New Value Creation through Green Innovation

Our Role Is to Effectively Utilize Forest Resources to Solve Social Challenges

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Under the Group basic policy of "Initiatives for Product Development –Green Innovation–", the role of our Innovation Promotion Division is to solve social challenges through "the creation of new value through the effective use of forest resources." On a foundation of diverse core technologies cultivated through paper manufacturing and forestation spanning the 150 years since our founding, we will be promoting innovation with a focus on the following three themes.

The first theme is "development of new materials derived from wood fiber." We are developing a variety of new materials to realize a recycling-oriented society by effectively utilizing the abundant forest resources we own in Japan and overseas. Specifically, wood-derived biomass plastics utilizing enzyme reaction and fermentation technologies, and biomass plastic films utilizing film forming technology. We are promoting development utilizing core Group technologies, such as cellulose nanofibers using nano-fibrillation technology, cellulose mats applying non-woven fabric manufacturing technology, and cellulose composites leveraging mixing technology.

The second theme is "challenge to the medical and healthcare field." With an eye on the medical care of the future, we are taking on the challenge of entering a new field that goes beyond the Oji Group's traditional businesses through our efforts to utilize our forest resources and proprietary technologies in the medical and healthcare field. Specifically, we are working on developing pharmaceutical products using hemicellulose, a main component of wood, as a raw material; and large-scale cultivation of medicinal plants utilizing our forest tree-breeding technology. In addition, utilizing proprietary technology, we are promoting the development of cell culture substrates for controlled cell orientation, which are expected to contribute to regenerative medicine.

The third theme is "development of eco-friendly paper products." Utilizing various paper products to achieve things such as CO_2 emissions reductions and reduce plastic usage is something that can only be accomplished by a company as knowledgeable about paper as we are. In order to meet a broad array of needs for environmental friendliness, we are promoting a variety of innovations. Examples include the development of plastic-free solutions utilizing paper materials, and laminated paper which can be recycled leveraging our paper production technology.

People around the world are holding great expectations for sustainable forest resources. We believe there are innovations which can only be achieved by a company like us which has long and dedicated experience in dealing with forest resources. By going back to the basics once again and reexamining the "Purpose" of the Oji Group, we will promote value creation to achieve our future goals.

Green Innovation Oji Is Aiming for

Effective Use of Forest Resources to Contribute to a Recycling-oriented Society	Challenge to a New Field in Light of the Future of Medicine and Healthcare	Using a Variety of Paper Products to Solve Various Environmental Issues
Development of New Materials Derived from Wood Fiber	**Challenge to the Medical and Healthcare Field**	**Development of Eco-Friendly Paper Products**

Green Innovation which Effectively Leverages Forest Resources toward Solving Social Challenges

Development of New Materials Derived from Wood Fiber

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2 ZERO HUNGER | 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE | 13 CLIMATE ACTION | 14 LIFE BELOW WATER

- Biomass plastics
- Biomass plastic films
- CNF (Cellulose nanofiber)
- Bioethanol
- Cellulose composites
- Cellulose mats

- Sheeting technology
- Fermentation and polymerization technology
- Nano-dot array technology
- Film forming technology
- Non-woven fabric manufacturing technology
- Chemical synthesis technology
- Adhesive processing technology
- Corrugated container manufacturing technology

- Wood-derived pharmaceutical products
- Cell culture substrates for controlled cell orientation
- Medicinal plants

3 GOOD HEALTH AND WELL-BEING | 12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Challenge to the Medical and Healthcare Field

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- Recycling-friendly paper products
- Plastic-free solutions

12 RESPONSIBLE CONSUMPTION AND PRODUCTION | 15 LIFE ON LAND

Development of Eco-Friendly Paper Products

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Paper

- Coating technology
- Lamination technology
- Paper manufacturing technology

Pulp

- Nano-fibrillation technology
- Fibrillation and mixing technology
- Water treatment technology
- Precise pulp-molding technology
- Enzyme reaction technology

Raw wood

- Refining technologies
- Forest tree breeding technology

New Value Creation through Green Innovation

Development of New Materials Derived from Wood Fiber

Effective Use of Forest Resources to Contribute to a Recycling-oriented Society

Toward solving climate change issues caused by increased greenhouse gas emissions, the Oji Group promotes the development of new materials derived from renewable wood and aim to realize a recycling-oriented society.

