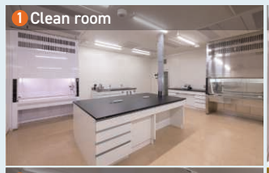
R&D (Innovation) Strategy

# The Research and Development Center That Opens Up the Future
# Kawasaki Frontience R&D Center


## Research facilities in domestic and international markets.

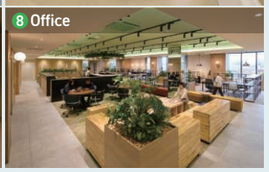
The Kawasaki Frontience R&D Center, opened in August 2024, is equipped with various facilities that enable advanced research and development, as well as a research environment that encourages the creation of ideas. Together with our customers, we will leverage innovative approaches and exceptional expertise to challenge the unknown, advancing technologies and creating new products that pave the way for the future.








## Focus development and research themes

### Next Generation Materials Laboratory

**Cellulose nanofibers**

We will advance the development of applied technologies for cellulose nanofibers, which are promising next-generation materials, aiming for practical applications both inside and outside the company.

**Medical care materials**

We will enhance our development capabilities in the medical care field, a growth area, and promote business expansion with attractive products such as hemostatic agents.

**Research aimed at the commercialization of iPS cells**

We will focus on developing commercialization technology based on the findings of the collaborative research by the Center for iPS Cell Research and Application at Kyoto University and our Institute for Advanced Sciences.

**Bio-synthesis technology**

We promote research and development of manufacturing that utilizes biological functions, and build technologies that contribute to a sustainable society.

**Materials for next-generation batteries**

We aim to develop solid electrolytes and other key materials for use in next-generation batteries.

### Research Solution Department

**Exploring high-value-added themes**

We will focus on growth areas such as semiconductors and mobility, leveraging our strengths in products and technologies to promote the expansion of our business scope.



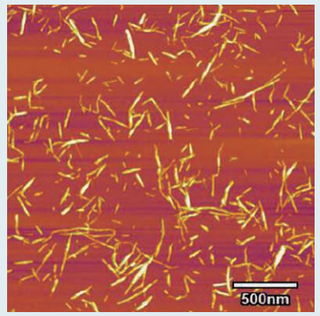


## Product development

### 1. Cellulose nanofibers

Our cellulose nanofibers (CNF) feature short fiber length and low viscosity, making them easy to handle. We are progressively developing applications that utilize these features. In addition to the development of applications for water-based systems, we will also promote the practical use of hydrophobic-modified materials that can be used in non-water-based systems.

#### Our CNF




- Dispersal and thickening applications
- Compounding with rubber

**Water-based**

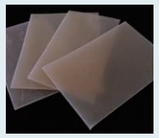
**Non-water-based**

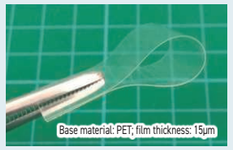
- Providing hydrophobic-modified and reactive properties
- Application in UV-curing resin, etc.

Dispersants

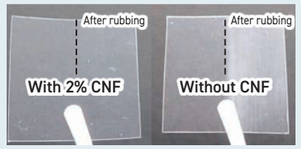
Thickeners

Rubber masterbatch






Achieves both surface hardness and bend tolerance




Scratch resistance also improved

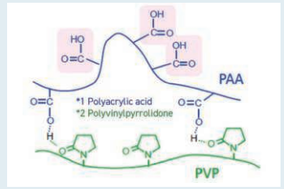
### 2. Medical devices and materials for medical devices

We are leveraging our polymer design, synthesis, and other technologies to develop several materials for medical applications. In the previous fiscal year, we obtained approval for a medical device and started manufacturing and sales of a hemostatic agent used as extraction sockets.* We will use this as a stepping stone to advance the development of new products.

*This product uses Wispecs® (https://www.wispecs.com/en/) technology.

