JACI NEWS LETTER
Japan Association for Chemical Innovation

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HEADLINE

Chemistry-Based Innovation – The Key to Japan's Revitalization –

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Happy New Year! I'm pleased to send heartfelt New Year's greetings to you all in the Japan Association for Chemical Innovation.

It has been more than seven months since I took over as president of the Chemical Society of Japan (CSJ) last May. During this time, through activities of CSJ, I have dedicated myself to the improvement of the chemical capability of Japan. In order to revive the Japanese economy, we need to deepen science, and in particular, *chemistry* that can have an impact on a broad range of industries, create the most advanced technology and products in the world through innovation, and continue to sustain global growth by developing and implementing advanced business models. For this reason, we have identified keywords for the activities of CSJ as "globalization" and "seeking to attain top positions in the world" by means of innovation. Toward the achievement of these two strategic goals, we are working by identifying the specific priority issues to be addressed.

One of the priority issues is the "promotion of industry-academia collaboration with exit-oriented and problem-solving activities." CSJ, working together with the JACI and the Japan Chemical Industry Association, is promoting industry-academia-government collaboration activities. As an example, Advanced Technology Program (ATP) at the annual meetings and the fall CSJ Chemical Festival, we offered presentations on industry-academia-government R&D activities. Thus, the JACI, the Japan Chemical Industry Association, and CSJ are working together in a fully integrated manner, and we will strengthen the relationship even further.

I would like to note that the JACI has built a platform from which all persons involved in chemistry can conduct coordinated activities, and are committed to the promotion of chemical technology innovation based on green sustainable chemistry (GSC). In particular, in the area of global-level industry-academia-government collaboration, Japan is expected to play the role of a mariner's compass, providing directions to "exits" and "problem solutions." As part of that activity, in July of this year, a seventh international GSC conference will be held in Tokyo with the participation of industry-academia-government representatives in the field of chemistry from various countries to discuss "Toward a New Development of GSC." I believe this is a truly relevant program. I have high hopes that, with the JACI paving the way, the direction in which the chemical industry must proceed in the future will be made clear, and a constructive exchange of opinions will be held, leading to epoch-making innovations.

JACI's human resources development program (1)

Career Path Guidance for university (graduate school) students

For the nurturing of technicians who will be shouldering the Japanese chemical industry in the future, the Human Resources Development Group of the JACI has been offering "Career Path Guidance (CPG)" that promotes changes in the students' awareness toward learning by working together with universities and academic societies. In response to the voices heard from the "industry" that they would like to see students pursue meaningful studies while in college, and from academia that "they would like to know what kinds of graduates the industries are seeking," in the CPG we convey images of the types of personnel that chemical companies are seeking in concrete terms, in an effort to motivate the students to study solidly with a clear view of what the future holds for them. Since 2012, the number of student participants has reached approximately 630 persons. While continuing to provide improvements as we move forward, we intend to deliver messages from the chemical industry to increasing numbers of students and university officials alike.

The JACI came into being in April 2011. Taking over the flow of events stemming from the human resources development program conducted by then Japan Chemical Innovation and Inspection Institute (JCII), the JACI established the Human Resources Development Group. Currently, the Group is mainly composed of recruitment and personnel management officials of nine member corporations. In the initial stages of the Group, we conducted discussions on what topics our activities should focus on, and as a result, issues were identified regarding a lack of the basic aptitudes of new hires at chemical industries in recent years; the abilities to think on one's own, figure out things, and conduct research; and a paucity of incentives for self-improvement as indicated by international comparative studies. Also, universities have offered comments that they would like to see students study in a goal-oriented manner, with the educational institution providing information to the students as to what types of work they would be expected to perform in the businesses and what types of personnel the employers are seeking.

In light of the situation, we decided to prod universities to provide guidance for the benefit of undergraduate and graduate students before they enter into corporations, to "kindle the motivation for learning" by developing a clear image of what they would like to be in performing their respective roles as members of society. We started with the first of such a program established with the cooperation of Waseda University, in May 2012; and during 2014, we expanded the scope of our activity to four universities and five faculties.