Producing Wood-derived Biomass Plastics to Move Away from Petroleum-derived Plastics

Wood-derived biomass plastics

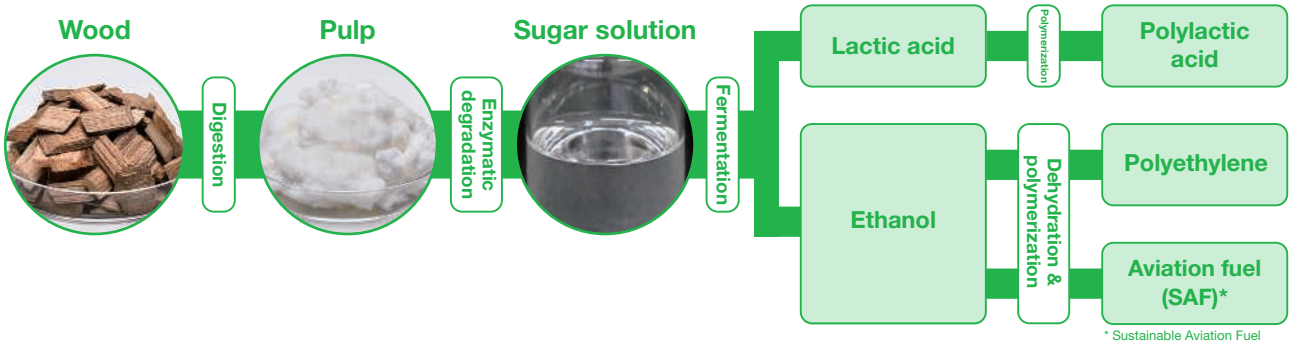
While the global need for biomass plastics is growing to reduce CO_2 emissions from fossil fuels, the diversification of raw materials for biomass plastics is required. We are exploring the manufacturing of biomass plastics by using inedible biomass derived from wood less susceptible to price fluctuations and tight supply-demand conditions due to the food situation. Before the end of FY2021, we succeeded in producing wood-derived polylactic acid and polyethylene through the commissioned project of the Ministry of the Environment*.

Going forward, aiming to popularize these wood-derived biomass plastics, we will work to establish a mass synthesis method and develop applications.

Furthermore, since the knowledge of producing polyethylene from ethanol may be applicable to the production of Sustainable Aviation Fuel (SAF) from ethanol, we will examine the possibility of providing wood-derived ethanol as raw materials for SAFs. Although there is an established method of producing SAFs from waste edible oil, the method of producing SAFs from ethanol is awaited with great expectations for their popularization and expansion.

Testing plant for enzymatic degradation and fermentation

* FY2019 to FY2021 Demonstration Project for a Plastic Resource Circulation System toward a Decarbonized Society



* Sustainable Aviation Fuel

Emission reductions of CO_2 from fossil fuels by the development of biomass plastic films

Biomass plastic film, Alphan G

We have been developing plastic films containing a plant-based plastic, polylactic acid. In response to a greater need for packaging films with low environmental impact to reduce CO_2 emissions from fossil fuels, we aim to contribute to this social need. Our new product Alphan G, a polypropylene film containing polylactic acid, was certified as a Biomass mark product* and has been commercialized and launched.

We will work on the development of heat-sealing biomass plastic films going forward, aiming to utilize them as pillow-type packaging films widely used for the food and pharmaceutical industries, and will continue to develop a wide variety of products that contribute to SDGs.

