Application of hydrophobically modified CNF/resin masterbatch "STARCEL®" to foamed materials

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TAPPI

Outline

- Foam products
- Short history of *CNF* Research
- "Kyoto Process" and "***STARCEL®***"
- Chemical foaming process
- Mechanical properties of *CNF* in chemical foaming
- Commercial application
- Conclusion

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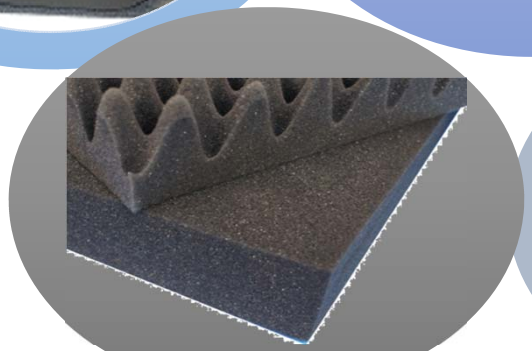
Foam Products

Automotive

Building Products

Food Container



Cushion

Sport Gear

<Features>

Light Weight

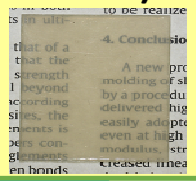
Thermal Insulation

Sound Absorption/ Shielding

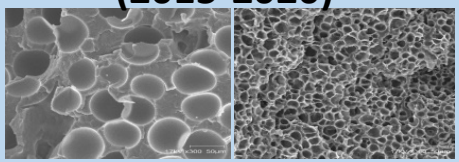
Cushioning/ Resilience

Short History of our *CNF* Research

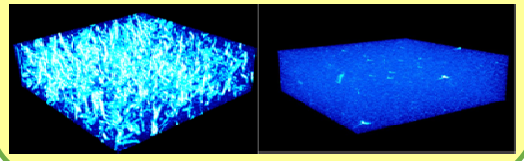
NEDO Project
"CNF Reinforced Plastics and Rubber"
(2007-2010)



JST・ALCA
(2015-2020)



NEDO Project
'Chemical modification of CNF for Automotive"
(2010-2013)



NEDO Project
"Novel production process for Ligno CNF/resin
(2013-2020)

R&D Phase

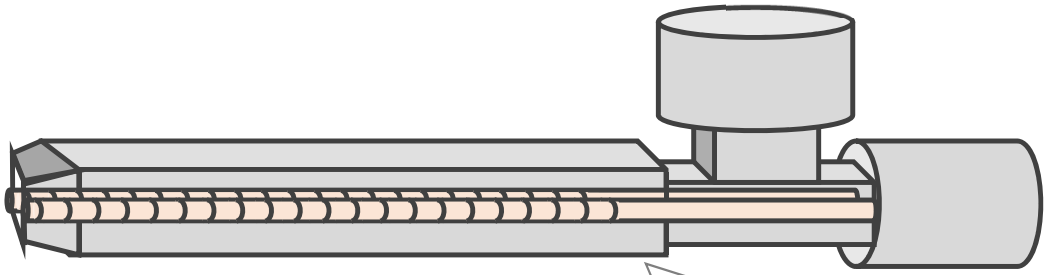
Innovation center establishment assistance program(2013-2014)

Nano Cellulose Vehicle Project(2016-2020)

Kyoto Process

Resin
(PE、PP)