#### Our new hemostatic agent: Aron cure

◆ The Aron cure technology




[Features]

- High adhesion to biological tissue
- Swells in water (forms a hydrated gel)
  ➡Demonstrates excellent hemostatic properties

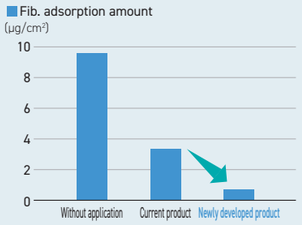
■ Clinical case of the use of hemostatic agent after the extraction of teeth


The bleeding was stopped immediately


The hemostatic agent has disappeared (no removal needed)

#### Medical coating agent

◆ Polymer with excellent anti-thrombogenic properties developed by Toagosei




[Features]

- Contains a large amount of intermediate water, suppressing the adsorption of fibrinogen and platelets
  ➡Demonstrates excellent anti-thrombogenic properties
- Coating is also possible on difficult-to-adhere materials such as PP
- Selectively adheres to specific cells

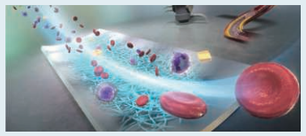
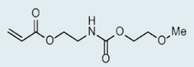


Illustration of anti-thrombogenic properties

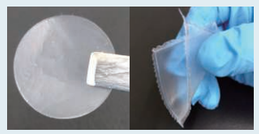



Monomer structure that demonstrates anti-thrombogenic properties

### 3. Electrolytes for next-generation batteries

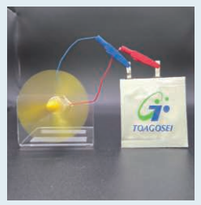
We are working on the development of high ion-conductive solid electrolytes for all-solid-state batteries in a dry room that can handle moisture-sensitive materials under ultra-low humidity conditions. We will pursue development through active collaborative research with academia and promote customer acquisition in domestic and international markets.

#### Organic electrolyte



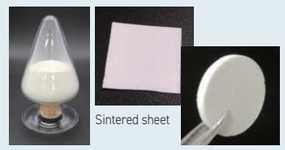
Electrolyte membrane

**We made a small cell including our newly developed product and checked that it works as a battery**




Pouch cell

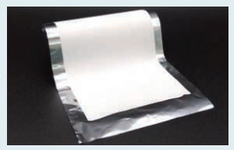
#### Inorganic electrolyte




Powder

Sintered pellet

#### Hybrid electrolyte



Composite membrane made of organic and inorganic electrolytes

**Forms a high-density filling and flexible film without the need for a high-temperature sintering process**

R&D (Innovation) Strategy

# Conversation on R&D

At the Toagosei Group, we have further strengthened our research and development system with the opening of the Kawasaki Frontience R&D Center (hereinafter the "Kawasaki R&D Center") in August 2024. In this section, Executive Officer Matsuzaki, who serves as Research Manager of the center, and Director Kato, an Outside Director of the Company and a leading expert in functional molecular chemistry, discuss strengths, challenges, and future prospects for research and development at the Group.

**Outside Director**

**Takashi Kato**

Doctor of Engineering
Former Professor of The University of Tokyo, currently Specially Appointed Professor of Shinshu University and Specially Appointed Professor of Okayama University

**Executive Officer**

**Hideo Matsuzaki**

Research Manager of the Kawasaki Frontience R&D Center

## Capturing true customer needs and solving them with technology: we will enhance the value we provide to society through open innovation.

### The unique quality of Toagosei's research and development as seen through an external perspective and internal aspirations

Kato: I feel that Toagosei is somewhat of an unsung hero in terms of its strength as a chemical manufacturer. There are various examples of research and development that demonstrate this strength. For instance, its acrylics chain: this technology allows for integrated production from acrylic acid to acrylic polymers. By utilizing the molecular design of monomers and structural control of polymers, it enables the production of a variety of functional materials and exemplifies Toagosei's unique strength. This strength is not flashy nor immediately obvious to the general public. However, the public benefits from Toagosei's technologies, even if it is unaware of its true strength or even its existence. This highlights Toagosei's unique characteristics and importance as a chemical manufacturer. The full extent of Toagosei's chemical capabilities is not easily visible from outside the Group, but since joining as an Outside Director in 2023, I have gained a new awareness of its advanced technologies.