* Biomass mark certified by the Japan Organics Recycling Association

Wood-derived Cellulose Nanofiber to Reduce Material Weight and Environmental Burdens

CNF (Cellulose nanofiber)

Cellulose nanofiber (CNF) is produced by nanofibrillation of pulp to a nanometer order (1nm = 0.000001mm), and is expected to contribute to the reduction of environmental burdens by replacing conventional functional materials derived from petroleum and mineral. We aim to apply CNF in a wide variety of fields, leveraging its functions and characteristics such as transparency, lightweight, durability, high resistance to deformation, and high viscosity.

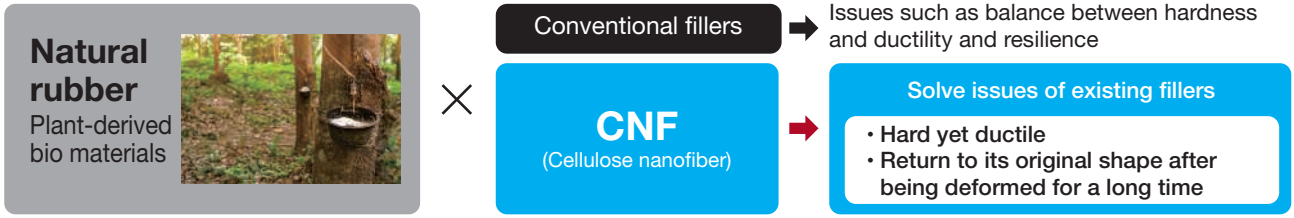
There are increasing applications of our CNF in sports products, cosmetics, and on construction sites. In order to accommodate a wider variety of needs, we will work on the development aiming to promote further practical applications.

Development of cellulose nanofiber and natural rubber composites

Natural rubber is a bio material derived from extract of tress such as *hevea brasiliensis*. Due to recent efforts to realize a decarbonized society, it is expected to replace petroleum-based synthetic rubbers.

Normally, natural rubber is reinforced by adding fillers such as carbon black. Although these existing fillers can increase strength of rubber materials, there are some issues namely loss of ductility and resilience (ability to return to their original shape after being deformed for a long time). When using our CNF as a new reinforcing filler for natural rubber, we found it has the potential to solve these issues.

Going forward, we will explore the possibility of deploying this new composite to the market, and establishing the mass production technology.

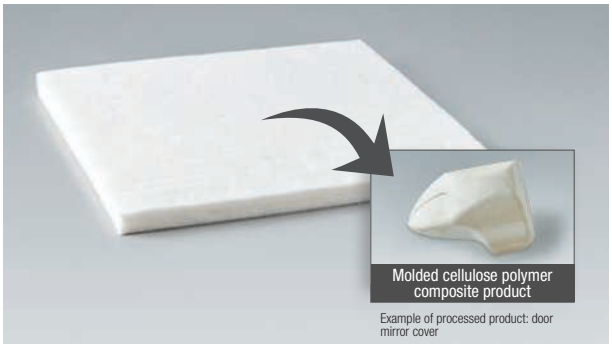


Light and Strong Less-Plastic Materials Using Cellulose as Reinforcing Fiber

Wood-derived cellulose mats

Mats using wood-derived cellulose fiber (pulp) as reinforcing fiber (cellulose mats) help reduce the consumption of petroleum-derived plastic by up to 70%. We have found that a molded product using cellulose mats shows much higher rigidity (flexural modulus) and impact strength than conventional plastics. We have now started providing cellulose mat samples.

We will continue the product development toward practical automotive applications.



Biodegradable Plastic-Cellulose Composites to Reduce Environmental Burdens

Cellulose composites, Resoil-Green

We are developing resin materials that are composites of biodegradable plastics and wood-derived cellulose (pulp). Since the product uses pulp, it can achieve high degree of biomass as well as high biodegradation rate. In addition, the product improves various properties of resin such as strength and stiffness. Since all raw materials of the products are biodegradable in soil, the products can contribute to reducing environmental burdens. Even if unaware discharges to the environment occur, those will be decomposed in the natural environment.

Currently, the product is well accepted by many customers, and we are working so that it will be adopted for a wide variety of applications.

