NEDO

focus NEDO

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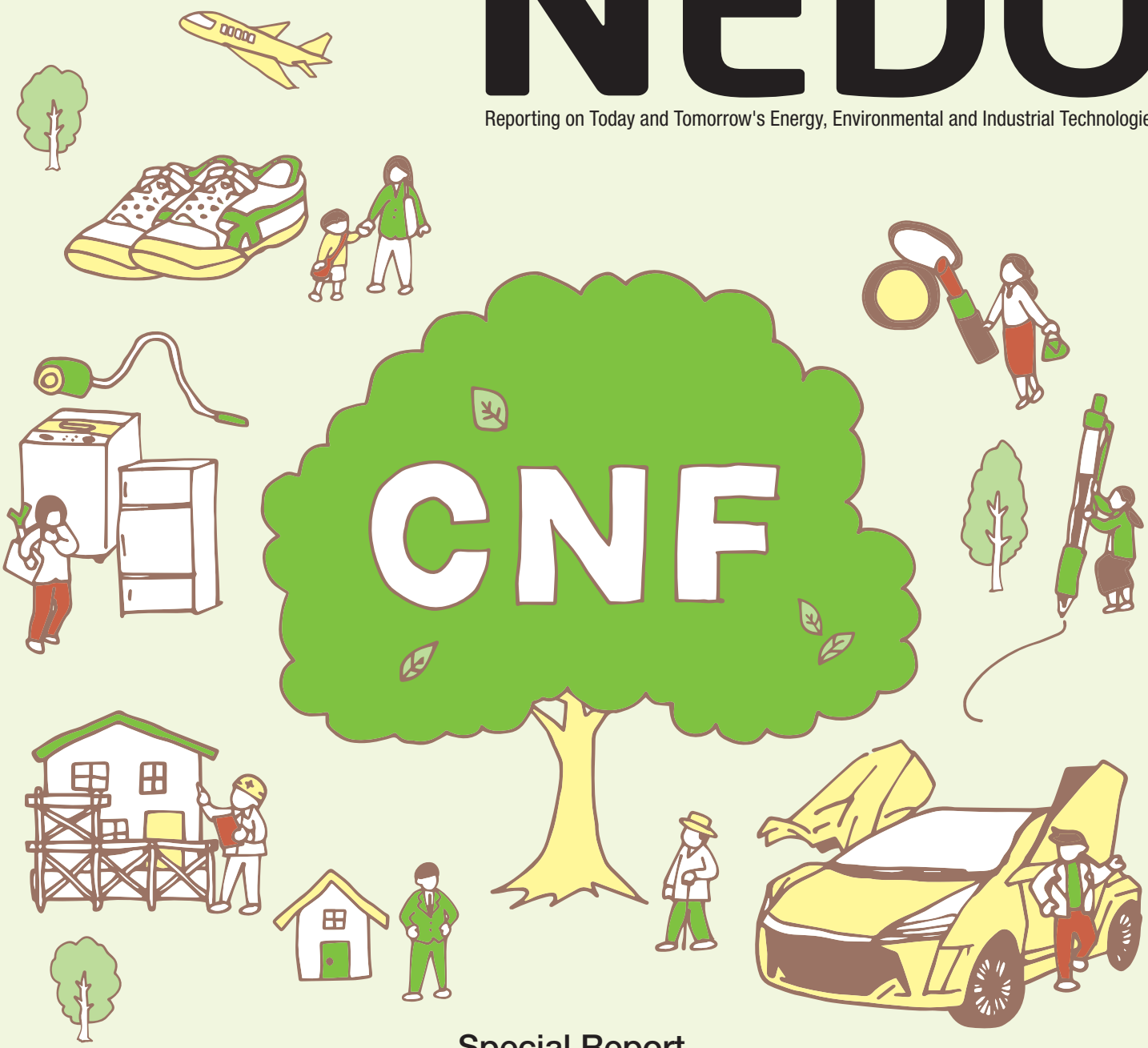
Reporting on Today and Tomorrow's Energy, Environmental and Industrial Technologies



Special Report

Countdown to Commercialization

Cellulose Nanofibers

New Energy and Industrial Technology Development Organization

PICK UP NEWS

Efforts toward realizing a green society

Bold Investments to Create Virtuous Cycle of Economy and Environment and Realize Carbon Neutrality in 2050

Portal site for Green Innovation Fund Program

https://www.nedo.go.jp/activities/green-innovation.html
(Only available in Japanese)

As momentum to realize a decarbonized society continues to grow around the world, more than 120 countries and regional organizations have been engaged in a variety of activities to realize carbon neutrality by 2050. In October 2020, the Japanese government announced its policy of Carbon Neutrality in 2050. However, realizing the goal of carbon neutrality in 2050 will only be achieved through extraordinary efforts and will require a structural transformation of the energy and industrial sectors as well as a significant acceleration of innovation through bold investments.

To accelerate research and development that contributes to realizing carbon neutrality, NEDO has started the Green Innovation Fund Program with 2 trillion yen in funding. Over the next ten years, based on ambitious concrete goals shared by the public and private sectors, this program will provide continuous support ranging from research and development to demonstration and public implementation for companies and other organizations demonstrating a commitment to pursuing these goals as issues for their business.

With the goal of realizing carbon neutrality in 2050, such bold investment efforts will both strengthen Japan's industrial competitiveness in the global carbon-neutral market and, at the same time, create a virtuous cycle of economy and environment by attracting ESG-related investments, estimated to be worth 3,000 trillion yen worldwide, to Japan.

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Contents

Outline of Green Innovation Fund Program

○This program supports R&D projects including public implementation, with significant policy effects and for which long-term continuous support is required in priority industrial fields where action plans have been formulated under Japan's Green Growth Strategy.

○The executives of project implementation companies and other organizations must be committed to pursuing challenging goals as issues for their business.

Scope of projects

The main targets are projects with total costs equaling at least the average level of conventional R&D projects carried out by NEDO and other organizations (approximately 20 billion yen).

Implementing organizations

The primary implementers should be companies or other profit-making businesses capable of carrying out the entire process of public implementation. The participation of small and medium-sized companies and startups is also encouraged and, under certain conditions, universities, research institutes, and technology research associations may also participate as subcontractors or consortium members.

Support process

After the Japanese government plans and finalizes the presentation and deliberation of proposed R&D and public implementation plans for each project, NEDO publicly solicits proposals from potential project implementers. After proposals are screened, project implementers are selected, and the support process begins.

14 priority industrial fields with Green Growth Strategy action plans

Energy-related industries

Offshore wind power generation industries
Windmill body, parts, floating wind power generation

Fuel ammonia industries
Power generating burner
(Fuels used in the transition to the hydrogen economy)

Hydrogen industry
Power generation turbine, hydrogen reduction steelmaking, carrier vessel, water electrolyzer

Nuclear industry
SMR, hydrogen producing nuclear power

Transportation/Manufacturing-related industries

Automobile and battery industries
EV, FCV, next-generation batteries

Semiconductor/information and communication industries
Data center/energy-saving semiconductors
(Improvement of demand-side efficiency)

Shipping industry
Fuel cell ship／vessel, electric-powered vessels, gas-fueled vessels etc.
(Hydrogen, ammonia etc.)

Logistics, people flow, and civil engineering infrastructure industries
Smart traffic, drones for logistics, FC construction machinery

Food, agriculture, forestry and fishery
Smart agriculture, wooden construction of high-rise buildings, blue carbon

Aircraft industry
Hybridization, hydrogen aircrafts

Carbon recycling industries
Concrete, biofuel, plastic raw materials

Household/office work-related industries

Houses and building industry/Next-generation solar power generation industry
(Perovskite structure)

Resource circulation-related industries
Bio-raw materials, recycled materials, waste power generation

Life style-related industries
Local decarbonization business

Note: By law, NEDO cannot carry out or subsidize research and development exclusively targeting nuclear energy.

Please let us hear your views!
Reader Questionnaire

We welcome your feedback and opinions on the content and technologies introduced in this magazine. Your feedback will be used for reference purposes in our future public relations activities and magazine publications. We look forward to hearing from you!