Matsuzaki: Did you know a lot about the Group before you became a director?

Kato: I was aware of its existence, of course, through the activities of the Society of Polymer Science, Japan, and the Chemical Society of Japan. However, I did not know the details of the Group's technologies apart from the research content it presented at academic conferences. I am also closely watching its research and development system.

Matsuzaki: I believe that one of the characteristics of the Group's research and development system is the high degree of freedom it allows. This enables researchers to thoroughly pursue their research interests. I believe that the Group's advanced development capabilities are only possible because we, as researchers, enjoy our work and approach it with passion.

Kato: Yes, I feel that too. It's an important element.

Matsuzaki: Speaking from personal experience, this atmosphere has enabled me to immerse myself in research and development and achieve product commercialization, contributing to profit. I joined Toagosei in 1990 and was engaged in research and development relating to acrylic polymers until 2013. When I first joined the company, I was initially responsible for products with high expected sales volumes, such as adhesives and binders. I studied emulsion polymerization dynamics and pursued cost reductions through the optimization of reaction conditions. This enabled me to gain experience in securing profits. On the other hand, I was driven by the desire to create high-performance products that would contribute more to society and achieve higher profit margins. Therefore I proceeded to immerse myself in particle structure control technology and worked diligently on its social implementation. These efforts resulted in the launch of high-profit products in fields such as mobility and cosmetics. Looking back, this development experience was both rewarding and personally fulfilling for me. My experience was founded on the direct guidance I received from renowned professors in polymer dynamics and particle synthesis through collaborative research and academic activities. I strongly realized the importance of learning fundamental theories from top-level experts.

Kato: In order to improve a product, it is vital to understand the fundamentals of that product. By understanding the "fundamentals," I mean knowing the structure of the product and fully comprehending the correlation between that structure and its physical properties and functions, to the extent that one can explain the overall effect that it has on the product. Based on the great freedom allowed by Toagosei's research and development system, collaboration with universities is prioritized. There is no doubt that the efforts that Toagosei has made to acquire and refine fundamental theories have been partly responsible for its sustainable growth.

Matsuzaki: The Group is mainly engaged in manufacturing as a B2B materials supplier, excluding some products for general consumers such as Aron Alpha. By understanding the challenges and needs of customers and developing products that meet those needs through our accumulated technology, firmly grounded in fundamental theory, we can create products that truly delight them, ultimately realizing value that generates profit. We firmly believe that the size of our profits is directly linked to our level of technology and its contribution to society.

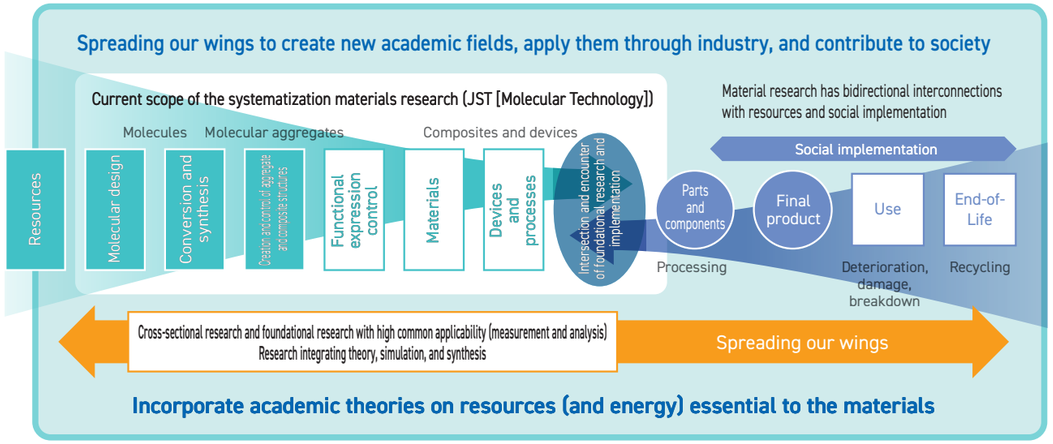
Kato: The purpose of any company's products is for people to use them. I think Toagosei has great potential as a chemical manufacturer that contributes to various possibilities in line with customer needs.