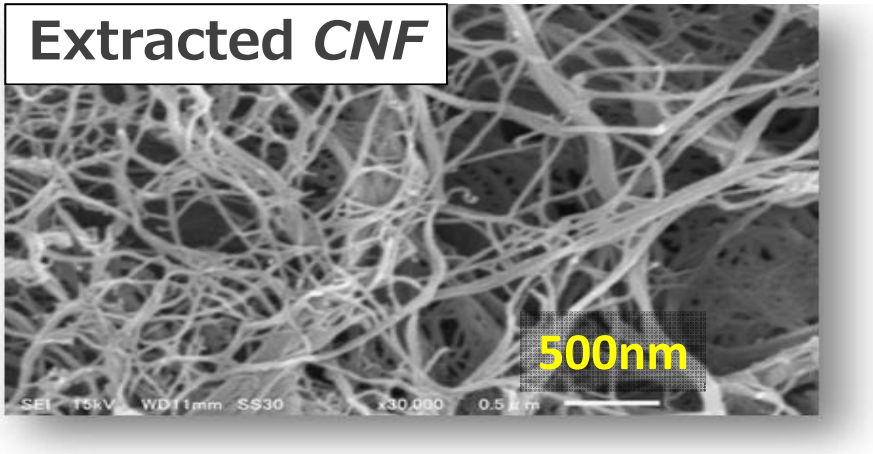
Chemically
Modified Pulp



Twin-screw extruder

CNF MB

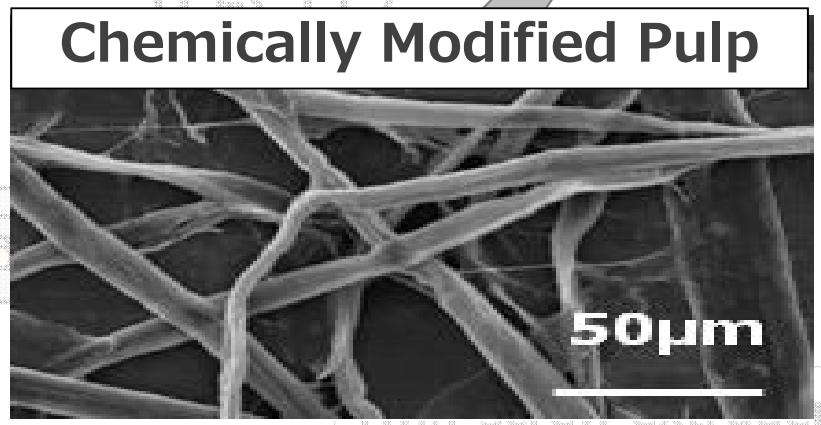
Kyoto Process



Resin

(PE, PP)

Chemically Modified Pulp



CNF MB

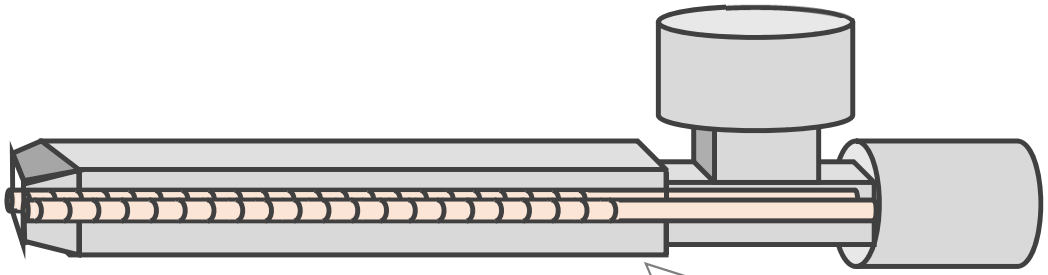
Kyoto Process

- **Chemically modified pulp**
  ⇒easy to fibrillate in molten resin

- **Fibrillation/dispersion in extruder**
  ⇒no need to fibrillate in water
  remove excess amount of water

Resin (PE、PP)