Challenge to the Medical and Healthcare Field

Challenge to a New Field in Light of the Future of Medicine and Healthcare

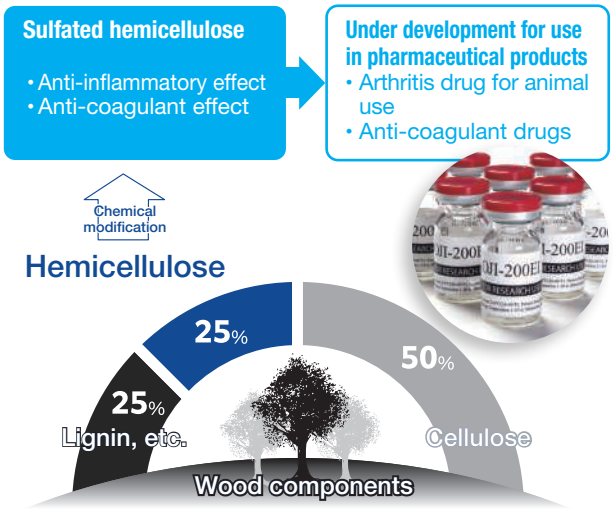
As the super-aging society progresses and interest in extending healthy life expectancy grows, there is a need for new and different form of medicine and healthcare. The Oji Group is challenging a new field beyond our traditional businesses through our efforts to utilize forest resources for medical and healthcare field.

Drug Discovery from Forest Resources

Wood-derived pharmaceutical products

The Oji Group aims to contribute to human and animal health through the development of "sulfated hemicellulose." Sulfated hemicellulose is a compound obtained by chemically modifying "hemicellulose," one of the major components of wood. Our joint research with companies and universities in and outside Japan confirms that it has anti-inflammatory and anti-coagulant effects. In addition, this compound is similar, in terms of chemical structure and pharmacological effect, to heparin, an animal-derived pharmaceutical product used all over the world. By replacing this animal-derived pharmaceutical product with wood-derived one, it is expected to accommodate a wide range of needs.

While we are currently filing a prior application for arthritis drug for animal use, we will develop into a drug for human use and work on the building of the pharmaceutical business, leveraging the property of being derived from wood.



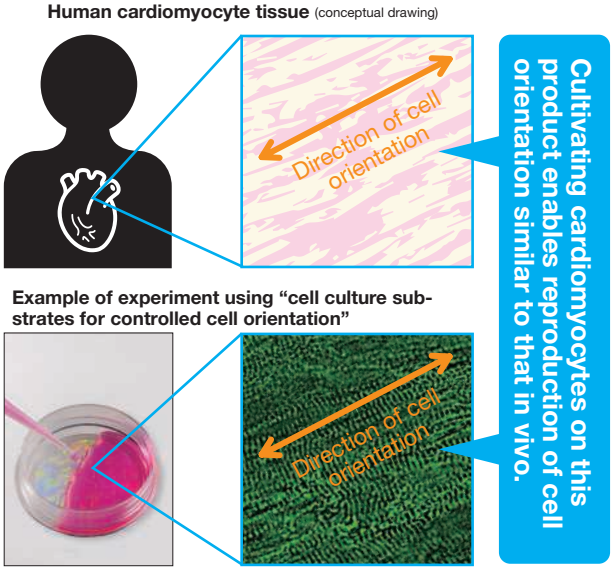
Nanostructure Technology for Regenerative Medicine and Drug Discovery

Cell culture substrates for controlled cell orientation

The Oji Group is developing cell culture substrates with a fine structure, by applying one of the semiconductor manufacturing process. While research on regenerative medicine and drug discovery using "iPS cells," which can develop into any cell, is actively carried out, there is an issue that immature iPS cells must be matured in order to be used for regenerative medical purposes*1. Focusing on the fact that human cardiomyocytes are "oriented" in vivo, we have developed culture substrates that induce cell orientation. This product is a cell culture substrate fabricated by our original technology, that has nanodot regions with a pitch of several hundred nm and planar regions interleaved in parallel stripes. It is confirmed that iPS cardiomyocytes cultured on this substrate enables reproduction of cell orientation similar to that in vivo, activating genes work like mature cells. We are currently conducting joint research with Juntendo University, etc.

