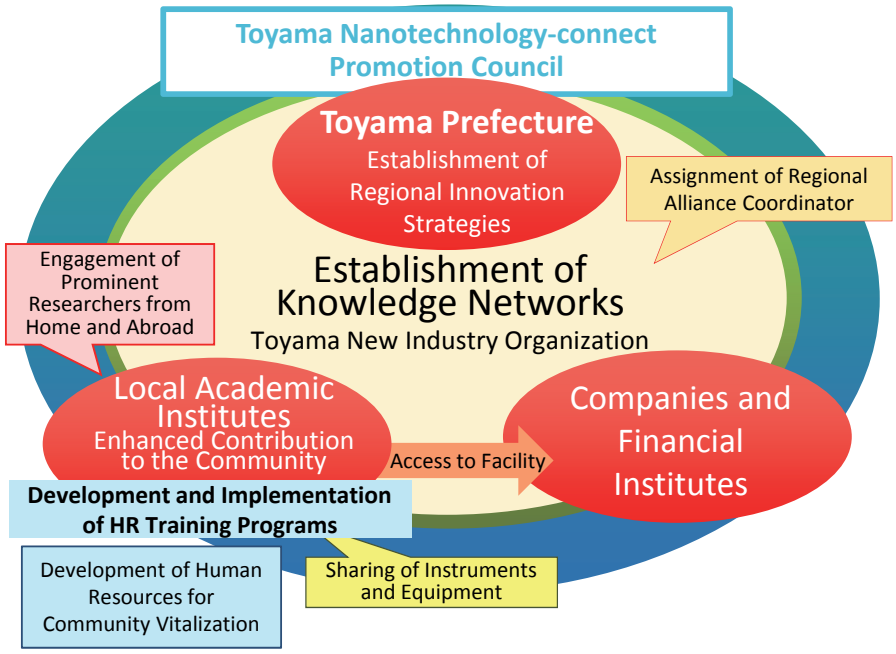
Regional Innovation Strategy Support Program
Japanese Ministry of Education Culture, Sports, Science and Technologies

Toyama Nanotechnology Manufacturing Cluster 1/2



【Project Structure】

➢ Toyama Nanotechnology-connect Promotion Council

Yasunori Yamazaki, President
(Vice-Governor of Toyama Prefecture, Director-General of Toyama New Industry Organization)
Members: 15 organizations from Industry, Academia, Government, and Finance

➢ Project Director

Motohiro Toriyama
(Director, Toyama Industrial Technology Center)

➢ Concentration of Researchers

Toyama University
Toyama Prefectural University
Toyama Monozukuri R&D Center
6 Invited Researchers

