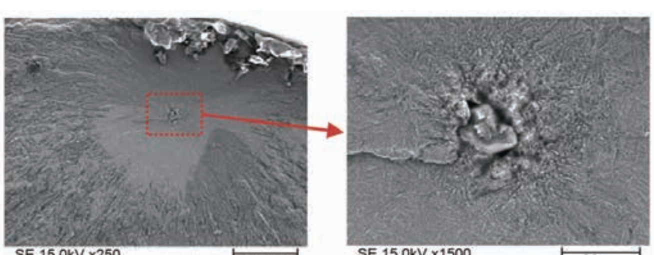


Fig. 5 Observation Image of an Inclusion in Specimen #3 (Secondary Electron Image)

Table 4 Size of Inclusions

| Specimen # | Specimen #1 | Specimen #2 | Specimen #3 |
|---|---|---|---|
| Size (Major Diameter) of Inclusions | 16 µm | 20 µm | 22 µm |

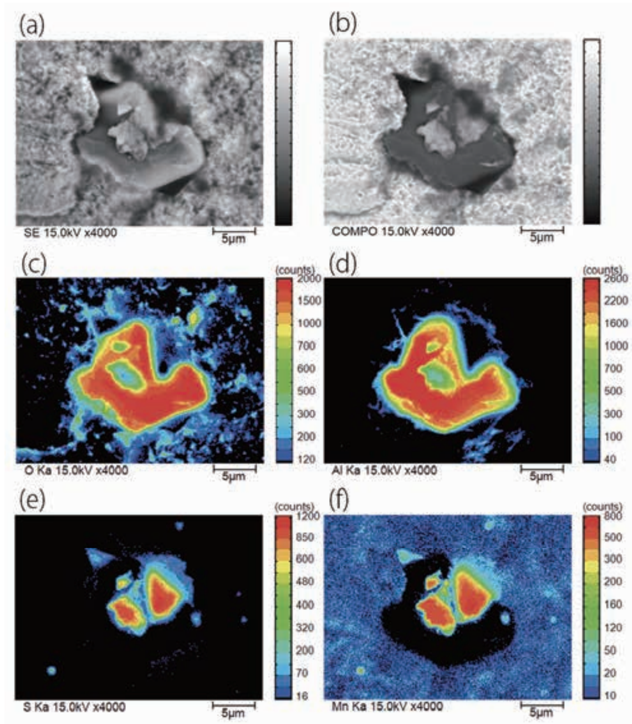


Fig. 6 Mapping Analysis Results of Specimen #1
(a) Secondary Electron Image,
(b) Backscattered Electron (Composition) Image,
(c) O-distribution Image, (d) Al-distribution Image,
(e) S-distribution Image, (f) Mn-distribution Image

## Conclusion

In this experiment, we performed the detection of inclusions in metal materials using an ultrasonic fatigue testing system. Actual fatigue testing is the best way for detecting inclusions which may cause an internal fracture and an ultrasonic fatigue testing system is an effective means to drastically shorten the testing time. In addition, we analyzed the inclusions using an electron probe micro analyzer to determine the size and constituent elements of each inclusion. From this, we confirmed that the size of inclusions may be affecting the variation in the number of cycles to failure and that observation of the fractured surface is indispensable in ultrasonic fatigue testing.

## References

*1 Yoshiyuki Furuya, Saburo Matsuoka, Takayuki Abe: Tetsu-to-Hagane, Vol. 88 (2002) No. 10 (in Japanese)
*2 Application News No. i258
*3 Yoshiaki Akiba, Keisuke Tanaka, Akira Nakatsu: Transactions of the JSME (Part A) Vol. 70 No. 695 (2004-8) (in Japanese)

# Shimadzu Selection

Shimadzu selected the following articles for this issue. They derive from application notes related to material sciences, and utilize a variety of Instruments we produce. Cutting-edge technologies are also included.

**Selection 1** Material Science

## Structural and Physical Properties of Liquid Marble

Pressure-sensitive adhesive (PSA) powder consists of particles with a soft adhesive polymer core and a hard particle shell morphology that shows no adhesion and flows like a powder in its original form. Droplets stabilized by adsorbing solid particles on its surface are termed as liquid marbles. Only after application of shear stress, does PSA show its adhesive nature. Adhesion is induced by rupture of the nanoparticle coating of the powder and outflow of the inner soft polymer. We investigated the structural and adhesive properties using a Nano Search® microscope, an electron probe microanalyzer (EPMA), a microfocus X-ray CT system, and a probe tack tester.