The CPG comprises three sessions:

1. Keynote lecture: Members of the Human Resources Development Group take turns as speakers, explaining the goal of the CPG, the present status of the chemical industry in Japan, the types of work needed in and types of personnel required by corporations and the importance of learning when one is an undergraduate or graduate student.
2. Lectures describing on-the-job experiences: A junior graduate of the university at which the CGP is held, who is now working at a corporation at which a Group member is working, speaks to the research life he/she led as a student, his/her current job and things he/she has learned from performing work, by sharing specific examples.
3. Group discussion and presentation: After the lecture, the attendees split into groups of six to seven persons each. The students discuss set topics, such as "In order to perform well in society, what a student should accomplish while in college or graduate school?" and present the results of the discussions.

Table 1 Summarizes the targets of CPG and the results that have been identified to date.

Fig. 1 Keynote lecture

Fig. 2 Group discussion

Table 1 Summary of CPG

Year	2012		2013			2014			
Universities and academic groups	a	e	a	b	a'	b	a	c	d
Target	M1	D&M	M1	M1	B1	M1	M1	B3	B3
Number of persons	88	80	51	126	59	106	30	42	46
(1) Understanding of the objectives	N.A.	N.A.	N.A.	N.A.	96.6	85.8	75.0	69.0	77.9
(2) Understanding of the abilities	N.A.	N.A.	N.A.	N.A.	88.1	81.1	75.0	73.8	69.8
(3) Changes brought on in one's awareness	N.A.	N.A.	N.A.	N.A.	32.2	75.0	75.0	88.1	65.5
Average of (1) - (3)	N.A.	N.A.	N.A.	N.A.	72.3	80.6	75.0	77.0	71.1

D: Doctoral students, M: Master's degree students, B: Undergraduate students. Numbers represent the school years of principal respondents. Number of persons: lecture attendees
Items (1) - (3) represent total scores obtained by multiplying the number of persons in percentage by the results of after-the-session evaluation results: high = 100, medium = 50, low = 0
Point scores not assigned until year 2013b. For 2013a' and 2014b, a, the Executive Office analyzed the comments by the participants and arrived at point scores.
For 2014 c, d, the scores are by self-evaluations provided by the participants in the questionnaire answer sheets.

Here, numerals (1) through (3) denote after-the-session evaluation items. Each item represents a numerical score, on a scale of 3, addressing (1) whether the respondent has a good understanding of the goal of the CPG, (2) whether the respondent has a good understanding of what would be expected of him/her as a career path person, and (3) whether, as a result of taking the CPG, the respondent has thought about changing his/her attitude toward studies. When read in conjunction with the comments submitted by participants after taking the CPG, it appears that the information conveyed by the lectures was well-received, and our original goal of helping to motivate the students to learn solidly while in college was achieved. Also, in terms of the types of students covered, the questionnaire results reveal that junior-grade students who are on the verge of being accepted into a research laboratory or who have begun to think about their future or job hunting, and who still have ample time left as students, seem to benefit most from the program.

As we move forward, with the cooperation of universities and academic societies, we would like to continue to provide CPG as a unique program of the JACI and get our message across to a wider circle of students and university officials. Toward that goal, we need to revamp our method of implementation, until now mostly relying on the help of Group members and university faculty, develop standardization to reduce the load on the lecturers, make greater use of websites and distribution of videos, assess the effectiveness of the program with respect to chemical businesses and obtain feedback. We will continue to improve the program further.

Glass teaching materials for high school chemistry classrooms

In June of 2013, the JACI provided a set of experiment-observing glass teaching materials sent as a gift to the Society to study Chemistry education for the Next generation (SCN). The set comprises four types of single plates and three types of multi-layer glass plates, for a total of seven types (each piece measuring 10 cm square). To make sure that the supply will not be a one-time deal, we provided it at cost. The price of the materials handed out was set extremely low, thanks to the assistance of the participating businesses.

Fortunately the glass teaching material set was well-received by the teachers in the classrooms, which led to the production of additional sets.

Also, because some recipients commented that a smaller size would be easier to use, we created a second series measuring 5cm square, and starting in November of 2014, we began to distribute the new sets (photo: the first series measuring 10cm square, and Teacher Yoshiyasu Tanaka representing the SCN).

It was Yoshiyasu Tanaka, a teacher at the Tokyo Metropolitan Toyama High School, who established the SCN. From a strong desire to pass on experimental skills to junior teachers with little experience in working with laboratory experiments, Mr. Tanaka launched the SCN in 2006. By hosting monthly study meetings, he has provided experience in conducting laboratory experiments to high school teachers, as well as counseling.