A Few Words from the Editor

In this issue, we present a special report on cellulose nanofiber (CNF), which is a new wood-based material on the verge of commercialization. Our expectation is that this report helps provide a sense of the role this new material will soon play in our daily lives. Many challenges have had to be overcome, such as reducing the cost of manufacturing, developing technologies for applications with the potential for cost-effective large-scale production, and developing safety assessment methodologies, but the day when CNF products will be widely available is drawing near. In Japan, where natural resources are scarce, forests are numerous and close-at-hand so, if managed carefully, can be used to realize CNF production.

After reading this special report, we hope everyone gains a deeper understanding of CNF's potential for commercialization.

Reporting on Today and Tomorrow's Energy, Environmental, and Industrial Technologies
"Focus NEDO" is the public relations magazine of the New Energy and Industry Technology Development Organization (NEDO), introducing the public to NEDO's various projects and technology development activities related to energy, environmental, and industrial technologies.

Note: To prevent the spread of COVID-19, persons appearing in photos wore facial coverings except during the time photos were taken.

Special Report

Countdown to Commercialization

Cellulose Nanofibers

Cellulose nanofibers (CNFs) are next-generation plant-derived materials which are lightweight, strong, and resistant to expansion. NEDO is focused on the development of potential CNF applications and is carrying out a project to promote their use.

Striving to create a world-leading industry and address environmental issues by promoting the use of CNFs

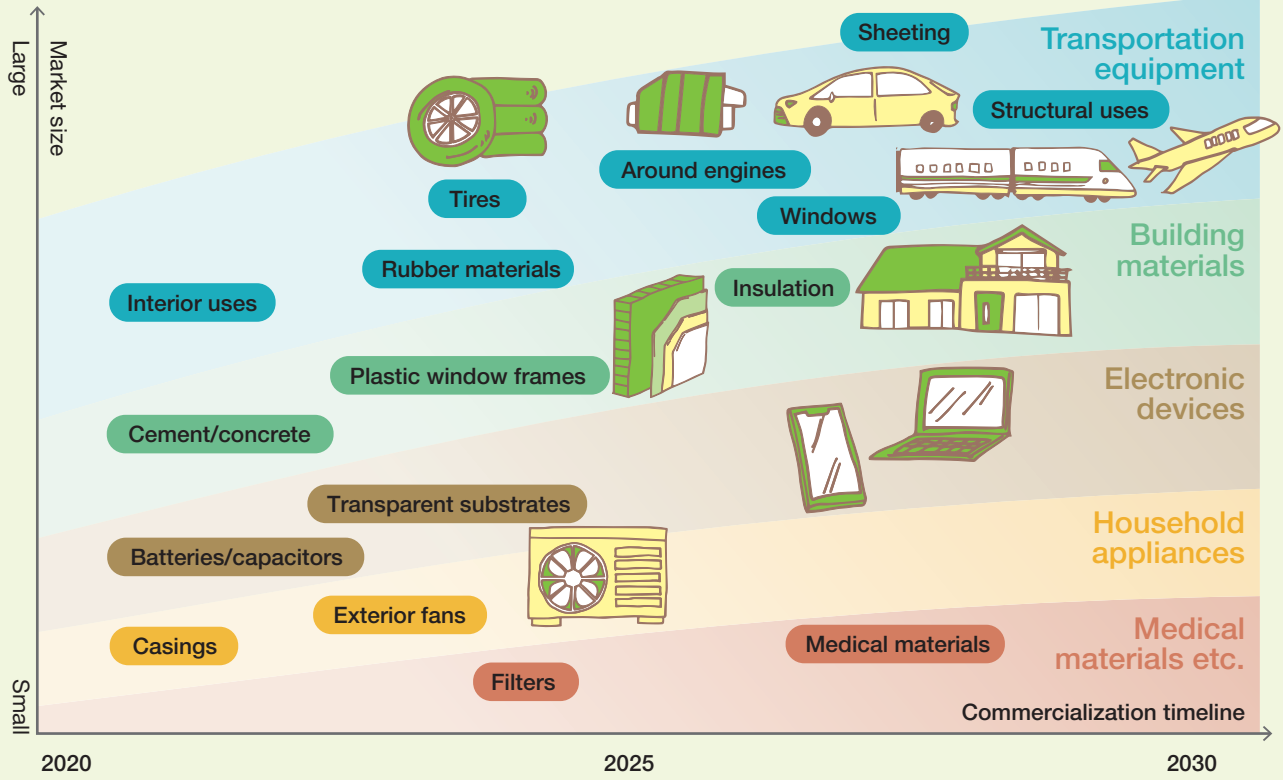
The movement to reduce CO_2 emissions to virtually zero is spreading around the world. In addition to the EU and other governments that have already announced their intentions, the Japanese government has also declared its intent to achieve this goal by 2050. In order to promote the transition to a Carbon Cycle Society in a smooth manner, it is necessary to utilize renewable sources of energy and switch to non-petroleum-based resources such as biomass materials. Against this backdrop, NEDO has been working on the commercialization of plant-derived CNFs as raw materials for new chemical products.

In a previous project, NEDO promoted the development of a highly efficient and continuous process for the production of high-performance nanofibers and CNF-reinforced composites. In addition, based on these technologies, a test plant for manufacturing resin composite materials from raw materials such as bamboo has been constructed and is now in operation on the Uji campus of Kyoto University.

CNFs, which demonstrate many excellent properties, offer a wide range of applications. For example, by taking advantage of CNF's viscosity characteristics, ink for ballpoint pens has been developed that is easy to write with and does not drip from the pen. CNFs have also been developed for use in a variety of consumer goods such as sports gear, audio equipment, and cosmetics.

To promote the dissemination and expansion of CNF markets in

Timeline and market size for commercialization of CNF materials



NEDO project

Cellulose Nanofiber-related Technology Development to Contribute to a Carbon Cycle Society

Fiscal years 2020-2024 (planned)

Innovative manufacturing 8P
Development of innovative technologies for CNF manufacturing processes

Technology applications 10P
Development of commercial CNF technology applications that offer the potential for large-scale cost-effective manufacturing.

Safety assessments 12P
Development of hazard assessment methods for various product applications and assessments of safety

the future, however, further cost reductions are necessary. In particular, major issues to be addressed include the development of innovative manufacturing processes and commercial applications that offer the potential for large-scale and cost-effective manufacturing. With this in mind, NEDO launched a project in fiscal year 2020 to improve manufacturing processes, develop commercial applications for fields with large-scale market potential, and establish a system for conducting safety assessments to support the commercialization and diffusion of new composite materials. The commercialization of CNFs will also contribute greatly to the realization of the SDG goal of taking concrete actions to combat climate change and, consequently, expectations for speeding up efforts in this area are growing in many quarters.

NEDO's Materials Technology and Nanotechnology Department, which oversees the current project, Cellulose Nanofiber-related Technology Development to Contribute to a Carbon Cycle Society, believes that if CNFs are used for everyday applications in the future, Japan, which currently relies on imports to obtain most of its resources, could become a major source for these plant-derived materials.

In the following pages, we will introduce various NEDO activities aimed at promoting the commercialization of CNF materials, including work to introduce innovative approaches to the CNF manufacturing process, expand the range of commercial CNF technology applications, and develop human resources who can utilize CNF materials.

Project Leader Interview

Project that holds the keys to CNF commercialization Accelerating innovation to create new industries and build a Carbon Cycle Society

Dr. Yao, the Project Leader, hopes to motivate corporate researchers by evaluating their efforts from a third-party perspective.

PROJECT LEADER INTERVIEW

Project Leader for Cellulose Nanofiber-related Technology Development to Contribute to a Carbon Cycle Society

YAO SHIGERU

The development of CNFs for commercial applications is accelerating.