**Selection 2** Material Science

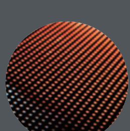
## Preparation of Mimetic Materials of Shells and Their Properties

Since the hardness and toughness of natural nacre are determined by hierarchical microstructures with organic matters, it is of great importance to control the microstructures of artificial free-standing $CaCO_3$ thin films. However, because the fabrication of such films has so far been quite limited, their mechanical properties have not been reported to a significant extent. To address this, free-standing calcite thin films were prepared through repeated cycles of layer-by-layer deposition of vaterite precursor composite particles with organic polymers, followed by a phase transition to calcite. The vaterite precursor composite particles were obtained by using a carboxylate-terminated poly(amidoamine) (PAMAM)-type T8-caged silsesquioxane-core dendrimer (POSS-(COOH)$^{16)}$ or an octacarboxy-terminated T8-caged silsesquioxane (POSS-(COOH)$^{8)}$. Incubation of the vaterite composite particles in distilled water for 3 days led to complete phase transition to calcite. Calcite thin films were obtained on a glass substrate pre-coated with a poly(diallyldimethylammonium chloride) (PDDA) layer or a multilayer of PDDA with poly(sodium 4-styrenesulfonate) (PSS) through repeated cycles of layer-by-layer deposition of the vaterite particles, followed by a phase transition to calcite. Free-standing calcite thin films were obtained through repeated cycles of this process after PDDA and PSS were coated on the surface of the calcite thin films. In this way, six distinct calcite thin film types were produced, with subsequent three-point bending tests revealing that all exhibit elastic bending prior to fracture.

**Selection 3** Material Science

## Color Analysis of New Optical Film (MLF) with Super Multilayer Structure Based on the Incident Angle of Light

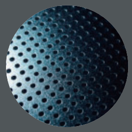
Teijin DuPont Films Japan Limited has developed a new multilayer optical film (MLF) that has a super multilayer structure. This structure is designed to mimic the wing of a morpho butterfly, which creates color structurally. The key characteristics of structural coloration are that coloration varies according to the angle of view, and unlike pigments, the color does not fade because the color is produced due to its structure. In this paper, we describe using the SolidSpec-3700DUV spectrophotometer with a variable angle absolute reflectance attachment to perform measurements of a new multilayer optical film based on the incident angle of light. We confirmed that changing the incident angle of light to a MLF film changes the transmittance spectrum. In addition, using the L*a*b* color space to evaluate the transmittance spectrum, we were able to digitize the color and confirm the correlation between the visual color changes and the numerical values.



**Selection 4** Material Science

## Fluorescence Measurement of Organic Electroluminescent Material

Screens, lighting, and other products that incorporate organic electroluminescent (EL) materials are being developed on a daily basis in the electrical and electronic goods sector. Organic EL material development involves the synthesis of new substances and verification of their optical properties using photoluminescence (PL) technique. Researching the PL allows us to find materials that emit light with high efficiency, and we can elucidate the mechanism of its fluorescence in solution. Organic EL materials are developed through this process to meet specific criteria that can include hue, low energy consumption, or high luminous efficiency. In order to evaluate organic EL materials, fluorescence must be measured quickly and accurately over a wide range of wavelengths. Introduced here are the measurements of porphyrin solution (solvent: chloroform), an organic EL material, using an RF-6000 spectrofluorophotometer, with the help of the Institute for Basic Science, Pohang University of Science and Technology (POSTECH), South Korea.