➢ Establishment of Knowledge Networks

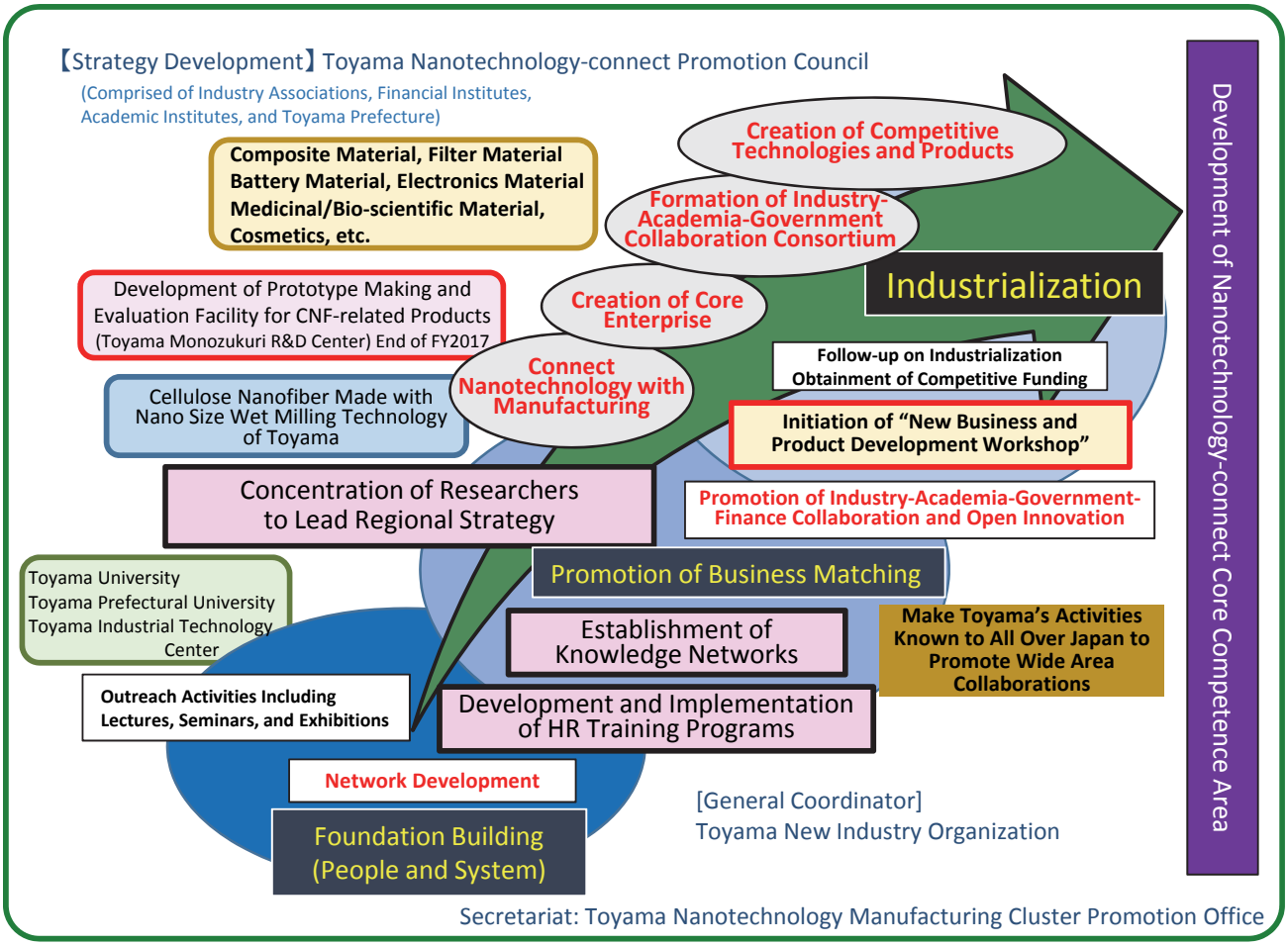
1 General Coordinator
R&D Coordinator (Concurrent with PD)
1 Industrialization Coordinator

➢ Development of Human Resource Training Programs

1 HR Development Coordinator

➢ Support for Sharing of Research Facilities

Technology Support Staff
Toyama Industrial Technology Center Researchers



Toyama New Industry Organization

Regional Innovation Strategy Support Program
Japanese Ministry of Education Culture, Sports, Science and Technologies

Toyama Nanotechnology Manufacturing Cluster 2/2

Connect "Nanotechnology" with "Manufacturing" through Industry-Academia-Government-Finance Collaboration

— Practical Application and Industrialization of Cellulose Nanofiber —

Cellulose Nanofiber
Developed by Nano Size Wet Milling Technology of Toyama
Plant Fiber Based New Material

- High strength & High elasticity
- Lightweight
- Transparent
- Low Thermal Expansion
- High Gas-barrier Property
- Distinctive Viscosity
- Large Specific Surface Area
- High Water Holding Property
- High Aspect Ratio

Revolutionary Nano Size Wet Milling Method using Material of Toyama

Core Technology
Nano Size Wet Milling Technology
(Eco-friendly and clean nano sizing technology)

Core Material
Cellulose Nanofiber
- Recyclable resource, reduces environmental burden
- Lightweight and high strength (Weighs 1/5 of iron, and is 5 times stronger than iron)
- Less thermal deformation (1/50 of glass)