In this interview, Dr. YAO Shigeru, the Project Leader, discusses the significance, progress, and prospects for this project, which aims to make a significant contribution to the realization of a Carbon Cycle Society

Dr. Yao, recipient of a Ph.D. in engineering, is a Professor in the Department of Chemical Engineering, Faculty of Engineering, at Fukuoka University. He is also the Director of the Fukuoka University Center for Industry-Government-Academia Collaboration and the Institute for Functional and Structural Materials. After graduating from the Kyoto University Faculty of Engineering in 1981, he worked as a group manager of the Nanotechnology Promotion Group at Ube Industries, Ltd. and as a senior research professional at the Mitsubishi Research Institute before assuming his current position in 2011. Dr. Yao specializes in research on polymer materials.

In fiscal year 2020, NEDO launched its project to accelerate the commercialization and diffusion of CNF materials. How did you feel when you were appointed as the project leader?

I have been paying close attention to the fascinating research taking place in this area since Dr. Yano of Kyoto University started his R&D activities 15-16 years ago in a collaborative project involving industry and university research organizations. In the previous NEDO project, Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants, the project team achieved solid results. For this project, I was entrusted with the next step aiming for commercialization, and although I feel a strong sense of responsibility, I took on this project because I wanted to contribute to the commercialization of CNF materials.

At this point, how do you feel after beginning work on this project?

First of all, the development of innovative manufacturing technology has produced positive results in terms of reducing costs. I think we are making steady progress toward achieving our goals. As for the development of technologies for commercial applications that can be cost-effective in large-scale production, I think we still have some issues that require further work. It's important to make the most of your achievements, but if you get too caught up in them, your thinking may harden, and you might not be able to make future breakthroughs. It may seem like a roundabout approach, but might it be more effective to explore the way forward using a different perspective? Since one of the keys to commercialization is the reiterative process, I would like to utilize my expertise in recycling plastic materials and my experience as a corporate researcher.

What do you consider to be the major challenges for this project?

In an online meeting we conducted in March 2021, many companies mentioned cost as an issue of concern. However, CNF is often transported as aqueous dispersions and since 90% is composed of water, which is unnecessary when used, one factor is that transportation costs are incurred for what is discarded. To commercialize CNFs, if companies can put aside cost consciousness and fully evaluate the profitability and potential of CNFs, I believe it is possible to curtail such waste.

Regarding the development of hazard assessment methods and safety assessments for various product applications, while CNFs are expected to be utilized in a wide range of fields, concerns have been raised about potential health hazards. To support commercialization efforts, I believe it is very important to conduct safety assessments of CNFs and then publicly release the results of such assessments.

Lastly, what are your expectations for this project?

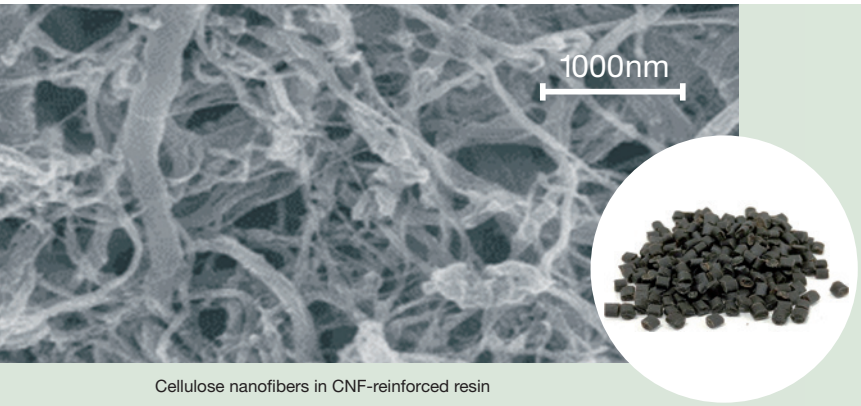
I think the advantage of NEDO projects is that various players can participate and exchange information from a variety of perspectives. It is unfortunate that due to the COVID-19 pandemic we haven't had as many opportunities for discussion as we would like, but in the future, while taking measures to prevent infections, we will look for opportunities to discuss issues and obtain insights from the front lines where actual products are being developed. In addition, I believe that the knowledge gained from the production and utilization of CNFs can be applied to many fields, but if we rely solely on forest resources for raw materials, new environmental problems may arise when CNF demand suddenly expands. We should therefore also keep in mind the diversification of sources for raw materials.

Project Manager YAMAMOTO Norikatsu (left)
Chief Officer, Bioeconomy Promotion Division
NEDO Materials Technology and Nanotechnology Department

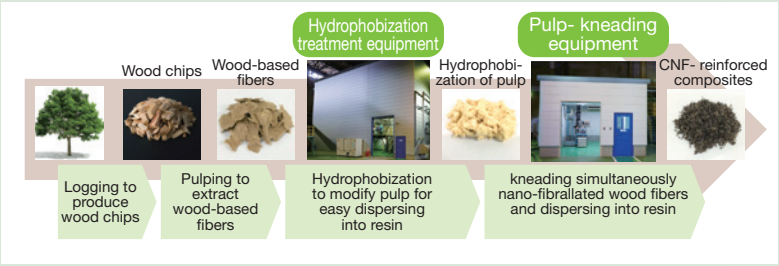
Innovative Manufacturing Projects

Toward large-scale production of low-cost, high-quality CNF-reinforced resin Industrializing the Kyoto Process

Nippon Paper Industries Co., Ltd./Ube Industries, Ltd.



Cellulose nanofibers in CNF-reinforced resin



NONOMURA Fuminari
Associate Director
Deputy General Manager, R&D Division
General Manager, Cellulose Nanofiber Research Laboratory
Nippon Paper Industries Co., Ltd.

FUKUDA Yujiroh
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NAKAGAWA Tomoyuki
Manager
Composite Materials Development Group
Engineering Plastics Development Dept.
Ube Industries, Ltd.

NOGAWA Norimasa
General Manager
Production Technology Center
Production Division
Ube Industries, Ltd.

Enhancement of direct pulp kneading method to meet growing demand for CNFs

Nippon Paper Industries introduced the Kyoto Process demonstration equipment used for this project through fiscal year 2019 and Ube Industries, using the nylon resin kneading process, achieved large-scale production at a level about 10 times higher than the Kyoto University test plant. Currently, the two companies are working together to further improve materials performance and innovate the manufacturing process to enhance the productivity.

NAKAGAWA Tomoyuki, Manager with the Composite Materials Development Group in the Engineering Plastics Development Dept. of Ube Industries says, “By collaborating with Nippon Paper Industries, which has a wealth of knowledge and know-how regarding CNFs, we can scale up from the lab level to commercialization and the future is therefore promising.” NAIKI Masahiro, General Manager in the Engineering Plastics & Fine Chemicals Division of Ube Industries notes that “we have nearly completed realizing pulp that is easy to nano-fibrillate when kneaded.”

DATE Takashi, Senior Research Manager at the Cellulose Nanofiber Research Laboratory of Nippon Paper Industries, says, “The manufacturing process we adopted is characterized by simultaneously disentangling pulp at the nano level and kneading it into resin, which we believe is the most suitable method for reducing costs.” In addition, regarding the future potential of this material, including its contribution to environmental issues, Senior Research Manager FUKUDA Yujiroh of Nippon Paper Industries notes that, “Wood-based biomass materials are recyclable. Since the issue of recycling is often highlighted in the media, we are aware of the great expectations in society.”

NOGAWA Norimasa, General Manager of the Production Technology Center of Ube Industries, says, "We are receiving more and more inquiries about CNFs and are encouraged by the increased level of interest, all of which makes us want to accelerate their commercialization.”

Focus of technology development:

Improved formulation of modified pulp for large-scale production and optimization of conditions for nylon resin selection and kneading.

Technology Development for Innovative CNF Manufacturing Processes

Developing technologies for manufacturing processes that pursue energy conservation and technologies for resin compounding that help overcome cost barriers

Daio Paper Corporation/Shibaura Machine Co., Ltd.