These activities have spread to Kanagawa and Miyagi prefectures, and the experience was featured in GSCN News Letter No. 41 (October 2011) as well. Mr. Tanaka's activities were noted by the Chemical Society of Japan, culminating in his having been awarded the 29th Chemical Society of Japan Award for Merits for Chemical Education for 2011.

I visited the Toyama High School and interviewed Mr. Tanaka.

-Since the establishment of the SCN in Kanagawa and Miyagi, have there been any new starts in other prefectures as well?

"Yes, the SCN has started in Okayama and Tokushima as well. When I'm invited to give a lecture and talk with local teachers, that could lead to the launching of a new SCN chapter. In this manner, I've seen the network grow."

-Do different prefectures have different needs in regard to whether or not a new SCN is to be initiated?

"Because most schools have only one chemistry teacher on their campus, if a teacher needs consultation, he/she has no recourse other than relying on a teacher at another school. In such a case, if there is no network, like a study group in the same prefecture, teachers end up thinking of setting up an SCN group on their own. In contrast, in the case of biology teachers for example, because they can take part in a retreat, including field work, set up by an existing study group, they feel little need to set up a new study group specifically intended to develop networks."

-In addition to the glass teaching materials, are there any other teaching materials that are needed in the classrooms?

"Yes, there are many teaching materials we would like to have. In the case of plastics, for example, there are pieces that can be used repeatedly, such as for comparing specific gravities, and pieces that we use by burning them little by little. So we would like to have different types, depending upon the specific purpose for which they are put to use."

-Given that many organizations are now providing support for science education, what kind of support would you expect from the JACI?

"Many types of support consist of one-time events, such as a chemistry experiment laboratory offered during the summer vacation. That works well if the purpose is to expose all kids to the fun that is chemistry. On the other hand, we would like to discover every year in classrooms, pupils who show an interest in conducting chemical experiments involving trial and error, not shying away from drudgery, that is, pupils who find an attraction to the manufacturing process itself. For this reason, we need continuing support rather than a one-time deal. In this sense, the glass teaching materials provided the JACI seem to be an ideal form of support."

GSC Topic

Development of the multi-layer film "ECOCeeeL" which contributes to resources saving

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Our company, having established a production method for a composite multi-layer film sheet based on the co-extrusion process, the first of its kind in the world, has conducted the manufacture and sales of a multi-layer film which is endowed with a variety of functions, including heat-sealing and barrier-providing capabilities. This paper describes the "ECOCeeeL" series of environmentally benign films that incorporate a strength-holding layer made possible with extensive use of micro-layer technology, attaining a quantum jump in film strength while maintaining the required functions and an amenability toward being rendered into thin film.

The ECOCeeeL series represents a multi-layer film endowed with a high impact tolerance and flex resistance by virtue of a strength-holding effect, through extensive use of micro-layer technology. In the work described in this paper, we compared a conventional film 180μm thick made by this company and an ECOCeeeL film 150μm thick.

As a first step, with respect to impact tolerance, we conducted evaluations by means of a falling-weight strength test (JISK7124-2). The results indicate that, despite being 30μm thinner than the control product, the ECOCeeeL exhibits a 2.7J total penetration energy compared with a 1.1J for the comparison product, or a better than 2-fold improvement (Fig. 1).

Secondly, we conducted evaluations by means of a Gelbo Flex test (ASTMF392). The results indicate that, whereas the conventional product showed an average film hole count of 8.2 after that test representing flex resistance, the ECOCeeeL exhibited an average count of 2.1, thus reducing the number of holes created to one-fourth (Fig. 2). These results confirm that the provision of a strength-holding layer produces significant improvements in impact tolerance and flex resistance.

Beyond the results on representative physical properties mentioned above, it was learned that in other mechanical properties also, the new product delivers a 1.3-fold improvement over the conventional products (Table 1). Consequently, the ECOCeeeL should be able to achieve performance levels comparable to the conventional products even when its film thickness is reduced by a factor of about 20%.