Chemically Modified Pulp



Twin-screw extruder

***CNF* MB**

Manufacturing Process of *CNF*/ Resin Masterbatch

Pulp

Surface Modification

Chemically Modified Pulp

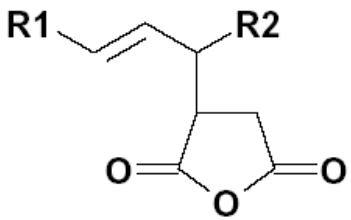
Resin

Twin-screw Extruder

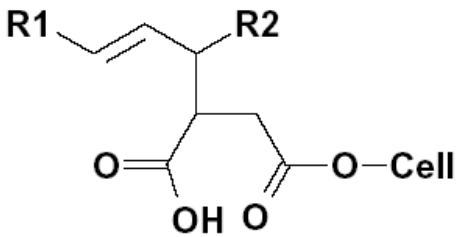
Fibrillation Kneading

CNF MB
STARCEL ®

water | acetone

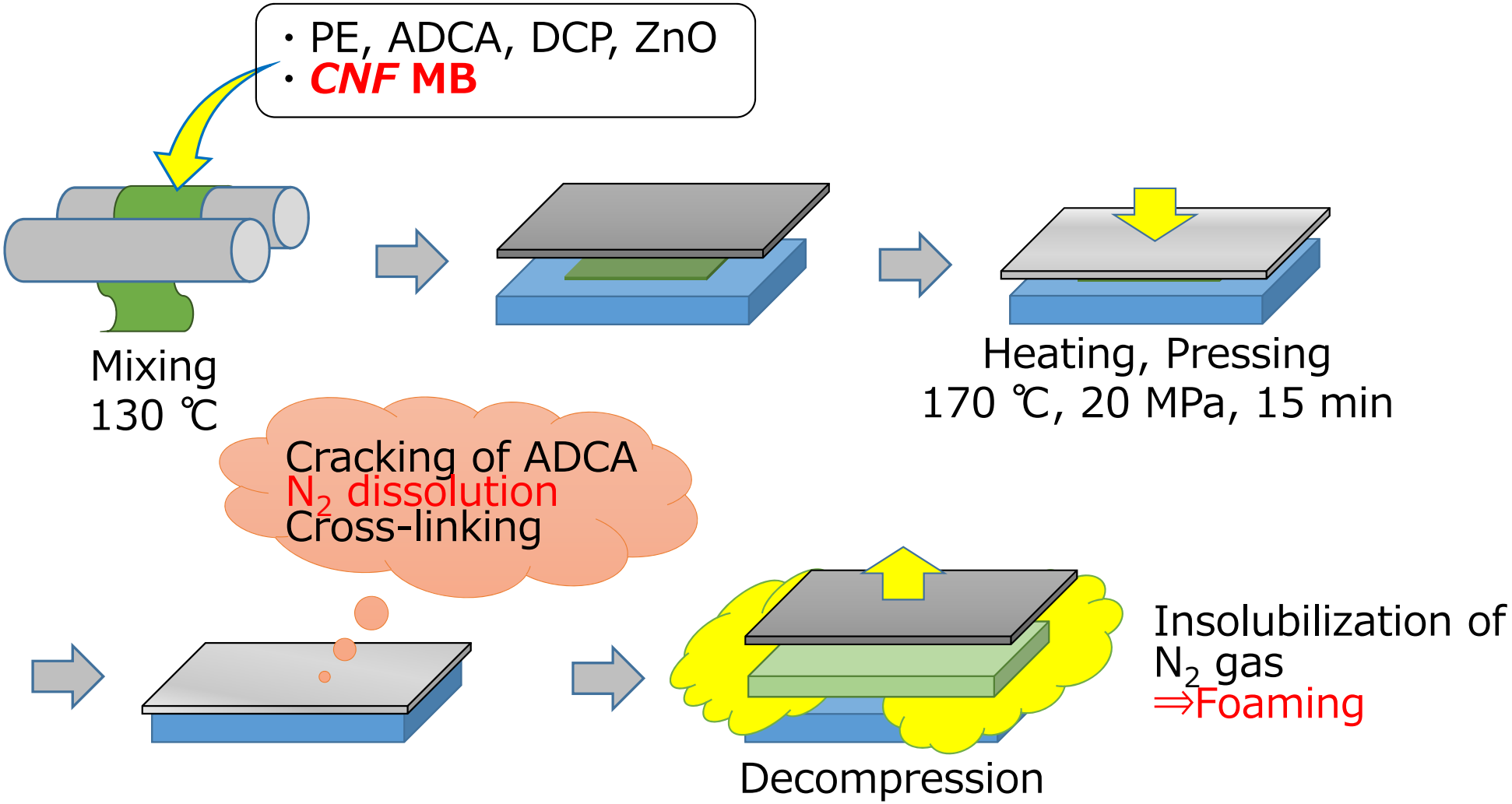