Promoting full-scale use of low-cost CNF composite resins that will impact the market

To contribute to the commercialization of CNFs, Daio Paper, a manufacturer of CNF materials, and Shibaura Machine, a manufacturer of industrial machinery, are working together to significantly reduce the manufacturing cost of CNF composite resins. To address the cost issue, it is essential to significantly improve productivity. A path forward has been identified by improving resin composite technology using a twin-screw extruder, a product for which Shibaura Machine is well known, and by enhancing the raw material treatment process at Daio Paper based on user feedback.

TAMAKI Michihiko, Senior Executive Officer at Daio Paper's Advanced Materials R&D Center, says, "We are also making use of our know-how in manufacturing paper, and would like to establish this business as soon as possible so it may contribute to the realization of a carbon recycling society."

Regarding the merits of this project, OISHI Masanobu, Chief Specialist at Shibaura Machine's Extrusion Machine Department notes that, "It was difficult to conduct demonstration testing in a production facility that would use a large amount of expensive CNF materials, but Daio Paper provided a sufficient volume of raw materials and development efforts have accelerated." Similarly, AMBAI Kenji of Shibaura Machine describes the positive outcome of the collaboration by stating, "Since the form of the raw material affects the processing capacity, we asked Daio Paper to devise a supply form for CNFs and as a result the processing volume has increased dramatically."

OKAWA Junya, General Manager at Daio Paper's Advanced Materials R&D Center, shows his enthusiasm for the project by saying, "The joint development with Shibaura Machine will help us resolve the resin composite issue. We have been able to meet the original project cost target and have now set a higher goal in the hope of making a big impact on the market."

Twin-screw extruder demonstrating excellent kneading performance.

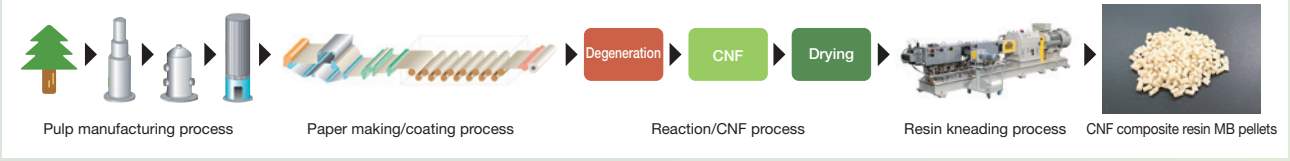
By supplying MB pellets in a form that is easy to mold and process, manufacturing and distribution costs can be reduced.

TAMAKI Michihiko
Senior Executive Officer
Advanced Materials R&D Center
Daio Paper Corporation

OKAWA Junya
General Manager
Advanced Materials R&D Center
Daio Paper Corporation

AMBAI Kenji (left)
Extrusion Machine Design Section
Extrusion Machine Department
Metal & Plastics Industrial Machine Company
Shibaura Machine Co., Ltd.

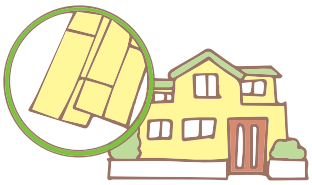
OISHI Masanobu (right)
Chief Specialist
Extrusion Machine Design Section
Extrusion Machine Department
Metal & Plastics Industrial Machine Company
Shibaura Machine Co., Ltd.



Solving various problems by improving productivity at each stage of the integrated manufacturing process, from CNF raw materials to CNF composite resin materials.

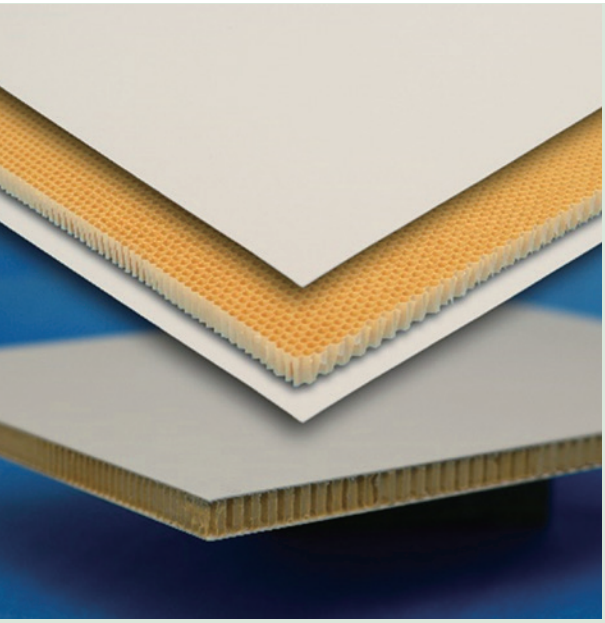
Focus of technology development:
Realizing productivity improvements through pretreating CNF raw materials and employing resin compounding technology with twin-screw extruders.

Applied Technology Projects

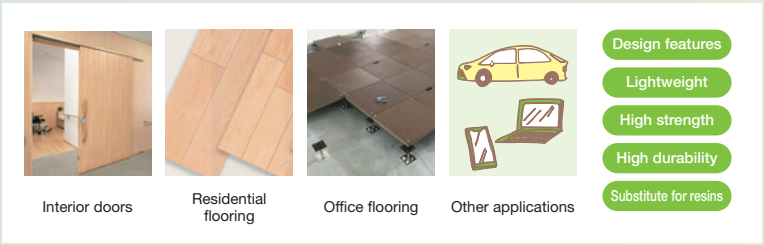


New uses for CNFs in interior building materials for housing and other applications

Daiken Corporation/Risho Kogyo Co., Ltd.



Molded sheets using 100% CNF materials developed by Risho Kogyo based on its expertise over many years in developing cellulosic materials.



High-quality and high-value interior building materials made from strong lightweight CNF-molded sheeting.

TAKAZAWA Ryosuke
Ph.D. (Bioresource sciences)
Manager, R&D Center
Daiken Corporation

IRIYAMA Tomoyuki
Ph.D. (Engineering)
Assistant General Manager, R&D Center
Daiken Corporation

OKUMURA Hiroshi
Ph.D. (Sciences)
Manager, Advanced Materials Development Department
Research and Development Division
Risho Kogyo Co., Ltd.

Aiming to replace current building materials with CNFs in products such as doors, flooring, and reinforcement materials

Daiken Corporation is developing interior building materials for housing and other structures using molded materials mainly composed of CNFs developed by Risho Kogyo.

A challenge to be addressed was the change in dimensions due to CNF's high level of moisture absorbency, but a breakthrough solution has been identified and is being optimized for each product. According to OKUMURA Hiroshi, Manager at Risho Kogyo's Advanced Materials Development Department, CNF is the ultimate material for paper products. Regarding the value of inter-industry collaboration, Okumura says, "The physical properties of CNFs when molded differ depending on the manufacturer, but, largely thanks to feedback from Daiken Corporation, we were able to identify a way to reduce dimensional changes in the material."

IRIYAMA Tomoyuki, Deputy Director at Daiken's R&D Center, conveys the significance of the product by saying, "If we can use Risho Kogyo's 100% CNF-molded products for building materials, we can create large demand for CNFs and reduce the cost of raw materials." Manager Okumura at Risho Kogyo adds, "Because we can clarify objectives at the beginning of the NEDO project, it offers a good opportunity for us to work seriously on commercialization efforts."

Deputy Director Iriyama envisions not only using CNFs to replace wood-based building materials currently used in interior design, but also using CNFs to replace building materials such as resin products and metal parts, taking advantage of CNF's light weight and high levels of strength and elasticity. TAKAZAWA Ryosuke, Leader at Daiken's R&D Center, conveys his high expectations when he says, "CNFs offer levels of strength that cannot be achieved using conventional wood-based materials and this will enhance their value as building materials."

Focus of technology development:

Creating high levels of demand by developing value-added building materials using 100% CNF-molded sheeting.