Application to a wide variety of industries

Superior Manufacturing Technology of Toyama

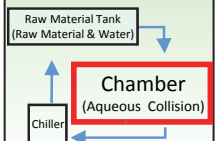
- Cluster of wide range of manufacturing industries including machines, metals, chemicals, pharmaceuticals, and electronics
- There are companies with world-class cutting edge technology

Toyama Manufacturing Industries' Meeting for Future Strategies

Toyama Nanotechnology Hub Creation Project

Toyama Monozukuri Research and Development Center

Development of advanced nano size particle and fiber refinement technology



Development of advanced processing technology

Machines & Metals

Development of dermally non-toxic material with longer retention of medicinal properties

Raw materials for skin care products including cosmetics and hair care products

Chemicals

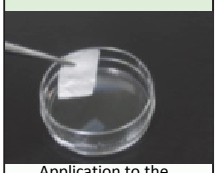
Development of fiber material featuring thinness, high strength and comfort for medical application

High performance medical materials including skin patches and tapes

Fibers

Toyama University Faculty of Engineering

Development of nanofiber which supports biocompatible material and is suitable for cultivation of cells for tissue engineering

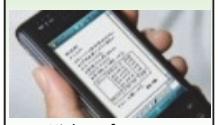


Application to the next generation medicines

Medicinal & Bio-Scientific Applications

Toyama Prefectural University Faculty of Engineering

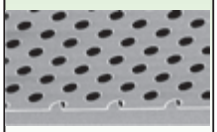
Development of resin with high strength and high thermal conductivity through hybridization of CNF and nanoparticle



High performance composite materials and others

Plastics

Development of gas-permeable mold material for nanoimprint and ultrafine fabrication technology



Nanoimprinting and others

Electrics & Electronics

Development of Prototype Making and Evaluation Facility for CNF-related Products

Formation of an innovative industrial cluster where the use of nanotechnology is the norm

Development of a sustainable system to create innovations through human resource development

Creation of New Value and Market
Creation of New Products and Businesses

Toyama New Industry Organization

Improvement of Atomization Technology for Production of Nanoparticles and Nanofibers

Toyama Industrial Technology Center
Satoshi Iwatsubo, Manager
Seigo Murayama, Researcher

Background and purpose of the project:

New materials with new functions by a structural change are required for functional improvement technology. In the manufacturing process, when products are molded from powder, the size of the powder greatly affects the performance of the final product. The aim of this theme is to establish the key technologies to produce nanoparticles for the next-generation manufacturing. We are developing the refinement technology of the nanoparticles and nanofibers of the materials used in electronic and cosmetic/pharmaceutical applications.

Project plans

In the current microfabrication technology, when the particle diameter is several tens of nanometers or less, the strong agglomeration of the particles occurs, making the manufacturing of the material for further refinement very difficult. In this project, we upgrade a wet jet milling technology.

(A) Monodispersion of fine particles
(B) Refinement of nanofiber

By developing these technologies, the biomass nanofibers with excellent dispensability were manufactured.

(Application field)
Electronic parts: high-performance batteries
Pharmaceuticals: highly effective products

Current Status

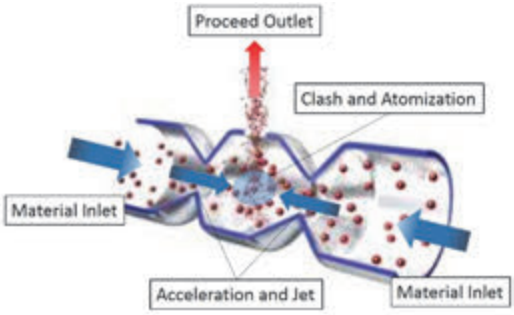
(A) Evaluation of aggregation/dispersion
(Electric static potential of nanoparticles by jet milling process)