We will continue to promote use of this product toward regenerative medicine and drug discovery applications.

*1 Since cardiomyocytes generated from iPS cells are inferior to those in vivo in terms of motility and physiological activity, it is required to make them closer (maturate) to those in vivo.
*2 α-Actinin (protein)



Picture of cultivating cells in red culture (left), and stained cells*2 in green (right)

Stable Supply of High Quality, Domestically Grown Raw Materials for Chinese Herbal Medicines

Large-scale cultivation of medicinal plants

Licorice, which is used in many Chinese herbal medicines, is imported from abroad (China), and domestic production is required due to fears of resource depletion in exporting countries and export restrictions. The Oji Group is applying its forest tree breeding technology to develop cultivation techniques within Japan, and has succeeded in conducting a demonstration test at our farm. In order to expand our business scale, we are now exploring the possibility of mechanized large-scale cultivation.

Development of Eco-Friendly Paper Products

Using a Variety of Paper Products to Solve Various Environmental Issues

Toward solving environmental issues, such as reduction of CO_2 emission and plastic consumption, the Oji Group establishes new business models using various eco-friendly paper products to provide solutions to accommodate a wide variety of needs.

Recycling-friendly Paper Products

Laminated paper using plant-derived polylactic acid

When disposing of ordinary laminated paper as combustible waste, combustion of petroleum-derived plastic layers results in CO_2 emissions from fossil fuels. Since plastic layers of the laminated paper we developed use plant-derived polylactic acid, combustion of the paper does not increase CO_2 in the atmosphere. In addition, this laminated paper is biodegradable under compost conditions.

Aqueous coated paper cup base

Traditional paper cups, made of plastic laminated paper, are not suitable for recycling and are generally treated as combustible waste. We have leveraged the technology cultivated in our paper manufacturing and successfully developed paper cup base which has water and oil resistance and heat sealability required for paper cups and is recyclable under the existing paper recycling system, by applying special aqueous resin to the cup base in a thin and even manner.

Sustainable Solutions (Paper Products which Accommodate a Wide Variety of Eco-friendly Needs)

Food trays that lead to both plastic reduction and food loss reduction

– Tapered paper tray with MAP capabilities –

This is a paperboard-based tray with a resin film that covers the surface. MAP* can extend food shelf life.

* MAP (Modified Atmosphere Packaging): a packaging system that involves replacing the atmosphere surrounding a food product inside a pack with a gas suitable for the preservation of food.

Cardboard that enables prolonged shelf life and attractive presentation of fresh foods

– FlatSkin® –

This is a package that is separable into cardboard and film. The vacuum packaging of meat and fish can suppress drip, and printing on the cardboard offers attractive presentation of foods.

Sustainable, heat-sealable package

– All paper-made blister pack –

This is composed of three pieces; paperboard-made top, tray and divider. Without the use of plastic films, it will secure and protect products inside. Printing on and window holes of this product offer effective presentation of daily goods inside.

Topics – Sustainability –

Reduction of CO_2 emissions by introduction of paper packaging

A comparison of the life cycle CO_2 emissions of petroleum-based plastic packaging and sustainable paper packaging shows that paper packaging emits less CO_2 than plastic packaging. Therefore, the introduction of paper packaging can contribute to CO_2 emission reduction. For more details, please see our website.

*1 CO_2 emissions are calculated by converting greenhouse gas (GHG) emissions such as carbon dioxide (CO_2), methane (CH_4), and dinitrogen monoxide (N_2O) into CO_2. The calculation is made based on LCA (Life Cycle Assessment) methodology.
*2 Calculation results of reduction rate change, depending on packaging material and layer structure. (It is assumed that the paper packaging material is MG bleached kraft paper 70 g/m^2 and that the type of printing is gravure printing.)

Sustainable packaging | CO_2 reduction effect

➡ https://solution.ojiholdings.co.jp/ojipaperpackage/sustainability/ (available in Japanese only)