Development of Applied CNF technologies with Potential for Effectiveness in Large-scale Manufacturing

Producing air filters with high levels of moisture absorbency in response to demand for energy-efficient automobiles

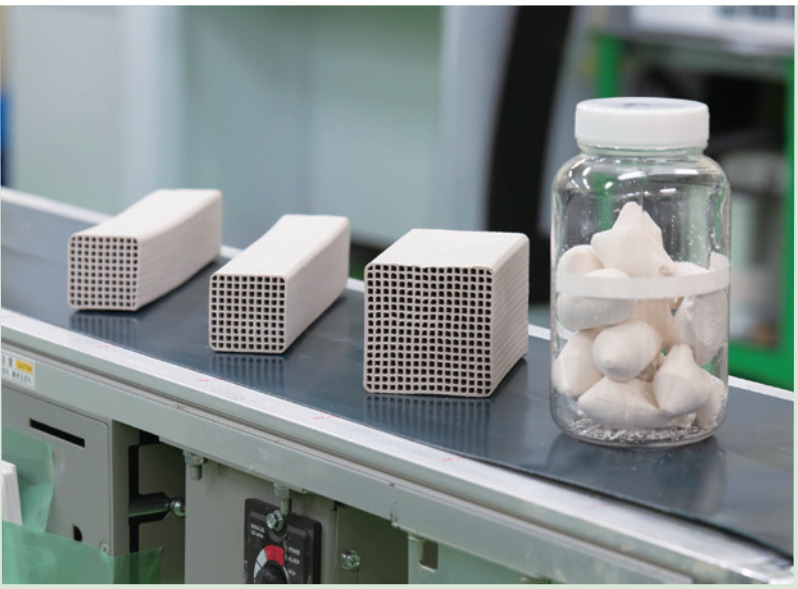
Shinwa Corporation

Filter system absorbs moisture that is discharged outside vehicle

Shinwa Corporation, a company specializing in products such as air filters for building and factory air-conditioning systems, participated in a NEDO project to commercialize a desiccant filter system that eliminates automobile window fogging by focusing on CNF's high level of moisture absorption. OKUYAMA Kazuhiro, Chief Manager at the Development Group in Shinwa's Innovation Planning Department, says, "This filter system is more energy-efficient than heat-based defogging systems. As passenger cars shift to electric power in the future, energy conservation is essential to extend the vehicle's cruising range and reduce the need for battery recharging, so we are responding to this demand as well."

The challenge was to select materials by assessing the characteristics of CNFs, but KOMORI Yosuke, Leader at Shinwa's Development Group in the Innovation Planning Department, says, "For materials, we have been helped greatly by the know-how acquired during the NEDO project by AIST and the Tokyo Institute of Technology. We are also grateful for the good suggestions received from them by providing feedback on the issues that emerged during the prototype stage.

One unit of this filter system is required for each vehicle and the system is also expendable, so continuous demand for the system is expected to be a major advantage. Shinwa had no previous experience in the automotive field, but with NEDO's support, Chief Manager Okuyama says Shinwa was able to take on this new challenge. Regarding prospects, Leader Komori says Shinwa plans to optimize the filter shape and conduct continuous operation tests using a full-scale demonstration vehicle and notes that "If we succeed with automobiles, with their strict safety standards and limited space, we can apply this technology to various other fields."



Filter elements being prototyped. Based on evaluations of CNF characteristics, research on filter shapes is progressing.

In the laboratory, there are filter prototypes, test equipment for evaluations of desiccant filter systems, and measurement equipment for evaluations.

OKUYAMA Kazuhiro(left)
Chief Manager
Development Group
Innovation Planning Department
Shinwa Corporation

KOMORI Yosuke(right)
Leader
Development Group
Innovation Planning Department
Shinwa Corporation

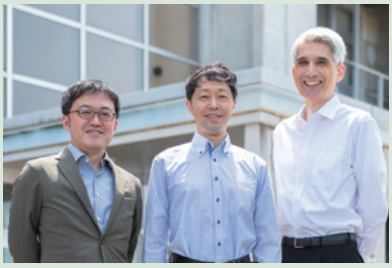
Focus of technology development:
Using CNF's high degree of moisture absorption to control humidity levels inside vehicles.

Safety Evaluation Projects

Assessing the safety of various CNF materials to promote their use

National Institute of Advanced Industrial Science and Technology (AIST)

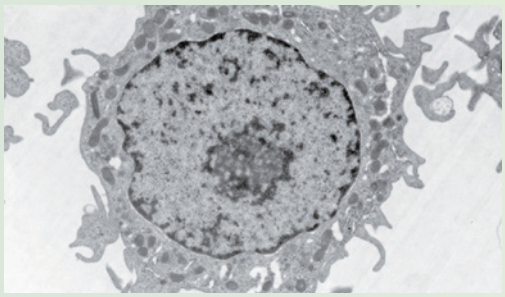
Ecological impact assessments examine effects of CNF materials on aquatic organisms (e.g., algae, crustaceans, fish).



Dr. MANO Hiroyuki (left)
Senior Researcher
Risk Assessment Strategy Group
Research Institute of Science for Safety and Sustainability (RISS)

Dr. OGURA Isamu (center)
Senior Researcher
Emission and Exposure Analysis Group
Research Institute of Science for Safety and Sustainability (RISS)

Dr. FUJITA Katsuhide (right)
Senior Researcher
Risk Assessment Strategy Group
Research Institute of Science for Safety and Sustainability (RISS)



Evaluating the inhalation toxicity of CNFs using cultured cells such as macrophages.

Aiming to test a wide variety of CNFs and publish an evaluation report

CNFs are expected to be used in a wide range of applications, but concerns have been raised about their potential health hazards. OGURA Isamu, a Senior Researcher at the AIST Research Institute of Science for Safety and Sustainability (RISS), explains the significance of safety assessments by saying, “To support the commercialization of CNFs, it is important to assess at an early stage the possible impacts they may have on the human body and the environment and release the assessment results.”

Under the previous NEDO project, Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants, carried out through fiscal years 2017 - 2019, AIST developed safety assessment methods for CNFs, and the current NEDO project focuses on assessing the safety of a greater variety of CNFs. Senior Researcher Ogura notes that, “To ensure diversity, we are asking a wide range of domestic manufacturers to provide us with CNF materials, and, since this is a NEDO project, it helps facilitate their cooperation.”

FUJITA Katsuhide, a Senior Researcher at AIST, describes the long-term process by saying, “Even if test results are unfavorable, we release them to the public, but I think the fact that, after many years of the NEDO project, more and more companies are accepting test results as being reliable is a good outcome.”

CNFs are prone to microbial contamination, which affects test results, so it is necessary to create technologies to prevent microbial contamination when assessing safety. This issue has been overcome by sharing information, and testing is progressing smoothly.

MANO Hiroyuki, a Senior Researcher at AIST, expresses his hopes for the project by saying, “There are few examples of ecological impact assessments of CNF materials, so I hope that this will be an opportunity for such assessments to become more commonplace.”

Focus of technology development:

Verification through assessments in three areas: inhalation impacts, ecological impacts, and levels of emissions/exposure.

Development of Hazard Assessment Methods for Various Product Applications and Safety Assessments

Verifying the long-term impacts of CNFs on organisms

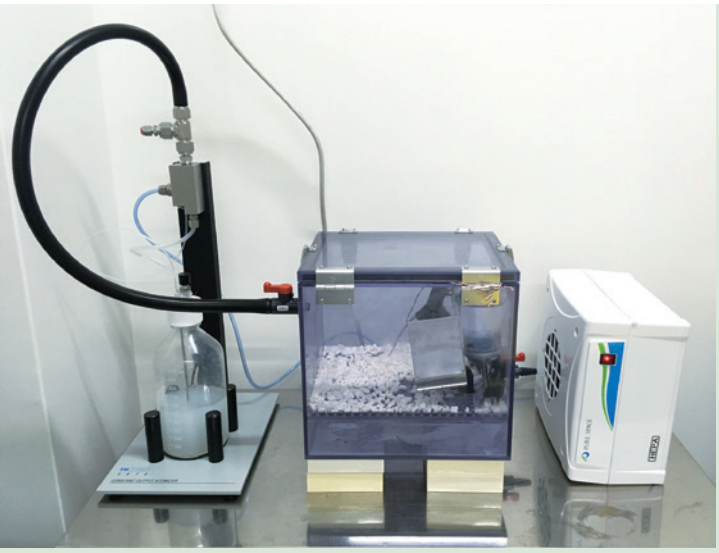
University of Fukui

In collaboration with the School of Medicine, strictly monitored experiments were conducted

CNFs only have a short history, and there are many unknowns as to the kind of impacts they may have. Asbestos was initially considered to be a safe substance, but, after many years, it was identified as the cause of various diseases, so it is necessary to carefully assess safety issues in this case as well. Professor TANOUE Shuichi, Director of the Fibers and Materials Research Center at the University of Fukui, emphasizes the importance of the project by saying, "It is generally recognized that CNF is an organic material that probably does not have an adverse impact on the human body. However, CNFs assume a variety of shapes when nanosized and if they are commercialized, a high volume will be used. As manufacturers may generate dust during various processes such as pulverization, compounding with resin, molding, and disposal, assessing the safety of CNFs is essential."