+ Cell—OH →



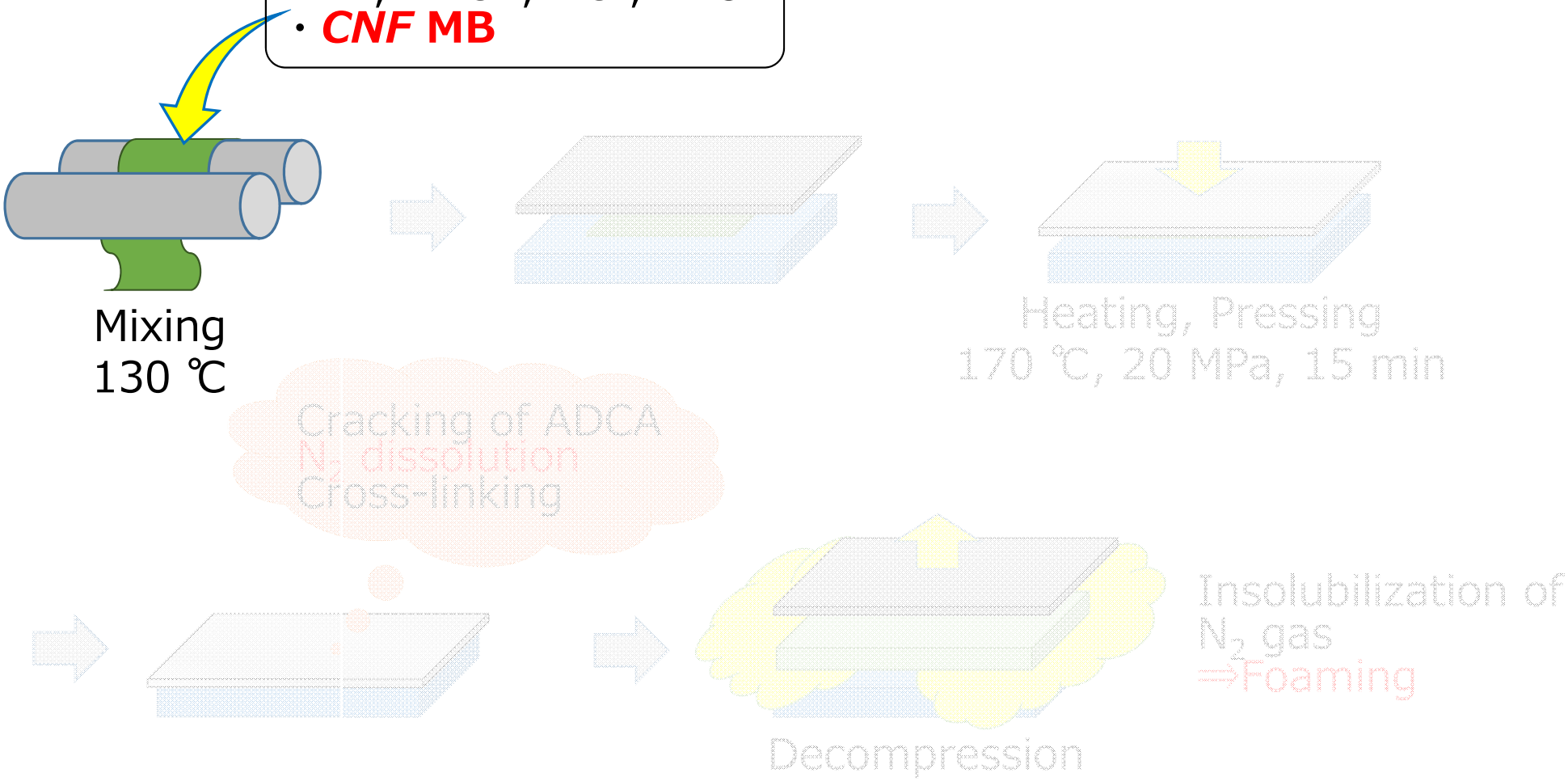
Alkenyl Succinic Anhydride
（A S A）

Chemical Foaming Process



Chemical Foaming Process

- PE, ADCA, DCP, ZnO
- ***CNF* MB**



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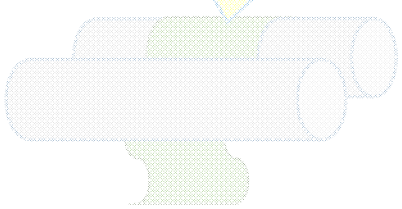
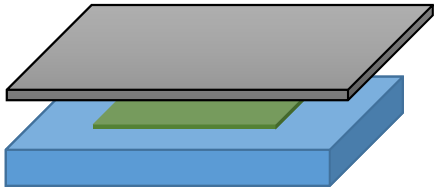
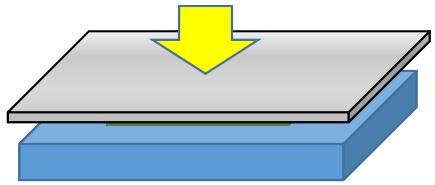