Let us now turn to a discussion on what environmental impact reduction effects can be achieved when the film thickness is reduced by a factor of about 20%. In the present work, we conducted a comparative evaluation using as an evaluation index the amount of CO_2 emissions reductions achieved when the film thickness is reduced. In calculating the volume of CO_2 emissions, we used the life cycle assessment (LCA) approach standardized by the Japan Environmental Management Association for Industry (JAMEI). The scope of life cycle covered by the calculations includes all stages of production of the raw materials for the resin, the product fabrication at our company, distribution, the use of the film and final disposal by incineration. In addition to the amount of CO_2 generated from the film during the incineration process, the calculations include the volume of CO_2 emissions produced during power generation for the electricity used at the various steps (software: MiLCA ver. 1.2.0; database: IDEA ver1.1).

The results indicate that, whereas the conventional product measuring 180μm thick produced 1124g CO_2 emissions per 1m^2, the 150μm thick ECOCeeeL generated 980g, achieving 144g per 1m^2, an approximately 13% reduction in CO_2 emissions (Fig. 3). Assuming that the amount of film used is 200,000 m^2 per year, the volume of CO_2 emissions reduced would be approximately 29 tons, equivalent to the volume of CO_2 absorbed by 2000 grown cedar trees (3.8 ha) ; thus, the new product can significantly contribute to an environmental impact reduction. Given the increased importance of environmentally benign products, our company, in response to market needs, will continue to work on expanding the penetration of the ECOCeeeL series into various fields of applications as we move forward.

Table 1 Comparison of properties between a conventional product (180μm thick) and ECOCeeeL (150μm thick)

Item number	Display		Conventional product	ECOCeeeL
Thickness	Thickness (um)		180	150
Flex resistance	Number of holes (each)		11.8	1.1
Impact tolerance strength	Total penetration energy (J)		1.10	2.30
Piercing strength	Piercing strength (N)		15.5	16.5
Mechanical properties	Tensile strength (N/mm^2)	MD	53.5	69.0
		TD	46.0	67.0
	Stretching (%)	MD	430	450
		TD	410	430
	Tearing strength (N/cm)	MD	1500	2100
		TD	1600	2000
Transparency	Light transmittance (%)		90.0	91.0
	Opacity		7.0	2.0
Barrier capacity	Oxygen permeability (mL/m^2·day·atm) @25℃×65% RH		1.4	1

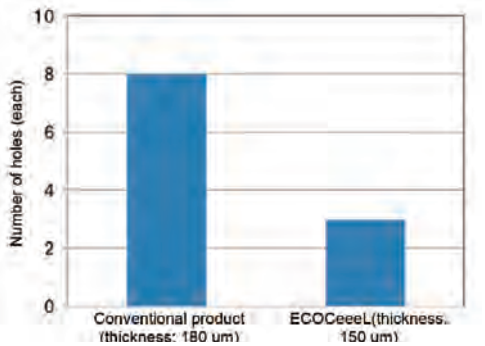

Fig. 1 Comparison of shock tolerance between a conventional product (180μm thick) and ECOCeeeL (150μm thick)

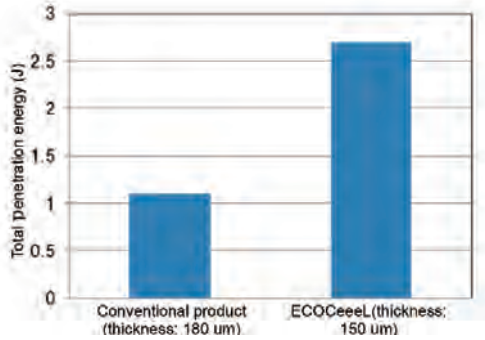

Fig. 2 Comparison of flex resistance between conventional product (180μm thick) and ECOCeeeL (150μm thick)

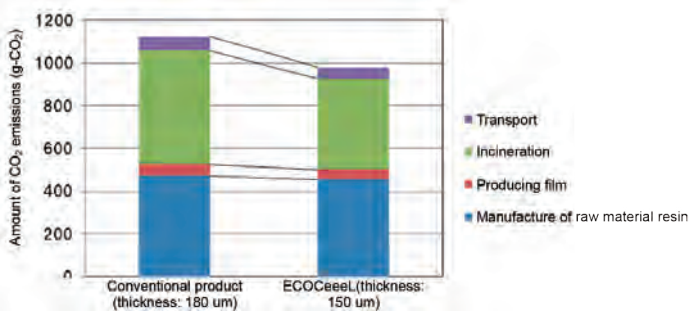

Fig. 3 Comparison of CO_2 emissions (per 1 m^2) between a conventional product (180μm thick) and ECOCeeeL (150μm thick)

Fabrication of valuable functional materials using waste slag

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Iron and steel making slag is a waste product generated during the iron refining process, with a total domestic output volume as much as 38,000,000 tons. Due to the compositional complexity, previous methods to convert slags into inorganic functional materials required complex, multi-step chemical processes. In view of the situation, we developed a simple approach that converts slag into high value-added functional materials by designing processes taking advantage of the characteristics of each metal component contained in the slag. This paper provides an overview of the iron-making slag conversion process that we have developed, and an outlook for its applications.