In order to assess safety issues related to living organisms, Professor YAMASHITA Yoshihiro of the University of Fukui, in collaboration with Associate Professor TOKUNAGA Akinori of the University of Fukui Faculty of Medicine and other researchers, are conducting experiments strictly monitored by the university's Animal Testing Committee, taking care to minimize the number of laboratory animals used for experiments and to cause as little pain as possible. Specifically, the impacts of adding CNFs to the diet of primates and the impacts of CNFs on the diet and inhalation of laboratory mice will be assessed to determine if there are any next-generation genetic impacts, since generational change in mice progresses quickly.

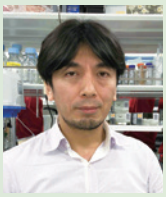
Professor Yamashita says, "As this is a collaborative project with AIST, we have been able to access the information and know-how they have already accumulated." In the future, the results of this project will be compiled into a safety assessment report, which will be widely used by people who work with CNFs, with the aim of accelerating the social implementation of CNF materials and products.



Equipment to measure level of exposure to CNF dust generated in typical workplace environment and assess impacts on inhalation.

Professor
YAMASHITA Yoshihiro
Doctor of Engineering
Research Center for Fibers and Materials
Advanced Division

Professor
TANOUE Shuichi
Doctor of Engineering
Director of Research Center for Fibers and Materials
Advanced Division



Associate Professor
TOKUNAGA Akinori
Doctor of Medicine
Life Science Support Center
Division of Biological Resources

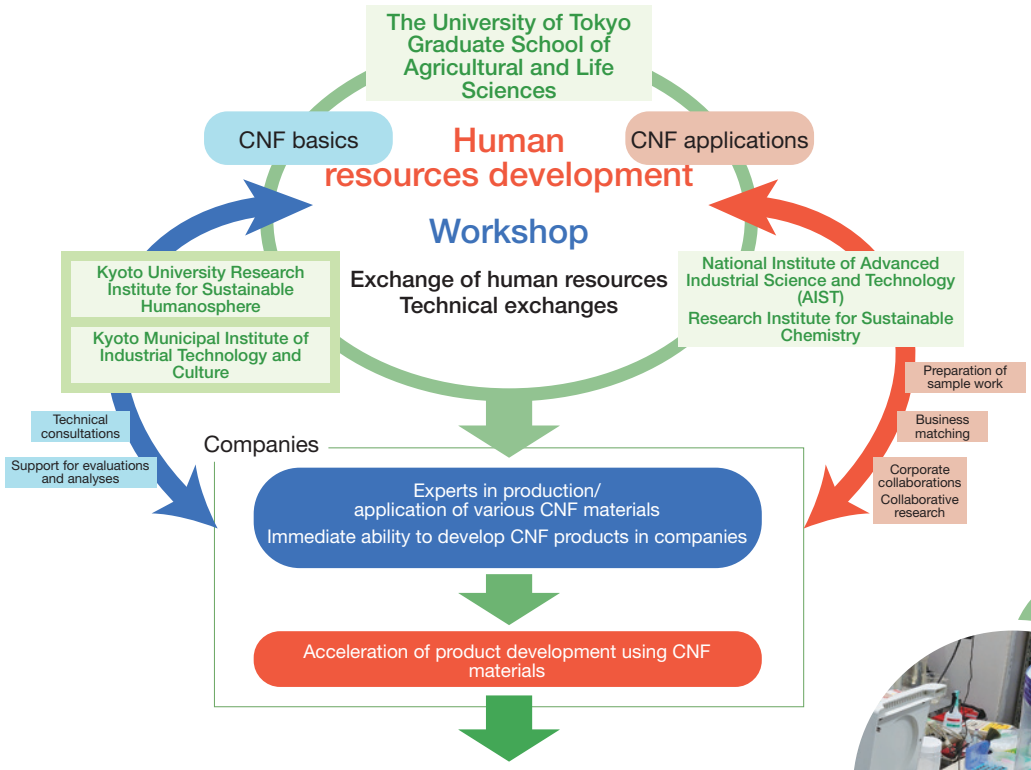
Focus of technology development:

Conducting long-term experiments in environments approximating everyday situations to assess impacts on living organisms.

NEDO Course

Course to Develop Human Resources Capable of Working on Creation of New CNF Products

In order to accelerate the commercialization of CNF materials, which are expected to be used in a wide range of fields as an alternative to existing petroleum-based materials, a special NEDO course has been conducted to train engineers in the development of advanced CNF materials. In addition to promoting the exchange of human resources in various fields, NEDO aims, through the provision of support and guidance on the preparation of sample work, analyses, and evaluations, to create a "virtuous cycle" in which human resources capable of working with relevant technologies are fostered in various specialized fields that may lead to the development of new fields and applications.



Practical training in compounding CNFs and natural rubber using automatic rotary mixer

Through lectures and practical training sessions, participants acquire the skills necessary for product development.

The course was launched in fiscal year 2020 at four research institutions: the University of Tokyo, Kyoto University, the Kyoto Municipal Institute of Industrial Technology and Culture, and the National Institute of Advanced Industrial Science and Technology (AIST). Lectures and practical training sessions are held twice a year during the first and second semesters. The course provides participants with the knowledge and skills necessary for product development, including areas such as manufacturing technologies ranging from the pretreatment of various CNF materials to resin compounding, molding, and processing, and includes analysis methods as well. In workshops, companies involved in the manufacturing of CNF materials are invited to provide presentations, and technical exchanges also take place between presenters and course participants.

NEDO established its Special Course Series in fiscal year 2006 with the aim of fostering human resources who can support technologies in advanced and interdisciplinary fields and creating a place to promote human resource exchanges and collaborations between industry, academia, and the government.

Four research institutions offering special courses

The University of Tokyo

TEMPO-oxidized CNFs
(Lecturer: Dr. ISOGAI Akira)

- Participants gain an understanding of the structure of plant cellulose and the basics of CNF preparation and structure, and learn about CNF R&D trends in Japan and around the world.
- Participants also learn about TEMPO oxidation of cellulose and the isolation/purification process and receive training on quantifying the carboxyl groups that control the degree of nano fibering.

AIST Chugoku

Compounding mechanically disentangled CNFs with polymerss
(Lecturer: Dr. ENDO Takashi)

- Participants learn about CNF manufacturing technology using the mechanical fiber separation process and receive training on evaluation and analysis methods.
- Participants learn about various molding and processing technologies through practical training sessions on compounding rubber with CNFs and resin.
- Participants conduct experiments and acquire understanding on strength testing and analytical evaluation methods for CNF composite molding.

Kyoto University
Kyoto Municipal Institute of Industrial Technology and Culture

Using the Kyoto Process to compound CNFs and resins

Kyoto University
(Lecturer: Dr. YANO Hiroyuki)
Kyoto Municipal Institute of Industrial Technology and Culture
(Lecturer: Dr. SEMBA Takeshi)

- Participants observe and receive training on integrated process mechanisms for raw materials, pulping, chemical modifications, nano-disentanglement and resin compounding.
- Participants receive hands-on training regarding the evaluation and analysis of physical properties for CNF nano-composite resins.
- Participants assess commercial applications for running shoes and automobiles.