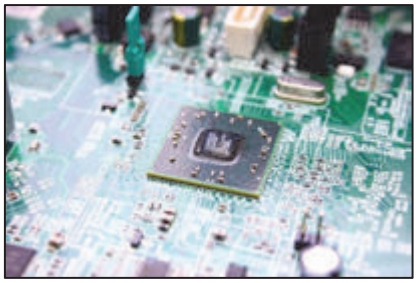
(B) Development of high-order dispersion technology for the nanoparticles by the following two methods
① Chemical method
② Physical method

(C) Evaluation methods of the nanoparticles and the nanofibers

Prospects:

Highly refined technology will lead to the innovative products



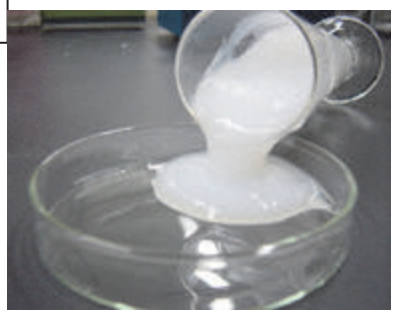


Biomass nanofiber for the skin care base material

Toyama Industrial Technology Center　Satoshi Iwatsubo, Manager
Kenji Kondoh, Researcher

Background and Purpose of the Project

It is desired to make an effective use of a cellulose and a chitin chitosan from inedible plants and crustaceans biomass. In fields of cosmetics, foods and medicines, the cellulose is widely used as an excipient for a shape preservation and a lipid absorbency base. The purpose of this study is to prepare the advanced skincare materials using the innovative biomass nanofibers.



2 wt.%　CNF suspension

Characteristics of the CNF

The cellulose nanofiber (CNF) "BiNFi-s" manufactured by Sugino Machine Co., Ltd. was used. The raw material is food additive cellulose. The results of safety test of the nanofibers are shown in a table.

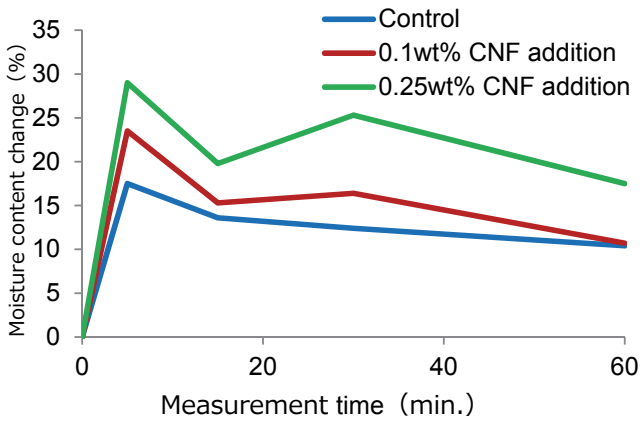
Safety testing (an alternative to animal testing)

Test	OECD TG	Results
Bacterial Reverse Mutation Test	471	negative
Primary skin irritation tests of three-dimensional models	439	negative
Eye mucous membrane irritation tests of three-dimensional models	492	negative
In Vitro 3T3 NRU Phototoxicity Test	432	Under consideration
human patch test		negative

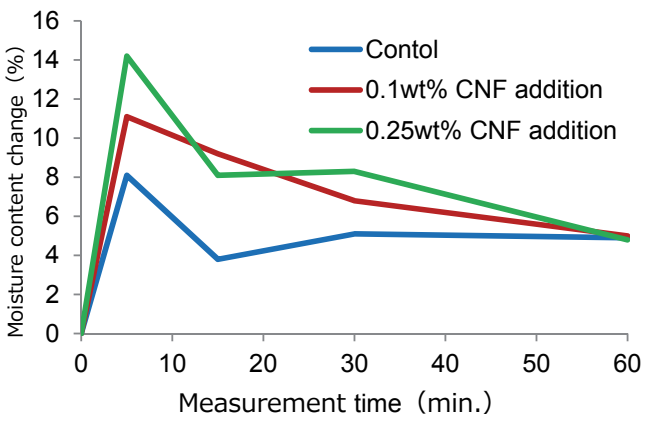
High safety of the nanofibers

The effect of water retention of the CNF in the case of addition to cosmetics

Liquid lotion



Base cream



The addition of the CNF to the cosmetics is effective in moisture retention of the stratum corneum. The water concentration of the skin increases.