### The Group's role in expanding the social applications of molecular materials

Matsuzaki: Professor Kato, you have presented numerous research results in the field of functional molecular chemistry, such as supramolecular liquid crystals, functional polymers, and bio-mineralization, which have attracted attention worldwide. How do you perceive the connections between these outstanding academic research results and the Group's businesses?

Kato: As the leader of the materials project at the Engineering Academy of Japan, I made recommendations for the further development of materials research. I aimed to show what the research and development of molecular materials should look like (see Figure 1). Academia is primarily responsible for long-term fundamental research based on academic principles in the realm of molecular technology, particularly concerning the design of molecules and the control of functional expression. Companies should then incorporate the results of this research through open innovation to achieve social applications. What is vital is materializing this contact point in terms of devices, processes, components, and materials. The Toagosei Group has the capabilities to independently engage in all the steps from molecular design to product commercialization, but it is also

◆Figure 1: Illustration of the development of molecular material research leading to social implementation




Source: The Engineering Academy of Japan Report "Fusion and Collaboration for the Further Development of Materials Research in Japan," (Materials Project, Leader: Takashi Kato; sourced and partially modified from page18 "Organization-building for the creation of new academic fields, industrial application, and contribution to society," March 16, 2018)

keenly focused on joint research with academia. I hope to see it implement cutting-edge research results from academia in the form of products with "dream functions" in society, thus achieving a greater social contribution and higher profits. In academia, we are also engaged in research related to resources, energy, and recycling in each wing of material research (see Figure 1). I feel that a mechanism is now in place that enables industry and academia to execute open innovation more efficiently and effectively, partly through the participation of academia-driven startups in the stages from device and process development to final product development. I hope to see the Group actively engage in the utilization of open innovation and expand the scope of value it contributes to society as a whole.

**Matsuzaki:** Based on our open innovation with academia, we aim to contribute to society and expand profits through the social implementation of cutting-edge technology. We are fortunate to have your great support for our research and development, Professor Kato, including advice from the perspective of molecular technology related to polymer materials and substances and their applications in industrial fields beyond functional expression control. In addition to providing consultations relating to specialized fields such as these and guidance on the challenges we face in our actual development work, there are also occasions when you help by using your extensive network to match us with clients who might be interested in the products we develop. We sometimes also ask you to give lectures or hold discussions for our researchers concerning your approach to research and development, how to structure stories, and new research results. It seems that having direct discussions and receiving advice from you, as a leading expert in functional molecular chemistry, has been a great encouragement for our promising young researchers.

**Kato:** Going forward, it will be essential for the Group to expand its initiatives from "points" to "areas" and "series." For example, the dental hemostatic agent that has been approved as a medical device is an impressive achievement in itself, but it is just a single product: a "point." Given its solid research and development basis, established with a consciousness of the application of polymer composite technologies, the Group should further broaden the range of applications through which it provides value.

**Matsuzaki:** As you say, we need to swiftly implement efforts to expand the range of products utilizing the technologies we have developed. In other words, we must expand our applications into "areas" and "series," so that we can be recognized as the go-to company for medical device and materials applications of polymer design technologies.