Slag is a by-product generated during the metal refining process. The type of slag that is produced in the largest volume is iron and steel making slag generated during the iron refining process. Because the iron and steel industry ranks as a basic industry in Japan, massive amounts of iron and steel making slag are produced. The total domestic output in 2012 was as much as 38,000,000 tons. Iron-making slag has been regarded as industrial waste because it requires high disposal costs if left unused. Therefore, for ages there has been a search for effective utilization of slag. Currently, a significant portion of this volume is reused in a broad range of civil engineering works, including cement/concrete, roadbed materials, and landfill materials. In Japan, however, limits on the availability of disposal sites, increasingly stringent environmental regulations and other issues have in recent years led to an urgent need to develop a recycling technology for iron-making slag.

Iron-making slag looks like rock or sand because of its vitreous structure composed of silica and other metal oxides. Previously, the synthesis of a specific inorganic functional material from slag required complex, multi-step chemical processes. In contrast, we have successfully achieved a simple conversion of slag into high value-added functional materials by fully exploiting the chemical properties of the each metal component contained in the slag. For example, by treating iron-making slag with phosphoric acid and sodium hydroxide, it is possible to convert slag into a hydroxyapatite-zeolite composite in one step. The technique takes advantage of the characteristics that the CaO component in the iron-making slag readily reacts with phosphoric acid to form a salt, and the component ratio between the SiO_2 and Al_2O_3 in the iron-making slag approximates that of zeolite. The developed process does not require addition of any external metal sources, allows synthesis at low temperatures below 100℃ , and thus it can be an alternative low-cost zeolite manufacturing process. Because hydroxyapatite and zeolite have an ability to adsorb microbes, volatile organic compounds and heavy metal ions, respectively, the synthesized composite can find applications as a versatile adsorbent in water treatment and deodorizing.

Of the components contained in iron-making slag, more than 40% is composed of CaO and MgO that derive from limestone added as a flux during the iron-making process. Using abundant CaO contained in the slag, we have also developed a process to convert it into calcium-based layered double hydroxide ($Ca_2Al(OH)_6Cl\cdot xH_2O$) and calcium silicate hydrate ($CaSiO_3\cdot xH_2O$). With excellent ion exchange capacities of these materials, it is possible to efficiently adsorb heavy metal ions and phosphate ions contained in wastewater. Currently, we are pursuing the development of a process to efficiently recover and recycle phosphorus, an element potentially exhaustible in the near future, through the use of the adsorbents synthesized from iron-making slag.

These inorganic functional materials manufactured from iron-making slag can find applications not only as a low-cost adsorbent but also as a low-cost solid catalyst. For example, the calcium-based layered double hydroxide manufactured from iron-making slag exhibits high catalytic activity in oxidation reactions, CO_2 addition reactions and biodiesel fuel synthesis reactions, as well as fundamental base-catalyzed reactions such as Knoevenagel condensation and transesterification reactions. Further exploration of applicable catalytic reactions may expand its applications as a low-cost alternative for existing catalysts.

The manufacturing process that produces commercially valuable materials from waste slags, and converts the "negative" into the "positive", is an extremely interesting concept especially in our country where resources are severely constrained. While further reductions in manufacturing cost and expansion of applications are needed before practical applications, the material recycling process described above may be applicable not only to iron-making slag but other types of "slag" as well, and holds enormous potential for future development.