Selection 5 Material Science

## Ultrasonic Fatigue Testing of Metal Materials

Generally it is known that with most structural metal materials the fatigue strength lowers until a load is applied $10^6$ times, and from $10^7$ times onward the fatigue limit is reached, at which no fatigue fracture will occur. However, it is also revealed that with highstrength metal materials that are hardened or surface treated, internal inclusions become an origin of a fatigue fracture and cause a fracture even at $10^8$ to $10^9$ cycles. On the other hand, recently, the functionality and endurance required for industrial products are becoming stringent, and according to this trend, metal materials forming industrial products must also meet rigorous requirements. Therefore, conventional testing with a maximum of $10^7$ loading cycles is now insufficient, and a fatigue test exceeding $10^9$ cycles has become required. However, such a fatigue test will take considerable time. For example, a test with $10^9$ cycles at a frequency of 10 Hz theoretically requires about 3.2 years. The ultrasonic fatigue testing system used for this experiment enables testing at a frequency of 20 kHz, achieving a test with $10^9$ cycles in about 14 hours. Therefore, this testing system is a very effective measurement system for fatigue tests exceeding $10^9$ cycles.
In this experiment, we used two kinds of metal specimens, SNCM439 and A6063, for testing according to WES 1112: 2017 (Ultrasonic fatigue testing method for metal materials) stipulated by the Japan Welding Engineering Society. The results are introduced in this article.

Selection 6 Material Science

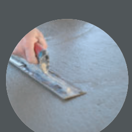
## Surface Analysis of PET Film Using a Benchtop MALDI-TOF Mass Spectrometer

MALDI-TOF mass spectrometers are a mass spectrometer type that is used in a wide range of fields likewise LCMS, in terms of high through-put and high sensitivity. These instruments have recently being utilized more and more for simple molecular weight measurement and profiling of synthesized products and high-molecular compounds. This is because instruments of this type have several features: singly-charged ions are generated so molecular weights can be recognized easily, the mass range is wide, and there are many solvent options because the sample is dried before measurement. On the other hand, due to changes in social conditions in these several years, government offices, universities, and private enterprises strongly request the reduction of costs for both introduction and running of instruments used for such applications. The benchtop "MALDI-8020" MALDI-TOF mass spectrometer is a new instrument that can sufficiently meet such market needs. The noteworthy point of this instrument is that it has a shorter flight tube, which is the key feature of its small size, while retaining the performance equal to or higher than that of a conventional model. In recent years, the usability of MS imaging using a MALDI-TOF mass spectrometer has become widely recognized and various techniques are being developed. On the other hand, needs for examining the compounds that exist on surfaces, rather than its "microscopic structure", are increasing in association with degradation and durability tests. This article introduces an example of analyzing a PET film surface using the benchtop MALDI-TOF mass spectrometer "MALDI-8020".

Selection 7 Material Science

## Evaluation of Photonic Materials with Biomimetic Structural Coloration

Colors occur either as pigments that absorb certain colors while reflecting/scattering others or as structural coloration caused by microscopic structures. Many living things in the natural world produce this type of structural coloration that results in vivid colors, including morpho butterflies, peacocks, and jewel beetles. Biomimetics is gaining attention as a field that utilizes the functions and structures of these living things in the development of new technology and manufacturing processes by mimicking them.
In Application News No. A502, we confirmed the existence of structural coloration on a multi-layered film produced by mimicking the wing structure of morpho butterflies, in which the coloration was caused by interference.1) The vivid colors observed on the wings of some birds are also structural coloration. For example, the structural coloration of peacock plumage is said to originate from the arrangement of melanin granules.2) Michinari Kohri, Associate Professor at the Division of Applied Chemistry and Biotechnology at Chiba University's Graduate School of Engineering, has succeeded in producing highly visible structural coloration by controlling the size, blackness, refractive index, and arrangement of melanin-mimicking particles (PSt@PSA particles) created by coating the surface of polystyrene particles (PSt) with polydopamine (PDA), which is similar to melanin.3) This article introduces measurements of photonic materials with structural coloration performed in cooperation with Associate Professor Michinari Kohri.



Selection 8 Material Science

## X-ray Diffraction Analysis of Cement (2)
## - Quantitative Analysis of Compounds Using the Rietveld Method -

Cement is manufactured through the processes of crushing and mixing raw materials, calcination, and finishing. The crushing and mixing process uses raw materials such as limestone, clay, silica stone, and iron oxide and these materials contain alite (C3S), belite (C2S), aluminate (C3A), and ferrite (C4AF). Since the ratios of these compounds differ according to manufacturer and product type and significantly affect product performance, cement is analyzed using X-ray fluorescence and X-ray diffraction. However, even with X-ray diffraction, which is capable of qualitatively analyzing powder samples, quantitative analysis of samples consisting of multiple components is known to be difficult due to considerable overlapping of diffraction lines. This article introduces an analysis example of a cement powder sample which is known the component composition and the ratio, using Siroquant software (Sietronics Pty. Ltd.) applying Rietvelt analysis method which is the one of the profile fitting method. Siroquant enables identification of composition components and quantitative analysis in addition to the element analysis using X-ray fluorescence in quality control of cement.