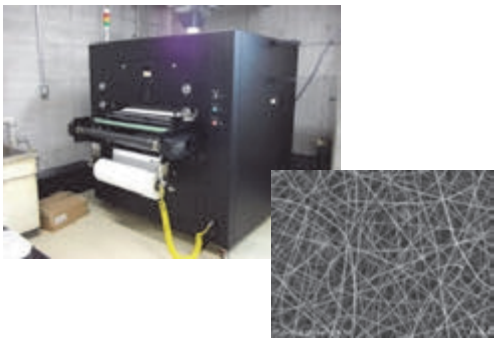
DEVELOPMENT OF HIGH PERFORMANCE PHARMACEUTICAL MATERIALS USING NANOFIBER

Toyama Industrial Technology Center, Human Life Technology Research Institute
Ryoji Kanamaru, Manager
Daisume Nanuse, Commissioned Researcher

Research Background

Nanofiber membrane sheets made with electrospinning are gaining attention as a material that has high filterability, moisture permeation and waterproofness. However, it has many problems with productivity and strength.

Therefore, in this research, we are working toward practical application of high performance medical nanomaterial using multi-nozzle type electrospinning machine. We are also studying new combination technology of knitting and nanofiber sheet, and CNF(cellulose nanofiber) and nanofiber sheet.



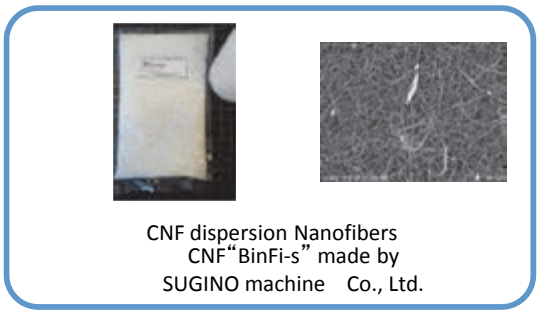
Multi-nozzle electrospinning device and Nanofiber sheet.

Research Progress

(a) Composite technology of nanofiber sheet and CNF.

⇒Coating technology on nanofiber surface.
- Reduce friction of nanofiber sheet.
- We attach reinforcement effects on the surface of the nanofiber.

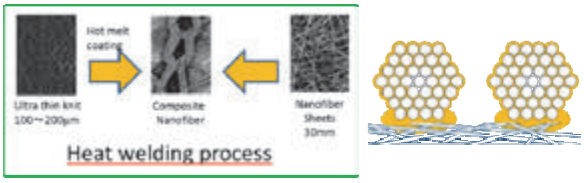
⇒Nanofibers kneaded and dispersed with CNF.
- Succeeded in a small sheeting.
- We plan to develop long sheets.



CNF dispersion Nanofibers
CNF"BinFi-s" made by
SUGINO machine Co., Ltd.

(b) Laminate technology with nanofibers sheets and knitting.

⇒Using "Heat welding process."
- We added strength and flexibility to nanofibers.



Composite technology of nanofiber and knitting.

Prospects

Nanofiber by electrospinning method has a high function. However, it has the disadvantage of weak strength too. To overcome this drawback, we are planning to produce ultrathin and highly functional nanofiber sheets by combining cellulose nanofibers or knitting.

The composite nanofiber sheets can be used as medical supplies directly applied to the skin. Such as bandages and surgical tape.

Conventional medical tape (left pic),
Skin attachment example of nanofiber sheet (right pic).