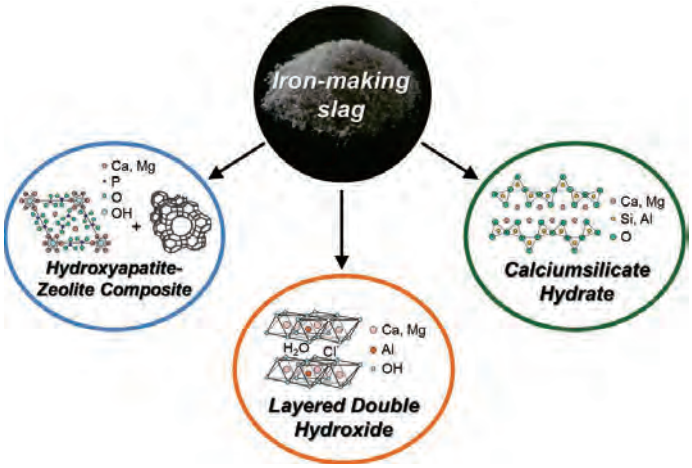

Fig. 1 Manufacture of functional materials from iron-making slag

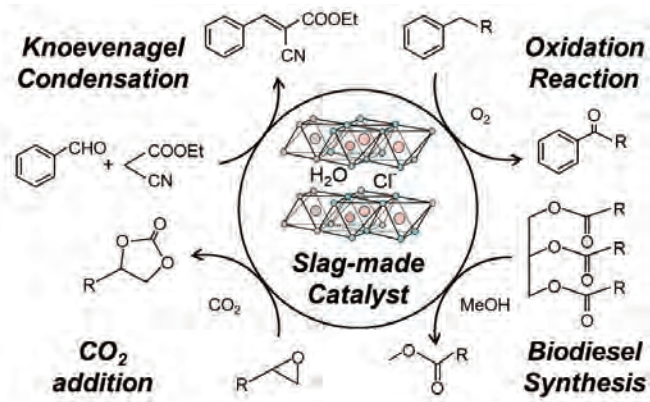

Fig. 2 Example of application to catalytic reactions

Holding an academia-industry poster session, the first of its kind

On October 30, we held an academia-industry poster session entitled "Advanced research in the field of life sciences – focusing on functional materials and required processing technology." A session from academia to industry is the first of its kind for JACI.

A total of 17 university, industrial technology research institutes and independent administrative agencies participated in the session. About 80 participants from the industry made short presentations. After that, the event shifted to the presentations of posters, and individualized presentations and discussions were held.

The poster presentations, scheduled for three hours, proved quite popular, so much so that even when break times were used, there was not enough time to cover everything. Discussions continued even during the social hour.
Many participants voiced favorable comments on the event, saying that it provided an opportunity to rub shoulders with others more deeply than had been possible previously. As we move forward, we are thinking of putting on another series of academia-industry sessions focusing on different topics.

July 2015
4th JACI/GSC Symposium
7th GSC International Conference in Tokyo

Sign-ups for Oral Presentation and Poster Presentation
Sign-ups for event attendance will be accepted beginning in December 2014

◇ When: July 5–8, 2015
◇ Where: Hitotsubashi Auditorium, Hitotsubashi University(Takehashi, Tokyo)
◇ Main theme: "For the further development of GSC"

Readers are invited to visit the dedicated website, http://www.jaci4gsc7.org, also from the Association home page.

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Japan Chemical Innovation and Inspection Institute, The Society of Chemical Engineers, Japan, Japan Association for International Chemical Information, Kansai Chemical Industry Association, Advanced Scientific Technology & Management Research Institute of KYOTO, The Kinki Chemical Society Japan, The Society of Silicon Chemistry JAPAN, Japan Thermosetting Plastics Industry Association, The Society of Polymer Science, Japan, The Society of Polymer Science Association, National Institute of Advanced Industrial Science and Technology, Chemical materials Evaluation and REsearch BAse, Catalysis Society of Japan, Japan Petrochemical Industry Association, The Japan Petroleum Institute, Research Institute of Innovative Technology for the Earth, The Electrochemical Society of Japan, Japan Surfactant Industry Association, The Chemical Society of Japan, Japan Chemical Industry Association, The Society of Rubber Science and Technology, Japan, The Ceramic Society of Japan, Japan Electronics Packaging and Circuits Association, Japan Paint Manufactures Association, Japanese Society for Biomaterials, The Japan Society for Analytical Chemistry, Japan Analytical Instruments Manufacturers' Association, Noguchi Medical Research Institute, Japan Bioindustry Association, National Institute for Material Science, Plastic Waste Management Institute, The Society of Synthetic Organic Chemistry, Japan, RIKEN