**Kato:** One effective method to facilitate such an expansion is to increase presentations to the outside world through academic societies and international conferences, as I mentioned at the beginning. This would enhance the Group's presence. There is the issue of confidentiality, of course. In the chemical industry, especially, there is a lot of know-how that is difficult to share externally. However, if the Group does not communicate its own information as much as possible, it will not gain access to external information that may be necessary and beneficial. To put it another way, unless it interacts with the outside world to some extent, the Group will find it difficult to gain opportunities for co-creation with external organizations and the discovery of potential new developments. Inquiries about the technologies and products announced by the Group may also lead to new uses and applications. I hope that the Group will also focus on organizing external presentations led by its R&D departments. I would like to see it develop new products with expansion potential through these research connections with the outside world.

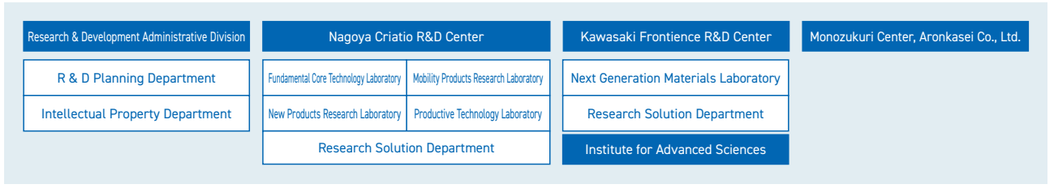
**Matsuzaki:** Following your advice, I made presentations on hemostatic agents at forums such as the meeting of the Japanese Society for Biomaterials in 2024. These presentations created opportunities for meaningful dialogue with university research institutions and dental professionals. They also made me confident that our technology and products are at a level recognized by academic conferences and provided opportunities to showcase the Group's presence to customers and the market. If we can find a way to communicate this progress to investors and shareholders, it is sure to lead to the enhancement of corporate value.

**Kato:** External recognition boosts researchers' morale. It also helps us with recruitment of outstanding talent as university professors and students will become aware of and evaluate the Group, which will have a positive impact on our talent acquisition.

## The Research Solution Department's quest to develop high-value-added core technologies

**Matsuzaki:** Before the opening of the Kawasaki R&D Center in August 2024, the Nagoya Criatio R&D Center (hereinafter the "Nagoya R&D Center") was known as the General Center of R&D. Today, the Nagoya R&D Center holds four laboratories — the Fundamental Core Technology Laboratory, the Mobility Products Research Laboratory, the New Products Research Laboratory, and the Productive Technology Laboratory — while the Kawasaki R&D Center holds the Next Generation Materials Laboratory (see Figure 2). At the Next Generation Materials Laboratory, we are pursuing research and development themes that are expected to be the Group's next growth drivers, such as medical devices, medical materials, and other medical care-related topics, as well as the development of new applications for cellulose nanofibers. In addition, our two R&D centers in Nagoya and Kawasaki are collaborating in the research and development of next-generation battery materials such as solid electrolytes for all-solid-state batteries. The Kawasaki R&D Center is also engaged in developing technology to commercialize the research results of the Institute for Advanced Sciences in areas such as functional peptides.

◆Figure 2: Structure of the Group's R&D departments




(See pages 28-29 "R&D Supporting the Growth Strategy" and pages 32-33 "Kawasaki Frontience R&D Center.")

**Kato:** The new Research Solution Department (hereinafter referred to as the "RS Department") established at each of the two R&D centers in Kawasaki and Nagoya will no doubt play a crucial role for the Group in the future.

**Matsuzaki:** The RS Department gathers human resources with new product development capabilities from both sales and R&D backgrounds. Its mission is to develop new customers, expand applications, and launch high-quality large-scale themes based on the Group's core technologies. It specifically targets growth areas such as semiconductors and mobility. In recent years, the high-performance inorganic products used in industrial adhesives, deodorants, and antimicrobial agents have struggled. In this context, it is urgent for us to launch new high-value-added large-scale themes in this area, and this is one of the most pressing tasks for the RS department. To acquire large-scale themes with rapid growth in growth areas, it is vital that we understand the reality of customer needs and quickly propose solutions. The RS department will ensure close communications with promising customers to identify their specific needs.