Please view the NEDO press release and AIST website for further information regarding the content of the lectures and for course registration.

https://www.nedo.go.jp/news/press/AA5_101294.html
(Only available in Japanese)

https://www.aist.go.jp/chugoku/ja/event/2020fy/0401-0930.html
(Only available in Japanese)

Matching services are also provided to facilitate joint research with companies, universities, and public research institutions.

For companies participating in the course, the four research institutions conduct peripheral research such as providing samples and examining analysis and evaluation methods, with the aim of applying them to new fields and applications. For companies that wish to pursue more focused research and development, NEDO will help match them with companies, universities, and public research institutions for potential collaborations, leading to separate joint research activities.

PROJECT REPORT

Take the next step from success

Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants

Fiscal years 2013-2019

Established technological foundation for realizing large-scale CNF production and achieved cost reductions exceeding original target

Establishing a world-leading and cost-competitive integrated manufacturing process

Under this project, which began in fiscal year 2013, NEDO promoted the development of an integrated process and equipment for the stable manufacturing of CNFs and CNF resin composite materials, and the development of innovative technologies to realize functions desired by end-users.

In 2016, as a result of this project, a collaborative group of industry and academic research institutions, led by Kyoto University, succeeded in developing the “Kyoto Process,” the first such process in the world for highly efficient and continuous production of lightweight, high-strength, high-performance nanofibers and resin composites reinforced with these materials.

The Kyoto Process is characterized by its "direct pulp kneading method," in which pulp composed of CNFs is directly kneaded with resin to achieve nano-scale disentanglement of the pulp and uniform dispersion of the nanofibers in the resin. Lignin-based pulp is produced by leaving water-resistant lignin on the surface of CNFs derived from wood-based biomass materials such as bamboo. After chemical treatments are carried out, the pulp is disentangled on a nano scale and kneaded at the same time into resin, which enables a significant reduction in production costs.

Based on this technology, a test plant was completed at the Uji campus of Kyoto University, and samples were provided to chemical and plastics manufacturers, as well as automobile, home appliance, and housing manufacturers. By working to optimize manufacturing technologies and incorporate feedback received, progress was made with evaluating the performance of various resins and plastic parts. Cost estimates indicate production costs were achieved in a range from 718 yen/kg to 927 yen/kg for a CNF-added masterbatch of nylon 6 for injection molding, far below the original cost target of 1,300 yen/kg.

Release of information on CNF safety assessments and evaluations of CNF characteristics to promote widespread use of CNFs

To support the development of safe CNF products andappropriate CNF safety assessments, a collaborative group of industry and university research institutions led by AIST has compiled and released a report on its efforts to develop methods for detecting and quantifying trace amounts of CNFs in samples, methods for conducting CNF-related hazard assessments, such as tests to measure the impact of CNFs on inhalation and dermal tissues, and methods for evaluating the potential for CNF emissions and exposure during the manufacturing, use, and disposal of CNF powders and CNF-applied products. The report will enable the sharing of safety-related data between manufacturers involved in the production of CNF materials and companies that use CNFs in their products, thereby promoting innovation and the development of new product applications.

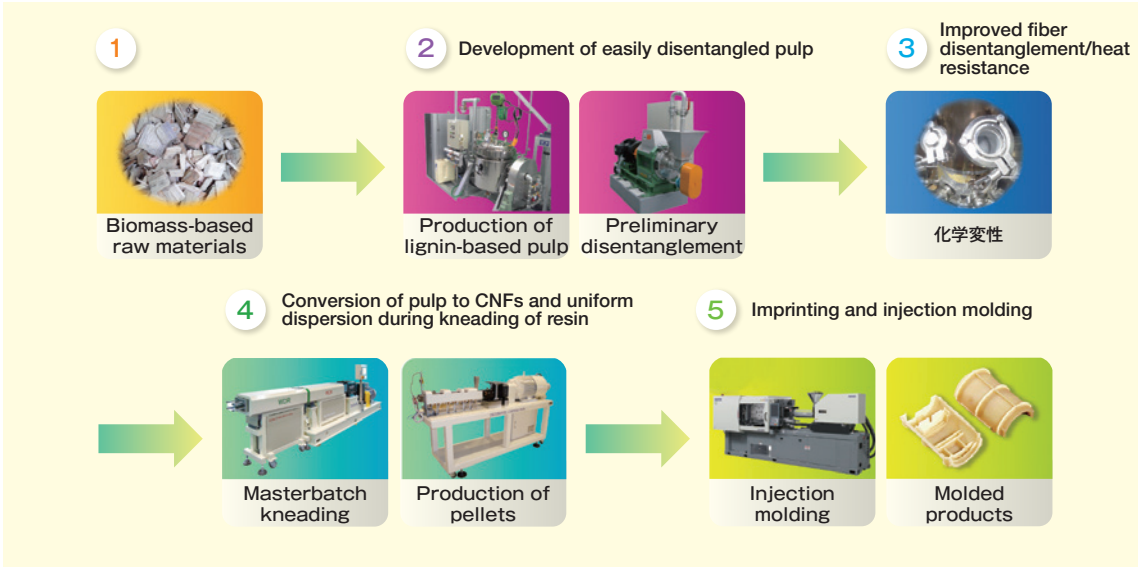
In addition, a collaborative group of industry and university research institutions, led by the Forestry and Forest Products Research Institute, has clarified the physical properties of wood-based biomass, pulped raw materials for producing CNFs, clarified their characteristics, and systematically summarized them in relation to the properties of the raw materials.

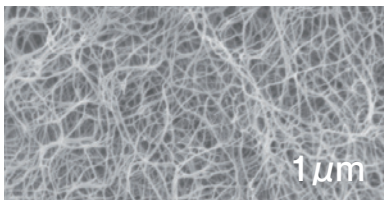
In order to support the effective selection of raw materials, the characteristics of raw materials, pulp, and CNFs, as well as the suitability of using CNFs in various products, have been summarized in a report on the evaluation of raw materials for the promotion of CNF utilization. Based on the information in this report, it is hoped that new collaborative networks will be created between the paper and timber industries and industries that utilize CNF materials.

To further reduce costs, expand the range of product applications, and establish safety assessments, the results of this project will be expanded upon under NEDO’s new project Cellulose Nanofiber-related Technology Development to Contribute to a Carbon cycle Society, which was launched in fiscal year 2020.

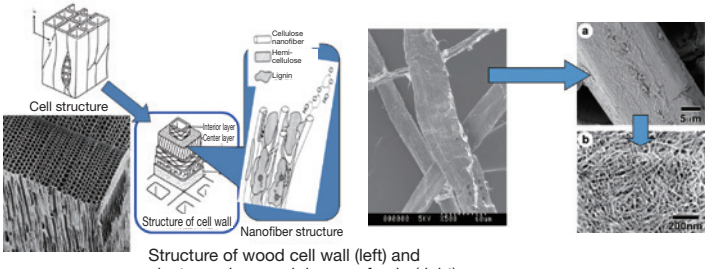
Kyoto Process

Integrated manufacturing process for modified lignocellulosic nanofibers and resin composites





Cellulose microfiber bundles in wood cell walls (cellulose nanofibers)



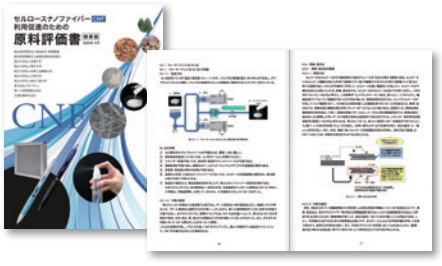
Structure of wood cell wall (left) and electron micrograph image of pulp (right)

Reports related to safety assessment methods

Press release regarding the report on CNF safety assessment methodologies
https://www.nedo.go.jp/news/press/AA5_101302.html
(Only available in Japanese)

The report on CNF safety assessment methodologies may be downloaded from AIST's website.
https://www.aist-riss.jp/assessment/45276/
(Only available in Japanese)

Reports related to evaluations of raw materials



Press release regarding the report on the evaluation of raw materials for the promotion of CNF utilization
https://www.nedo.go.jp/news/press/AA5_101300.html
(Only available in Japanese)

The summary version of the report on the evaluation of raw materials for the promotion of CNF utilization is available on the AIST website.
https://www.aist.go.jp/chugoku/ja/event/2020fy/0326.html
(Only available in Japanese)

Startup Support and Beyond
The Future for NEDO Startups

NEDO Startups Future

Innovator File.15

Nihon Techno Service Co., Ltd.