**Selection 9** Material Science

## Quantitative Analysis of Lead in Bismuth Bronze - Matrix Elements/Profile Correction and Comparison with AA -

Some copper alloys are added with lead (Pb), but with the regulation of environmentally hazardous substances such as RoHS, it has been replaced by bismuth (Bi) in recent years. In X-ray fluorescence analysis, Bi interferes with Pb, that is, spectra overlap, so the quantitative accuracy of low content Pb may not be sufficient. In such cases, calibration curve method applying overlap correction by coexisting elements is effective. Metal samples are generally measured in the plane of cutting and polishing, but there are cases in which the samples are irregular shapes such as chips and wiring. For irregularly shaped samples with coexisting elements, shape correction is required in addition to the overlap correction described above. This article introduces an examination of the quantitative analysis precision when applying these corrections to a flatsurface sample and chip sample through a comparison with atomic absorption (AA) analysis.

**Selection 10** Material Science

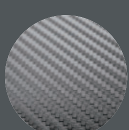
## Measuring Polyethylene (PE)-Polypropylene (PP) Blend Samples

Polymeric materials are blends of two or more types of high molecular materials that are mixed to improve mechanical properties. Blends are often created to obtain properties that a single type cannot possess; however, this requires an understanding of component ratios. Unlike copolymers, mechanically blended polymeric materials exhibit the characteristics of each component, such as melting and crystallization, and multiple changes derived from each component can be observed through measurement with a DSC (differential scanning calorimeter). This research utilizes this process to introduce examples of determining the component ratios of blended high molecular materials by measuring the heat of fusion with a DSC.

**Selection 11** Material Science

## Analysis of Polycarbonate Using a Benchtop MALDI-TOF Mass Spectrometer

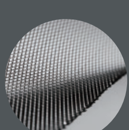
In recent years, recycling related laws have been enforced for the purpose of global environmental preservation, which in turn has increased the amount of recycled plastic products around us. This trend entails the needs of rapid and detailed analyses of recycled products. In such cases, sufficient information may be obtained by analyzing not the entire polymers but oligomers. Conventionally, oligomers are analyzed by combining rough separation using the dissolution/reprecipitation method, etc., and various chromatographic or spectroscopic techniques. On the other hand, recently MALDI-TOF mass spectrometers are extensively used for oligomer analysis. By using such instruments, the information of terminal groups and monomer units can be obtained rapidly. This article introduces an example analysis of polycarbonate, which was performed by combining rough separation of oligomers by the dissolution/reprecipitation method and measurement and analysis using the benchtop MALDI-TOF mass spectrometer "MALDI-8020".



**Selection 12** Material Science

## Compression After Impact Testing of Composite Material

Carbon fiber reinforced plastic (CFRP) has a higher specific strength and rigidity than metals, and is used in aeronautics and astronautics to improve fuel consumption by reducing weight. However, CFRP only exhibits these superior properties in the direction of its fibers, and is not as strong perpendicular to its fibers or between its laminate layers. When force is applied to a CFRP laminate board, there is a possibility that delamination and matrix cracking will occur parallel to its fibers. Furthermore, CFRP is not particularly ductile, and is known to be susceptible to impacts. When a CFRP laminate board receives an impact load, it can result in internal matrix cracking and delamination that is not apparent on the material surface. There are many situations in which CFRP materials may sustain an impact load, such as if a tool being dropped onto a CFRP aircraft wing, or small stones hitting the a CFRP wing during landing. Consequently, tests are required for these scenarios. One of these tests is compression after impact (CAI) testing. CAI testing involves subjecting a specimen to a prescribed impact load, checking the state of damage to the specimen by a nondestructive method, and then performing compression testing of that specimen. This article describes CAI testing performed according to the ASTM D7137 (JIS K 7089) standard test method.