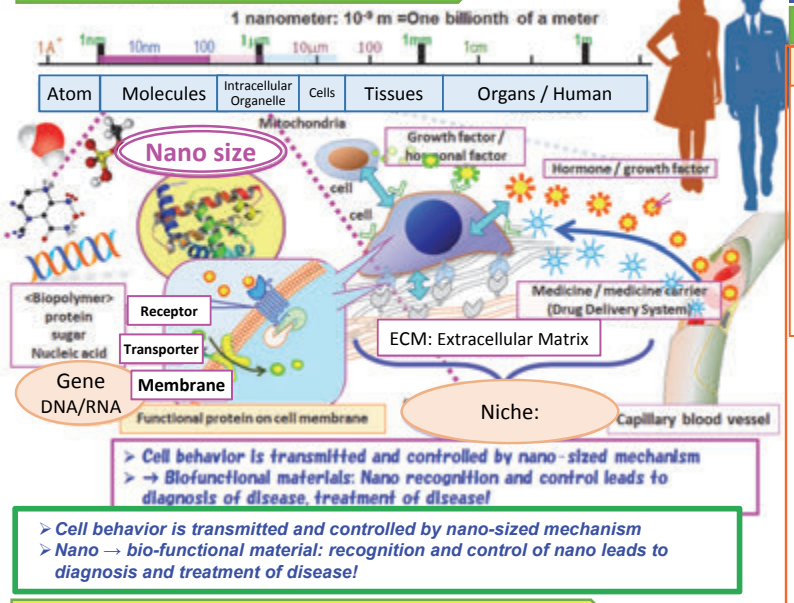
TOYAMA nanotechnology manufacturing cluster

Ministry of Education, Culture, Sports, Science and Technology
Local Innovation Strategy Support Program
Toyama Nanotechnology Connect Next Generation Manufacturing Creation Program

Development of biocompatible material supported nanofibers

Makoto Nakamura, Tanveer Ahmad Mir (Invited researcher):
Graduate School of Science and Engineering (Engineering), University of Toyama

■ Nano size in Medical and Life Sciences



➢ Cell behavior is transmitted and controlled by nano-sized mechanism
➢ → Biofunctional materials: Nano recognition and control leads to diagnosis of disease, treatment of disease!

➢ Cell behavior is transmitted and controlled by nano-sized mechanism
➢ Nano → bio-functional material: recognition and control of nano leads to diagnosis and treatment of disease!

■ Nanofiber manufacturing technology in Toyama

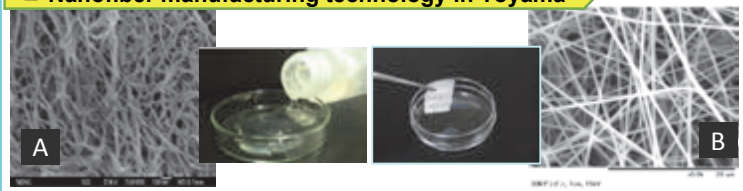


Figure A: High Pressure Water Jet: Milling to Nanofiber with Ultra High Pressure Water Flow: (BiNFi-s: Sugino machine)
Figure B: Electrospinning: Fabrication of nanofibers by spinning in high pressure electric field (Gelatin · Nanofiber 2011: Toyama University · Toyama Prefecture Industrial Technology Center · Tayca Pharmaceutical)

■ "Can we make organs with machines?" (Toyama University, Nakamura Lab.)

3D bio printing technology

① 3DBioprinter (Units 1 to 3)

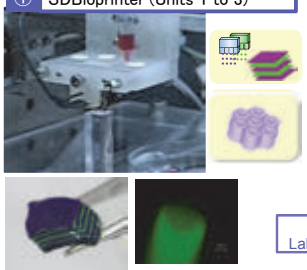
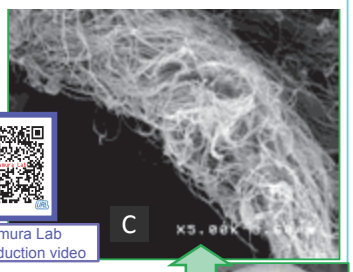


Figure C: Nanofibers of extracellular matrix (Porcine kidney nanofiber: University of Toyama)



Nakamura Lab
Lab introduction video

① 3D Bioprinter (Ver. 1 to 3)
② Inkjet type fine particle making apparatus
③ Composite gel fiber making apparatus
④ Electro spinning device