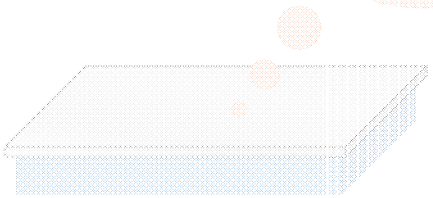
Mixing
130 ℃

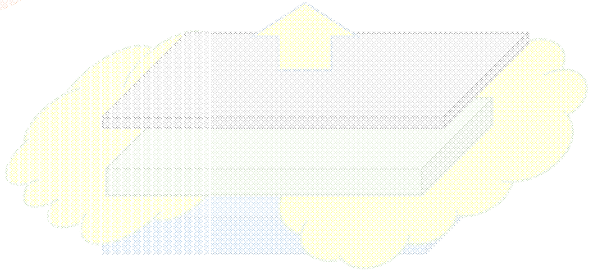




Heating, Pressing
170 ℃, 20 MPa, 15 min

Cracking of ADCA
N_2 dissolution
Cross-linking

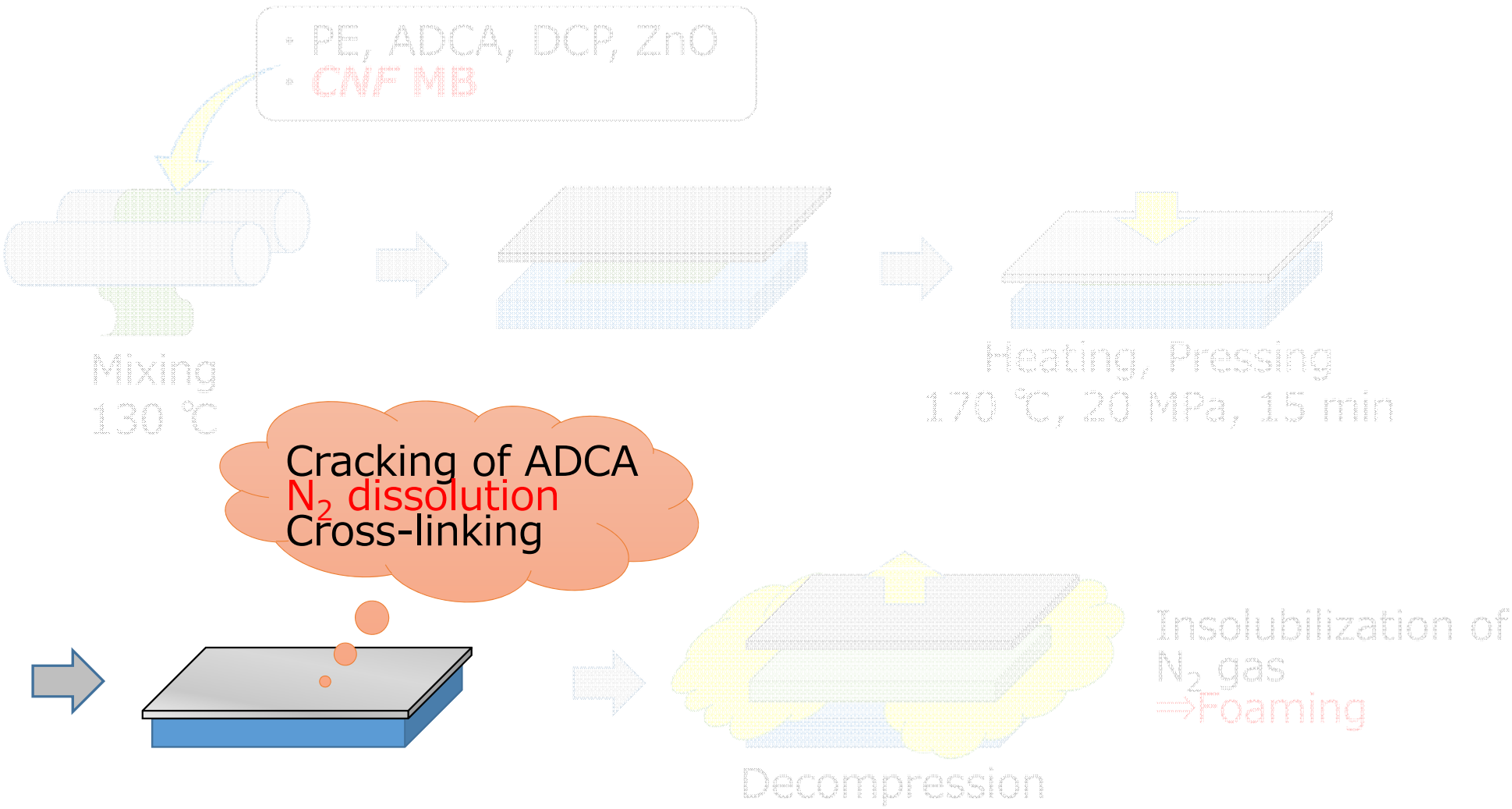




Decompression

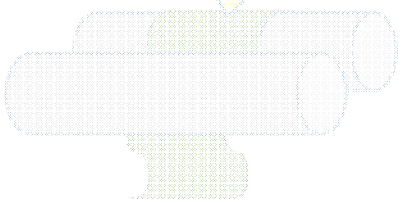
Insolubilization of
N_2 gas
⇒Foaming

Chemical Foaming Process



Chemical Foaming Process

- PE, ADCA, DCP, ZnO