**Selection 13** Material Science

## Compression Test of Composite Material

Even among composite materials, carbon fiber reinforced plastic (CFRP) has a particularly high specific strength, and is used in aeroplanes and some transport aircraft to improve fuel consumption by reducing weight. Compressive strength is an extremely important parameter in the design of composite materials that is always tested. However, due to the difficulty of testing compressive strength there is a variety of test methods. A major compression test method is the combined loading compression (CLC) method found in ASTM D6641. The CLC method can be performed with a simple jig structure, untabbed strip specimens, and can be used to simultaneously evaluate strength and measure elastic modulus. We performed compression testing of CFRP according to ASTM D6641.

# Shimadzu has acquired AlsaChim, a specialist for high-quality analytical isotope labeled standards

### AlsaChim brand becomes a 100% part of the Shimadzu Group / Clients benefit from one-stop solutions of complex analytical systems /

Shimadzu has joined forces with the France-based AlsaChim company, an independent contract research and development organization. AlsaChim specializes in stable isotope-labelled compounds, metabolites and pharmaceutical related substances, and analytical purposes. With immediate effect, Shimadzu Europe has acquired AlsaChim by 100%.The brand name will be kept for the future complemented by the subtitle "a Shimadzu Group Company". The price for the acquisition is kept confidential.

(News released on June 21, 2017)

### AlsaChim's standards and solutions extends Shimadzu's hard- and software products

The AlsaChim technology complements Shimadzu's product and solution portfolio in the clinical market. AlsaChim is an established and well-known innovative company and provides standards and stable isotopes; particularly the latter are key differentiators for customers in the clinical and diagnostic fields. AlsaChim's expertise and market-proven stable isotope standards as reference material for application kits are value-adding line extensions to Shimadzu's hard- and software. For example, for the LCMS-triple quadrupole instruments and the LAM-2000 automated sample pretreatment system, Shimadzu will be able to complete the application packages by standards and kits.

Through the acquisition of AlsaChim, Shimadzu also adds value to its European Innovation Center (EUIC), particularly for the clinical segments which is one of EUIC's focus areas. This innovations-oriented Think Tank combines academic-scientific expertise from well-known European universities with Shimadzu's cutting-edge technology to provide even more customer-focused service.

"With AlsaChim, we have a strong partner in our organization who is able to finalize and validate new application kits and utilize the developments done by EUIC and transfer them into ready-to-use products", said Bjoern-Thoralf Erxleben, Senior Manager Analytic Shimadzu Europa, based in Duisburg, Germany.

## Clients now benefit from one-stop solutions of complex analytical systems

The broad range of products, AlsaChim's comprehensive knowledge in synthesis of stable isotopes and the big number of reference materials, offers a lot of opportunities. Now, Shimadzu is able to enter the market with complete solutions consisting of hardware, software as well as application kits. This generates a new market recognition and follow-up business with continuously running customer relationships. Whereas different providers were involved in the purchasing process so far, clients now benefit from one-stop solutions of complex analytical systems covering a complete validation of the application, including sales, service, support and consumables.

Shimadzu and AlsaChim expect new customers for both brands. The EUIC and its strong cooperation partners provide a platform for new and additional business. Having with AlsaChim a strong partner for development of application kit solutions, this will increase Shimadzu's business in the clinical and diagnostic market, but also in other market segments. "Being part of the Shimadzu Group, the AlsaChim brand expects additional demand for their products in new sales areas as well as stronger marketing support than before", said Jean-Francois Hoeffler, President of AlsaChim.

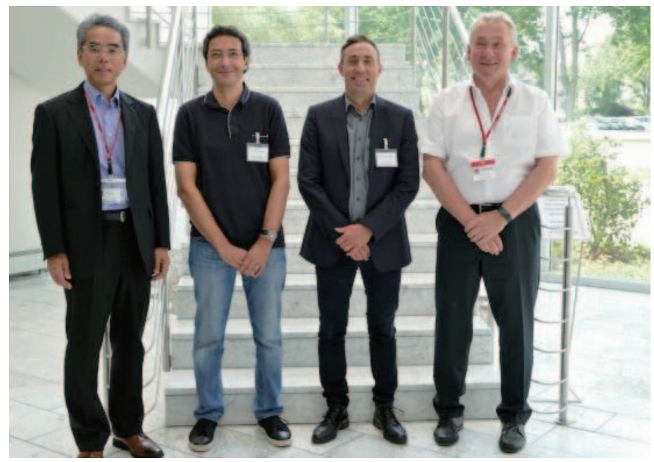


Fig. 1 (left to right): Yasunori Yamamoto, President Shimadzu Europa, Toufik Fellague, Managing Director AlsaChim; Jean-Francois Hoeffler, President AlsaChim Juergen Kwass, Managing Director, Shimadzu Europa
(News released on June 21, 2017)