② Micr oparticles
③ Composite gel fiber

University of Toyama

■ The aim of our research

Theme: Development of nanofibers carrying biocompatible materials

Application of nanofibers and nanoparticles is expected to be applied to the fields of medical, biotechnology and medicine.
In this research, we aim to do "development of nanofibers carrying biocompatible materials" by combining Toyama's unique nanotechnology technology with the technology and know-how of Toyama University. We add and fuse biological functions and further combine it with three dimensional modeling technology, various printing technologies and micro nano processing technologies, and develop useful culture substrates and tools for cell culture and regenerative medicine, as well as next - generation pharmaceuticals etc Aim for application to manufacturing

1. Add cell biological function

- Natural polymer
- Synthetic polymer
- Biological material
- Hybrid material

➢ Recognition and control of cell function

2. Higher dimensional nanocomposites

➢ Research and development of materials, equipment, equipment, etc. that contribute to basic medical research, pharmaceutical research and development and clinical medicine field

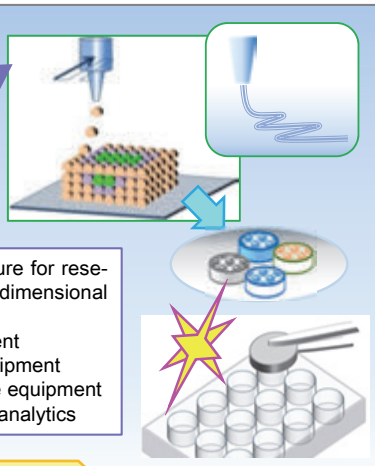
Manufacturing Processing → product

- ➢ Advanced design
- ➢ Advanced MONODUKURI
- ➢ New technology.
- ➢ Development of new products
- ➢ Contribution to promotion of regional industry

Application example

Three dimensional cell biology era "Development of equipment for 3D cell culture"

Biomaterial
Nano material
Bio-nano material
Hybrid material



- Equipment for cell culture for research in the age of 3-dimensional cell biology
- 3D cell culture equipment
- Special cell culture equipment
- Tailor-made cell culture equipment
- New biosensor and bioanalytics

Call for ambitious collaborators
Contribute to the development of Medicine

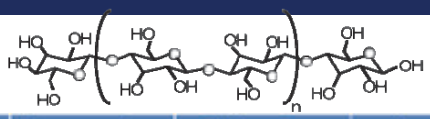
- ■ 3D cell biology
- ■ Organ regeneration
- ■ 3D regenerative medicine

- 3D micro environment of cells and tissues
- 3D cell culture
- Biosensor
- Drug screening
- · Toxicity test
- Animal experiment alternative method
- Regenerative Medicine
- Embryology

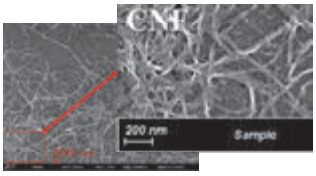
Development of high strength and high thermal conductivity resin by hybridization of cellulose nanofiber and nanoparticle

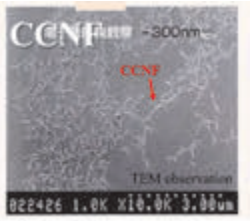
Department of Mechanical Systems Engineering, Faculty of engineering, Toyama Prefectural University
Professor Kazuaki Sanada
Visiting Professor Kazuya Nagata

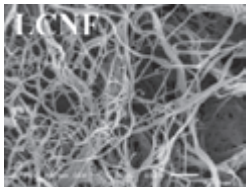
Cellulous Nanofibers



Type	Shape of fibers	Water content	Compounding & Molding Processability	Filler price	collar
CNF	Diameter 4 to 100 nm Length greater than a few μm	60 to 99wt%	Very difficult	Expensive Greater than ¥10,000/kg at Dry powder	white
CCNF	Diameter 20 to 100 nm Length 200 to 800 nm	50 to 3wt%	easy	low cost	white
LCNF	Diameter 50 to 100 nm Length greater than a few μm	60 to 90wt%	Difficult	low cost	Dark brown