- CNF MB



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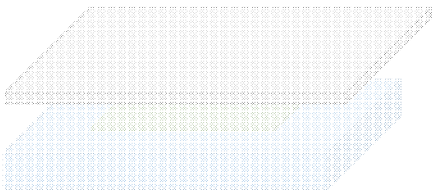

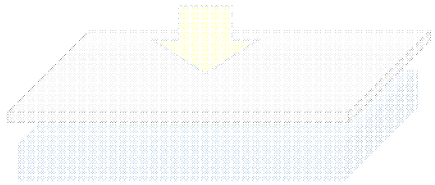

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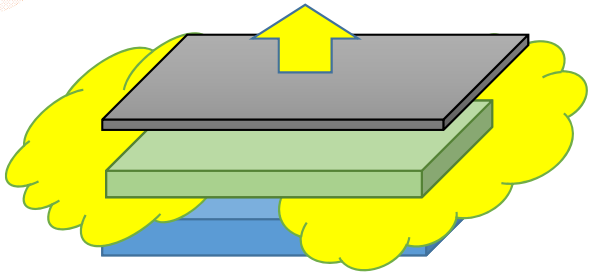
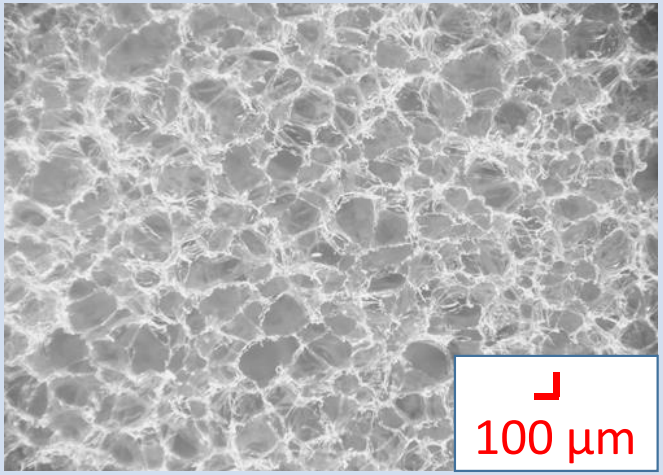
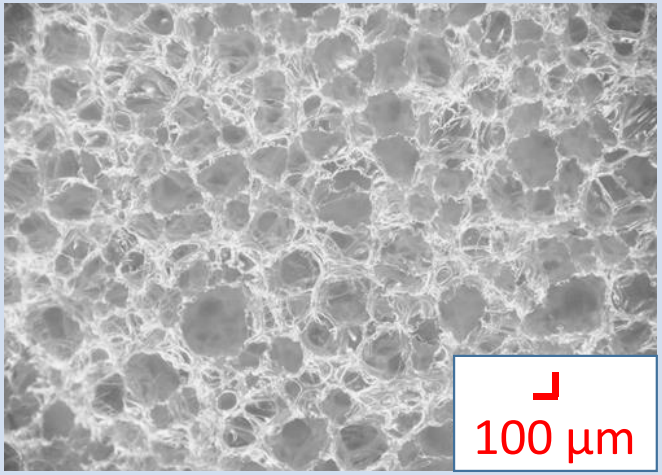
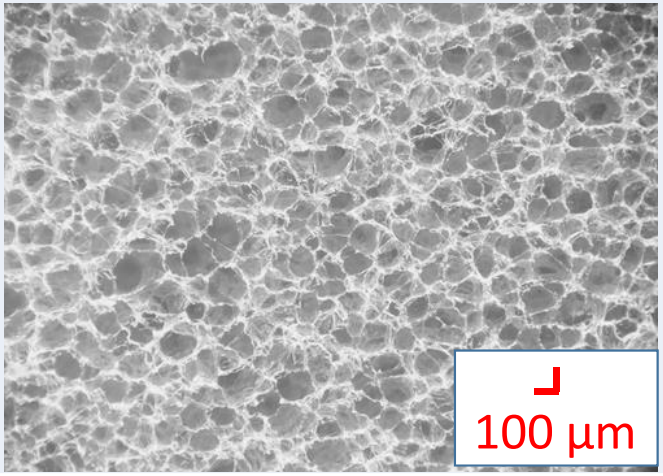
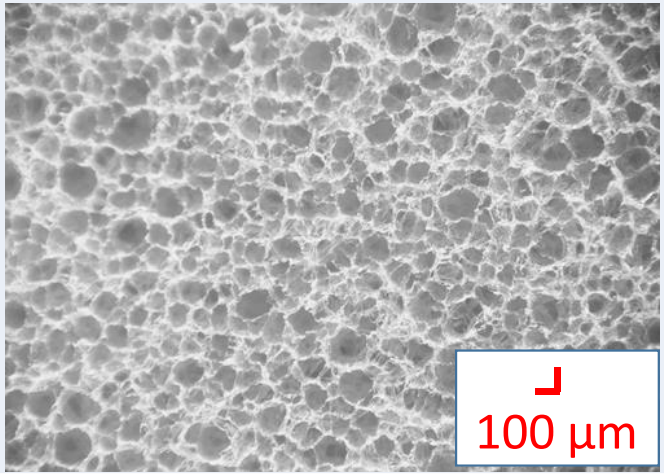