ALSACHIM
a Shimadzu Group Company

Fig. 2 new logo

## Summary

Shimadzu has joined forces with the France-based AlsaChim company specializing in stable isotope-labelled compounds, metabolites and pharmaceutical related substances. With immediate effect, Shimadzu Europe has acquired AlsaChim by 100%.The brand name will be kept for the future complemented by the subtitle "a Shimadzu Group Company". Through this acquisition, Shimadzu will further develop and extend its activities in the clinical market which is one of the focus areas for the European Innovation Center (EUIC). The AlsaChim technology complements Shimadzu's product and solution portfolio in the clinical market. Now, Shimadzu is able to enter the market with complete solutions consisting of hardware and software as well as application kits. Clients now benefit from one-stop solutions of complex analytical systems.

### For further editorial questions, please contact:

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## Shimadzu Promotes the Creation of Products Using Key Technologies Through Joint Research and Development Innovation Centre in Singapore in Operation

Shimadzu has established the Innovation Centre in its oversea subsidiary Shimadzu (Asia Pacific) Pte Ltd. (SAP) to manage most advanced joint research and development with local researchers, and started operations on November 17, 2017.

Shimadzu Innovation Centre in Singapore has 7 members of staff working to promote joint research and development and create products using promising research outcome and results collected from external organizations such as universities and research institutes in Asia and Oceania. Shimadzu will organize project teams including engineers and marketing personnel from the Head Office in Japan in accordance with the core key technologies developed outside Shimadzu, so that designing of peripheral components and development of practical applications can be started jointly at an early stage with the aim that products will be created using each technology. After developing prototypes in Singapore, the technology will be transferred to the Head Office in Japan for creating the final products. In this way, we will eliminate barriers and solve issues, so called "valley of death," encountered during the process of creating a product.

Shimadzu is currently working with the National University of Singapore Environmental Research Institute in developing a high sensitivity environmental sensor to detect phosphorous and nitrogen contained in rivers and lakes, aiming to create a product by the end of 2020. We plan to increase the range of themes handled by the Innovation Centre in Singapore.

### Shimadzu's Joint Research and Development Outside Japan

Shimadzu is promoting joint research and development with universities, research institutes, and companies with innovative technologies. As Shimadzu's sales for its main analytical and measuring instruments business have been more extensive in countries outside Japan, it is important to quickly develop products and application systems that meet local needs and satisfy latent needs.

Based on this policy, in 2015 Shimadzu established an Innovation Center with about 20 employees in its subsidiary Shimadzu Scientific Instruments, Inc., located in Maryland in the United States, to conduct joint research with advanced researchers in the United States and create products utilizing research outcomes. Shimadzu also opened the Mass Spectrometry Center in its subsidiary Shimadzu (China) Co., Ltd., in Beijing in the same year to develop and establish high-end mass spectrometry systems. In 2017, Shimadzu designated advanced universities and research institutes that conduct joint research and development with Shimadzu as innovation centers, and established a headquarters in its subsidiary Shimadzu Europa GmbH located in Duisburg, Germany. The Head Office in Japan and innovation centers worldwide including the new Innovation Centre in Singapore will work together to accelerate the development of truly unique and number one products.

# Shimadzu Donates Mass Spectrometer to the IAEA supporting developing nations by applying nuclear technology to food safety


Shimadzu Corporation Chairman Akira Nakamoto (left) and IAEA Director General Yukiya Amano

Shimadzu Corporation and the IAEA (International Atomic Energy Agency, headquartered in Vienna, Austria)*1 have agreed on the donation of a Shimadzu LCMS-8060 High-Performance Liquid Chromatograph Mass Spectrometer*2 to the agency. IAEA Director General Yukiya Amano and Shimadzu Corporation Chairman Akira Nakamoto attended the signing ceremony for the Memorandum of Cooperation at Shimadzu Corporation Head Office (Kyoto, Japan) on October 2, 2017.