**Kato:** I look forward to seeing the Group's future growth in this area. At the risk of repeating myself, I might add that using the presentation materials from academic conferences is probably an effective way to approach customers. As well as providing a more understandable explanation from a technical perspective, I think these materials will establish the Group's credibility by demonstrating its solid status within the academic community. If it can accurately perceive customer needs, the Group will be able to demonstrate its true capability to match these needs with a high level of precision and reflect them in product development.

## The Group's vision for its R&D departments and the expansion of future possibilities

**Matsuzaki:** Looking ahead, we aim to build the R&D departments so that they can focus on our efforts for social implementation, having firmly established a solid foundation in science. The motivation of each individual researcher is crucial to achieving this goal. This motivation is undoubtedly enhanced by the researchers' experience of making customers happy with the technology and products they have developed themselves. To achieve this, we will ensure we listen to the voices of our customers and make sure our Group works on a grass-roots level to gather the true needs of society. We will also strengthen our collaboration with academia to develop technologies to address these needs and expand the value we provide to society.

**Kato:** The past quarter of a century has seen great excitement over the potential of nanotechnology, which has garnered significant attention in the world of science and technology. Today, we have already developed it to a very high standard of material construction capabilities and advanced analytical abilities. This technology, developed to precisely control atomic and molecular structures at the scale of nanometers (one millionth of a millimeter), will lead to the further advance of next-generation manufacturing, contributing to sustainability in ways such as solving environmental and energy issues and realizing a super-smart society. Chemical manufacturers that can provide new value through the pursuit of molecular technology, encompassing everything from resource development to product commercialization and recycling, are in a unique position to achieve this. I have high expectations for the potential of the Toagosei Group's research and development. I intend to provide the Group my full support as an Outside Director in the research field as it takes challenges for the future.

R&D (Innovation) Strategy

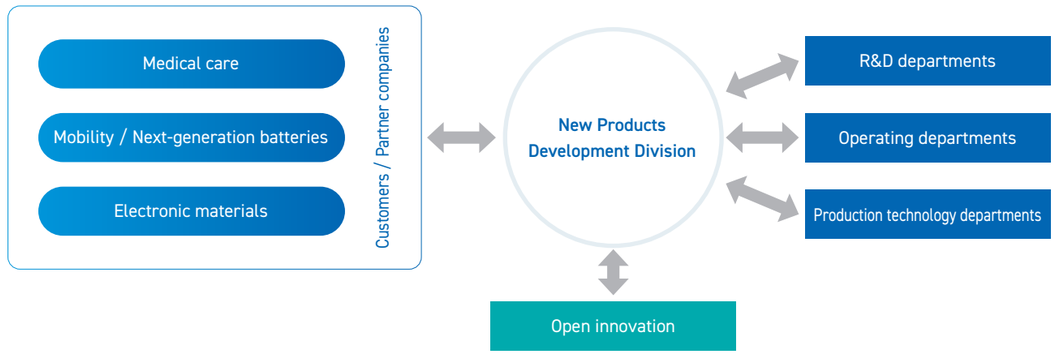
# Developing New Businesses

The New Products Development Division is engaged in the research and development of innovative chemical materials that pave the way to the future. Our mission is to provide new value to our customers and society focused on three key areas: medical care, mobility, and electronic materials. Using our core technologies in the areas of molecular design, compounding, and analysis, we explore innovative ideas and pursue the highest quality, providing high-value-added products that meet the sophisticated demands of our customers.

We especially value close connections with our customers and aim to propose order-made solutions that quickly and accurately address their needs. Diverse human resources from our R&D departments, operating departments and production technology departments work as a unified team to strengthen collaboration with our partner companies and research institutions, utilizing open innovation in ongoing endeavors aimed at achieving a sustainable society.