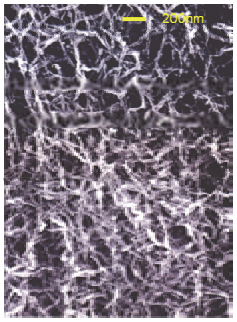


Our Cellulous Nanofibers CCNFs concept

hydrophobic agent coating CCNF
: hydrophobic agent

Compounding By twin screw extruder

Schematic view of CCNF network structure in a polymer



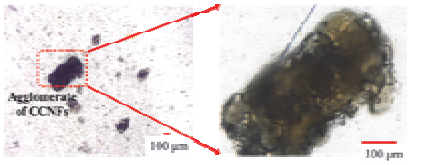
Hydrophobic agent coated CCNF powder water content of less than 3wt%

CCNF composites

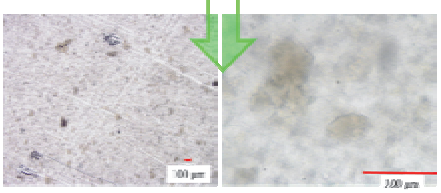
- ✓ High strength and rigidity
- ✓ Light weight
- ✓ Low coefficient of linear expansion
- ✓ Transparency
- ✓ Low friction coefficient
- ✓ Gas barrier
- ✓ Biomass material etc.

- ☐ Automobile parts
- ☐ Electronic parts
- ☐ Packing materials etc.

Dispersibility of HA coated CCNF in polymer

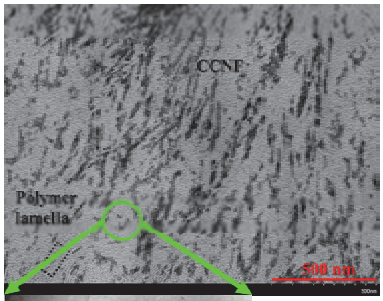


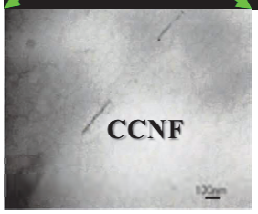
HDPE/5wt% CCNF noncoated hydrophobic agent(HA)



HDPE/5wt% CCNF coated HA

There are almost no agglomerates lager than 10 μm in HDPE





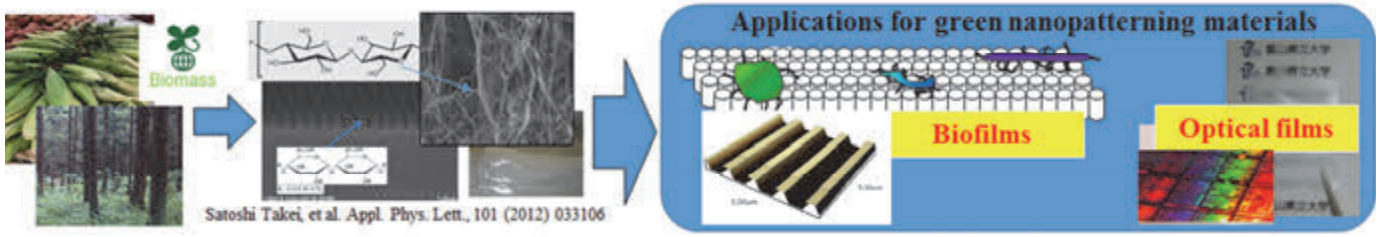
Nano Analysis : TEM observation

Development of gas permeable template in nanoimprint process and green lithography derived from biomass

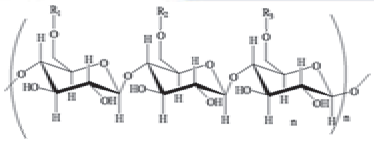
Satoshi Takei. Makoto Hanabata
Department of Pharmaceutical Engineering,
Faculty of engineering, Toyama Prefectural University

TOYAMA PRE UNIV

Goal



Nanoimprint



Green lithography