Decompression

Insolubilization of N_2 gas
⇒Foaming

Morphology of foam

	0.05 g/cm³	0.1 g/cm³
PE foam		
PE + *CNF* foam		

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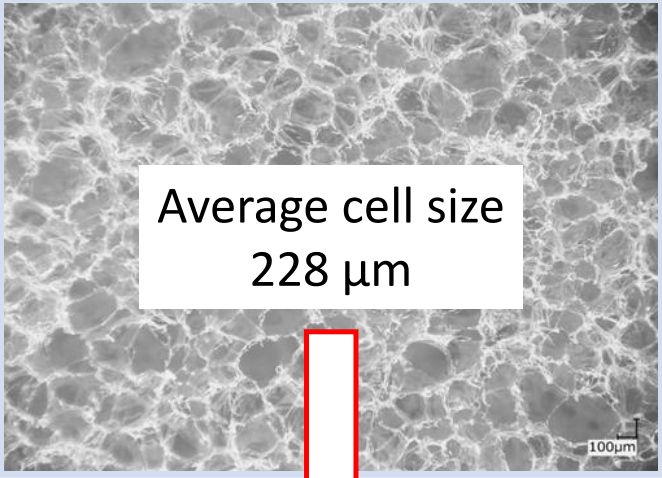
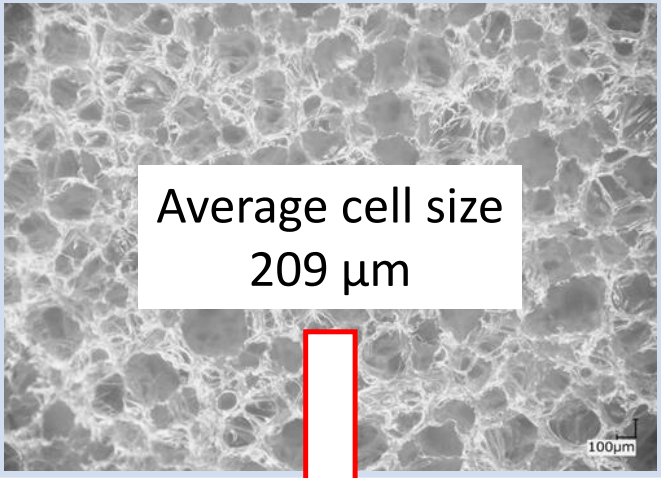
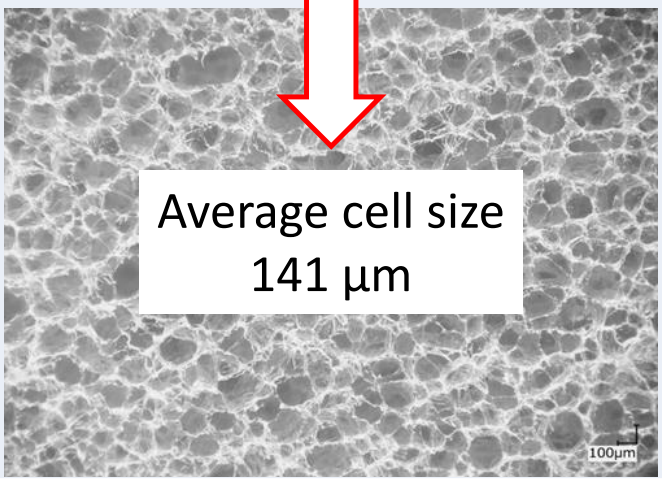
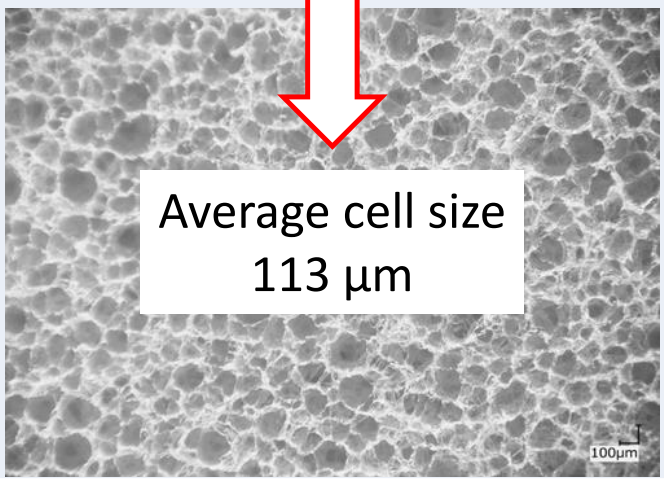