Executive Officer, General Manager,
New Products Development Division
**Toshiaki Takei**

### Role of the New Products Development Division



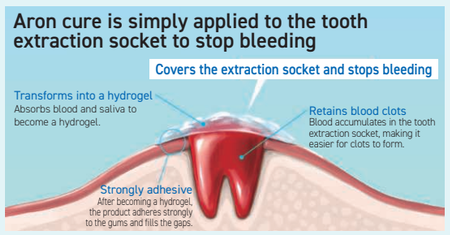

## CASE 1 Hemostatic agent

### Aron cure

Last year, we obtained pharmaceutical and medical device marketing approval for a secondary healing hydrogel wound dressing and protective material, which is classified as specially-controlled medical devices, and commenced sales. This product was developed through the introduction of polyacrylic acid-based technology* and launched after consultation with several experts. In the dental field, it can be used to protect the surface and shallow portions of tooth extraction sockets through its ability to absorb fluids such as blood and saliva, becoming a flexible hydrogel. Looking ahead, we will utilize post-product-launch feedback received from the medical front line to improve this product so that we can continue to help enhance the quality of life for patients and healthcare professionals.

*Wispecs: Polymer composite technology
<Developer>
Dr. Yoshiyuki Koyama
(Director, Obara Hospital Research Institute and Visiting Professor, Institute of Medical Science, Tokyo Medical University)
Dr. Tomoko Ito
(Deputy Director, Obara Hospital Research Institute and Visiting Lecturer, Institute of Medical Science, Tokyo Medical University)

Example application




Hemostasis and protection through adhesive power (illustration)

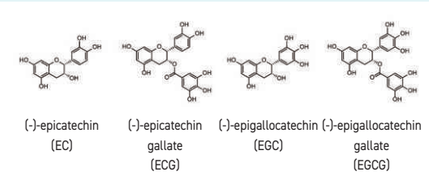
## CASE 2 Developing medical care products with new materials

### EGCG-modified gelatin sponge

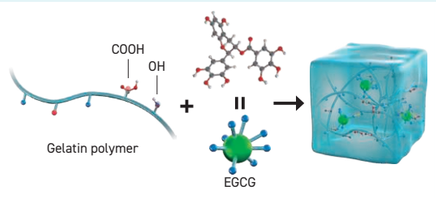
We focused on EGCG*-modified gelatin sponge, a material developed at universities using polymer technology, through the joint efforts of Professor Honda of Osaka Dental University and Professor Tanaka of Kyoto Institute of Technology. EGCG is one of the catechin groups obtained from green tea, and while it has many physiological effects, its low retention and tendency to easily leach out of the body have made practical applications challenging. To solve this problem, it was found that by compounding EGCG with a highly biocompatible polymer (gelatin), we can create a functional material with excellent properties, and we are advancing joint development together with universities. Looking ahead, we aim to apply our experience in sponge manufacturing gained from hemostatic agents to accelerate product development in the medical care field, with the goal of contributing to regenerative medicine.

*EGCG: (-)-epigallocatechin gallate

### Catechins found in green tea




### Schematic diagram of the preparation of EGCG-modified gelatin sponges (EGCG-GS) by aqueous synthesis




## CASE 3 Contributing to carbon neutrality in the mobility field

### Solid electrolytes for next-generation batteries

We are exploring high ion-conductive solid electrolytes, which are key materials for all-solid-state batteries, aiming to further expand our battery business. We have been working on the development of competitive solid electrolytes, leveraging our technological capabilities based on our Group's extensive business scope in both organic and inorganic materials. Hybrid solid electrolytes, which combine organic and inorganic electrolytes, can form a thin, high-density filling, and flexible film with excellent performance in lithium-ion conductivity. Starting in 2025, we have been working on mass-production processes. We will also proceed to engage in customer acquisition in domestic and international markets, aiming for applications in the all-solid-state lithium-ion batteries that are currently under active development and the all-solid-state sodium-ion batteries that are expected to play a part in the future.