CEO: MASAKI Takashi

Manufacture and sale of DNA/RNA synthesizers and vacuum freeze dryers
Provision of research support services in areas such as DNA/RNA synthesis and import/sales of DNA/RNA synthesis reagents

1991: Founding of Nihon Techno Service Co., Ltd.
2016: Selected for NEDO projects Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants/Development of Data Analysis Systems for Production of Highly Productive Microbes.
2018: Based on NEDO project outcomes, the M-96-LD synthesizer for long-chain DNA materials was developed.

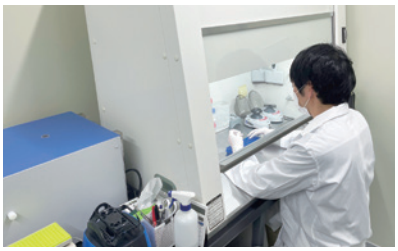
https://www.ntsbio.com

Prototype device

Q1. How did you take advantage of NEDO's support programs?

Since our company is a Japanese manufacturer of DNA synthesizers, professors at Kobe University conducting R&D on long-chain DNA knew about us, and this connection afforded us the opportunity to participate in the NEDO project.

In the NEDO project, in order to efficiently produce chemically synthesized DNA, which is the material for long-chain DNA, we improved the washing process and feeding mechanism of conventional DNA synthesizers and optimized the chemical reaction conditions, such as the concentration and feeding amount of DNA reagents. This allowed us to develop and commercialize a synthesizer for long-chain DNA materials that enables synthesis in a short amount of time and at a low cost.



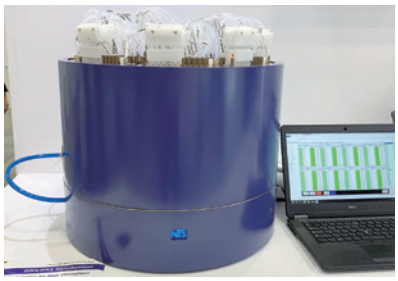
Development of reagent preparation

Q2. What is Nihon Techno Service's vision for the future?

By getting involved in the NEDO project, we were able to develop a device that would have been difficult to develop on our own. We have already sold four units of the commercialized system and will also launch a synthesizer for lab-scale DNA synthesis mounted with a new feeding system and trityl yield monitoring mechanisms developed in the NEDO project. We are planning to launch the device in the fields of DNA chemistry and medicine and are planning to export it to customers in China and the United States. We will also continue to develop and enhance equipment for the synthesis of long-chain RNA and modified RNA, which are also used for infectious diseases.

Q3. What is your company's relationship to Synplogen?

Synplogen is a startup that spun out from Kobe University, and we worked together on the verification of technology developed under the NEDO Smart Cell Project. Synplogen was also the first company to introduce the synthesizer we developed for long-chain DNA synthesis. We hope to work with them in the future on efforts to develop long-chain DNA synthesis technology in Japan.



Prototype device at BioJapan trade show

NEDO Comment

DNA, the blueprint of living organisms, tends to break easily in long chains, making it very difficult to handle. The company, in collaboration with Kobe University, has developed a method for synthesizing long-chain DNA, which had been difficult to accomplish in the past, and has commercialized its technology in a cost-competitive manner.

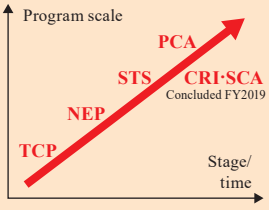
NEDO startup support programs for R&D related to industrial technologies

More information on NEDO startup support programs

https://www.nedo.go.jp/activities/ZZJP2_100063.html

(only available in Japanese)

Programs used by startups featured in this section



TCP Technology Commercialization Program

Support for entrepreneurial development at universities, research institutions, and startups

To revitalize the economy, it is important to foster entrepreneurs that have competitive new technologies. NEDO provides startup support from a variety of perspectives to develop research and development-oriented startups and entrepreneurs. Here, we examine notable startups that are continuing to grow toward the future.

Innovator File.16

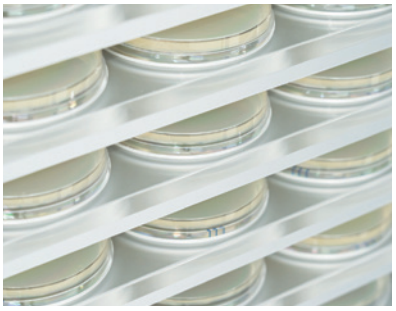
Synplogen Co., Ltd.

Director and Co-founder: Dr. TSUGE Kenji

Provision of services including DNA synthesis and the development of DNA libraries as well as services related to the analysis, production, and development of vectors for genetic therapies.

2016: Selected for NEDO projects Development of Technologies for Manufacturing Processes of Chemicals Derived from Inedible Plants/Development of Data Analysis Systems for Production of Highly Productive Microbes.
2017: Founded as startup spun out from Kobe University.
2019: Launch of R&D Center. Transfer of NEDO project technology outcomes from Kobe University.
2019: Introduction of DNA chemical synthesis device developed under NEDO Smart Cell Project.
2020: Relocation and expansion of R&D Center to Creative Lab for Innovation in Kobe.

Japanese HP http://www.synplogen.com/
English HP http://www.synplogen.com/en/



Long-chain DNA synthesis technology using Bacillus subtilis

Q1. How did you take advantage of NEDO's support programs?

Kobe University, my alma mater, participated in the NEDO Smart Cell Project, under which we built an integrated DNA foundry manufacturing facility for long-chain DNA using chemically synthesized DNA as the starting material. It is difficult for a university laboratory such as ours to develop such a large-scale technology on its own, but the NEDO project made this possible for the first time. By transferring the various technologies developed during this process to Synplogen, we were able to start a DNA synthesis business for long-chain DNA materials.

Q2. What is Synplogen's vision for the future?

To enhance the value of our core long-chain DNA synthesis business, we are putting our energy into the creation of long-chain DNA libraries and the synthesis of DNA sequences that are difficult for other companies to handle. Utilizing our DNA synthesis technology, we are also working on the in-house development of technologies using viral vectors for genetic therapies. Our goal is to provide a technology platform for the design and enhanced production of viral vectors.

Q3. What is Synplogen's relationship to Nihon Techno Services?

We co-developed a low-cost synthesizer for long-chain DNA under the NEDO Smart Cell Project in which Kobe University participated.

Interior of R&D Center

DNA chemical synthesis devices

NEDO Comment

The ability to tailor any sequence of long-chain DNA has made it possible to drastically change the function of biological cells all at once. In addition, the time required to develop microorganisms that can be employed in the creation of useful products will be greatly reduced, so we can expect further expansion of the bioeconomy.

NEP NEDO Entrepreneurs Program
Support for entrepreneurs through provision of specialists who assist with commercialization efforts

STS Seed-stage Technology-based Startups
Support for commercialization of seed-stage technology-based start-ups by promoting collaborations with venture capitalists and other relevant entities

CRI Collaboration with Research Institute
Support for R&D-based startups to develop commercial applications
Concluded FY2019

SCA Startups in Corporate Alliance
Support for R&D-based startups to conduct joint research with project companies
Concluded FY2019

PCA Product Commercialization Alliance
Support for R&D-based startups to develop concrete business plans for sales activity approximately three years after submission of proposal

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URL: https://www.nedo.go.jp/english/index.html

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