The IAEA supports development in emerging countries through the application of nuclear technology in fields such as food safety, environment, and healthcare. The LCMS-8060 donated by Shimadzu is slated to be installed at the Food and Environmental Protection Laboratory (FEPL), which is located at the Seibersdorf Laboratories near the IAEA Headquarters. The FEPL, which conducts research related to food safety and traceability management, had needed a high-speed, high-sensitivity mass spectrometer for the analysis of metabolites in order to analyze residual antibiotics, mycotoxins, and agricultural chemicals in foods, and to detect adultration in ingredients or origin.

In addition to the LCMS-8060 High-Speed Liquid Chromatograph Mass Spectrometer, the donation includes the dispatch of Shimadzu engineers to install the unit and assist in the establishment of analysis methods, support during the warranty period, and inspection at the end of the warranty. The total amount of the donation comes to 409,925 euros (51.24 million yen, converted at 1 euro = 125 yen). Shimadzu Corporation, with its Corporate Philosophy of "Contributing to Society through Science and Technology", aims to solve social problems through innovative product development.

*1 Established in 1957 to promote the peaceful use of nuclear energy and to prevent its military use. Its contributions for many years have been recognized, and it won the Nobel Peace Prize in 2005.
*2 The flagship model that combines the world's highest sensitivity and detection speed. Released in May 2015.

Comments by the two participants of the signing ceremony are as follows.
Yukiya Amano, IAEA Director General
The IAEA has long used the motto "Atoms for Peace", but as of the 60th anniversary of our founding we have now adopted "Atoms for Peace and Development". I have great hopes that Shimadzu's products can contribute to "Development", the new part of our motto, in other words, support for developing nations. I would like to learn analytical techniques from the experts of Shimadzu and spread the knowledge throughout the IAEA."

Akira Nakamoto, Shimadzu Corporation Chairman
"As the IAEA's support for emerging countries in the food safety field is consistent with our Management Principle, "Realizing Our Wishes for the Well-being of both Mankind and the Earth", we made the decision to help by donating our analytical instrument. Our LCMS offers the world's highest levels of analytical sensitivity and speed. We hope that in the future, it would be used not only for food safety, but also for environmental and medical research."

The LCMS-8060 High Performance Liquid Chromatograph Mass Spectrometer

# New Products

## HITS-TX
### (High-Speed Impact Testing Machine)

Click here>>

The new HITS-TX high-speed impact tesitng machine can perform tensile tests of plastics and resin-based composite materials at a maximum speed of 20 m/s (72 km/h).

**Features**
- Allows a wide variety of tensile tests, from high-speed to low-speed, with a single machine
- Acquires low-noise waveforms utilizing new data processing technology
- Enables visualization of ultra-high-speed phenomena when combined with high-speed video camera offers high usability

## MALDI-8020
### (Benchtop Linear MALDI-TOF Mass Spectrometer Microscope)

Click here>>

The MALDI-8020 matrix assisted laser desorption ionization-time of flight (MALDI-TOF) mass spectrometer boasts the world's highest level of resolution and sensitivity of a linear benchtop model designed for installation on a laboratory workbench.

**Features**
- Compact, High-Performance Benchtop Model
- High Speed and Long Operating Life
- Low Running Costs

## Polymer Additives Library
### (GC/MS Mass Spectra Library for a wide range of Additives utilized in polymer materials)

Click here>>

Shimadzu has released the Polymer Additives Library for its gas chromatograph mass spectrometers (GC/MS). This product will be useful in the analysis of polymer additives for a variety of purposes, ranging from quality control to new materials development and compliance with regulatory controls.

**Features**
- Includes Nearly 4900 Mass Spectra
- Retention Indices and Classification Information Are Registered

## IRSpirit
### (Compact Fourier Transform Infrared Spectrophotometer)

Click here>>

The IRSpirit is equipped with a dedicated IR Pilot program that simplifies analysis and, in spite of their compact size, which is smaller than an A3 size sheet of paper, provide outstanding expandability.

**Features**
- Compact, Yet Highly Expandable
- Dedicated IR Pilot Program Offers 23 Application-Specific Workflows
- System Configurations Can Be Optimized for the Specific Purpose and Environment of Use

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