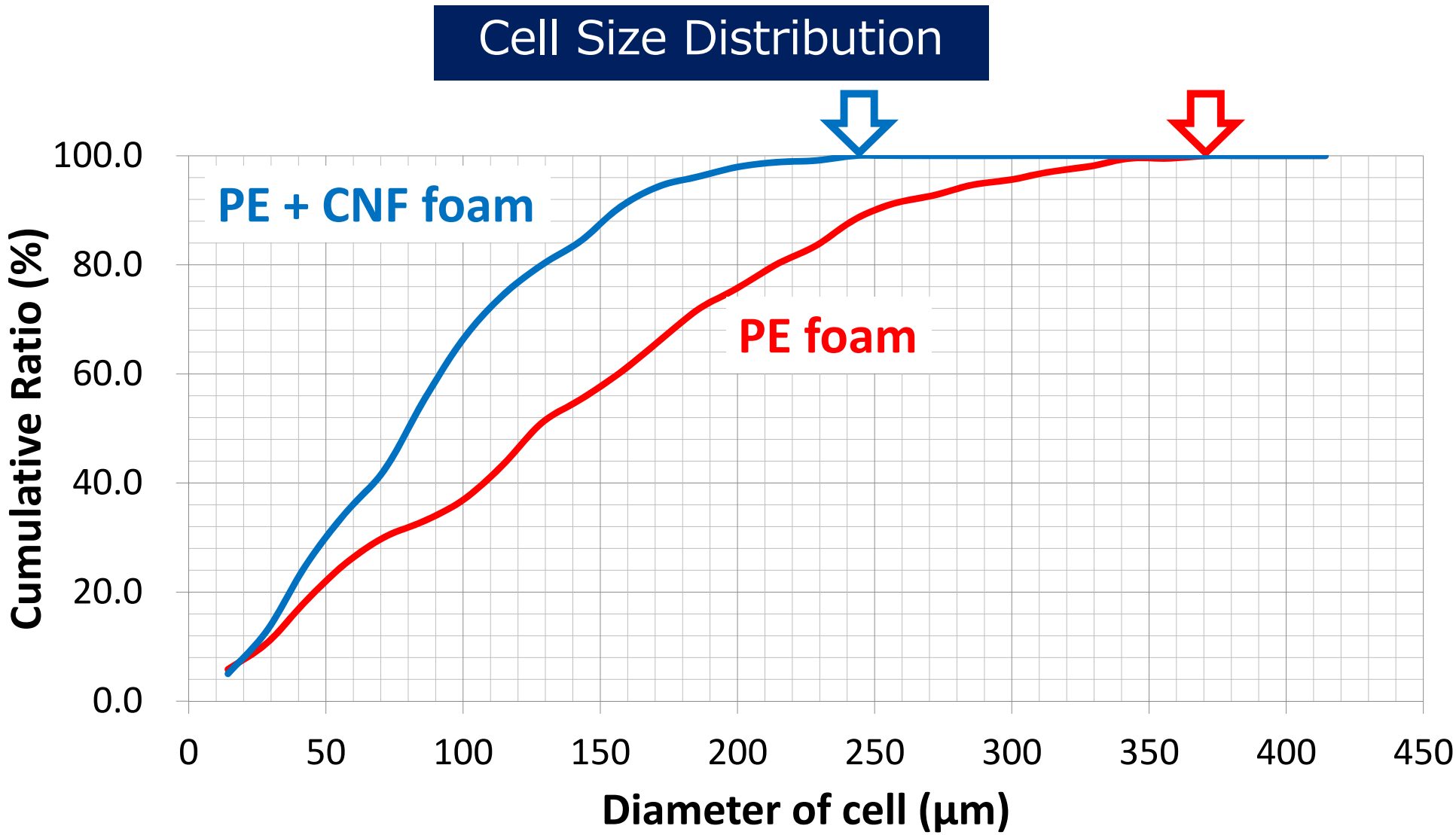
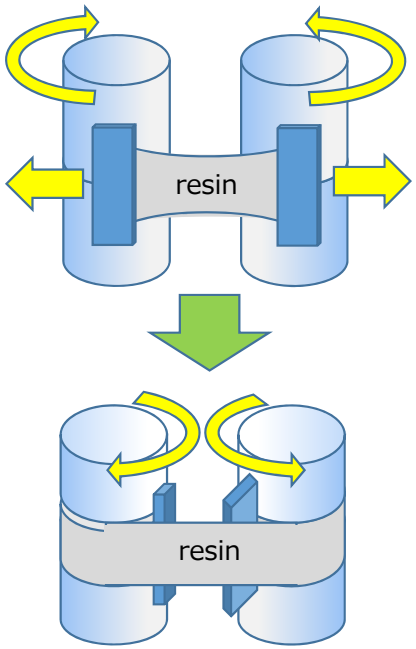
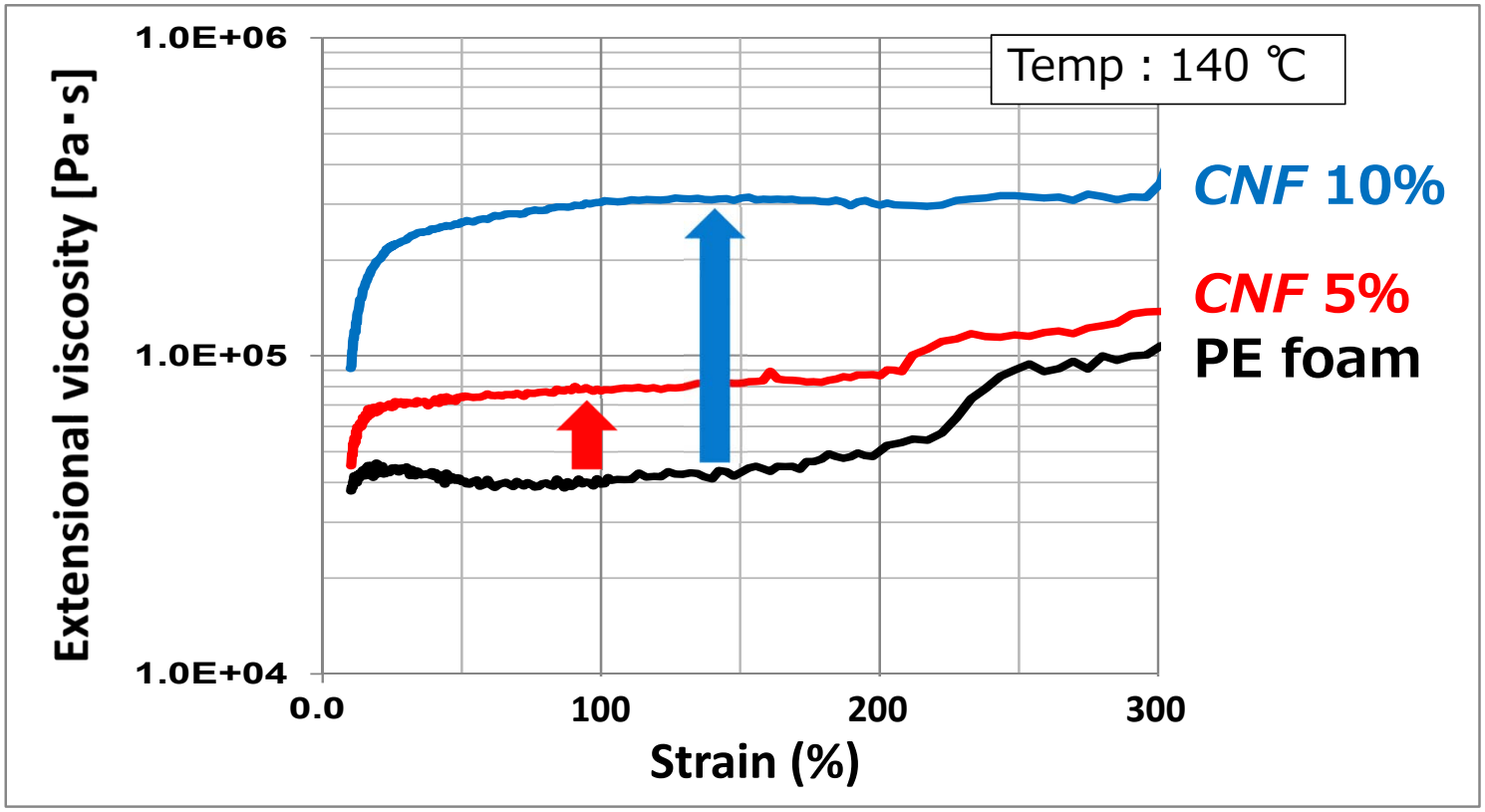
PE foam		
PE + *CNF* foam		


Cell Size Distribution
PE + CNF foam
PE foam
Cumulative Ratio (%)
100.0
80.0
60.0
40.0
20.0
0.0
0
50
100
150
200
250
300
350
400
450
Diameter of cell (μm)

Extensional Viscosity

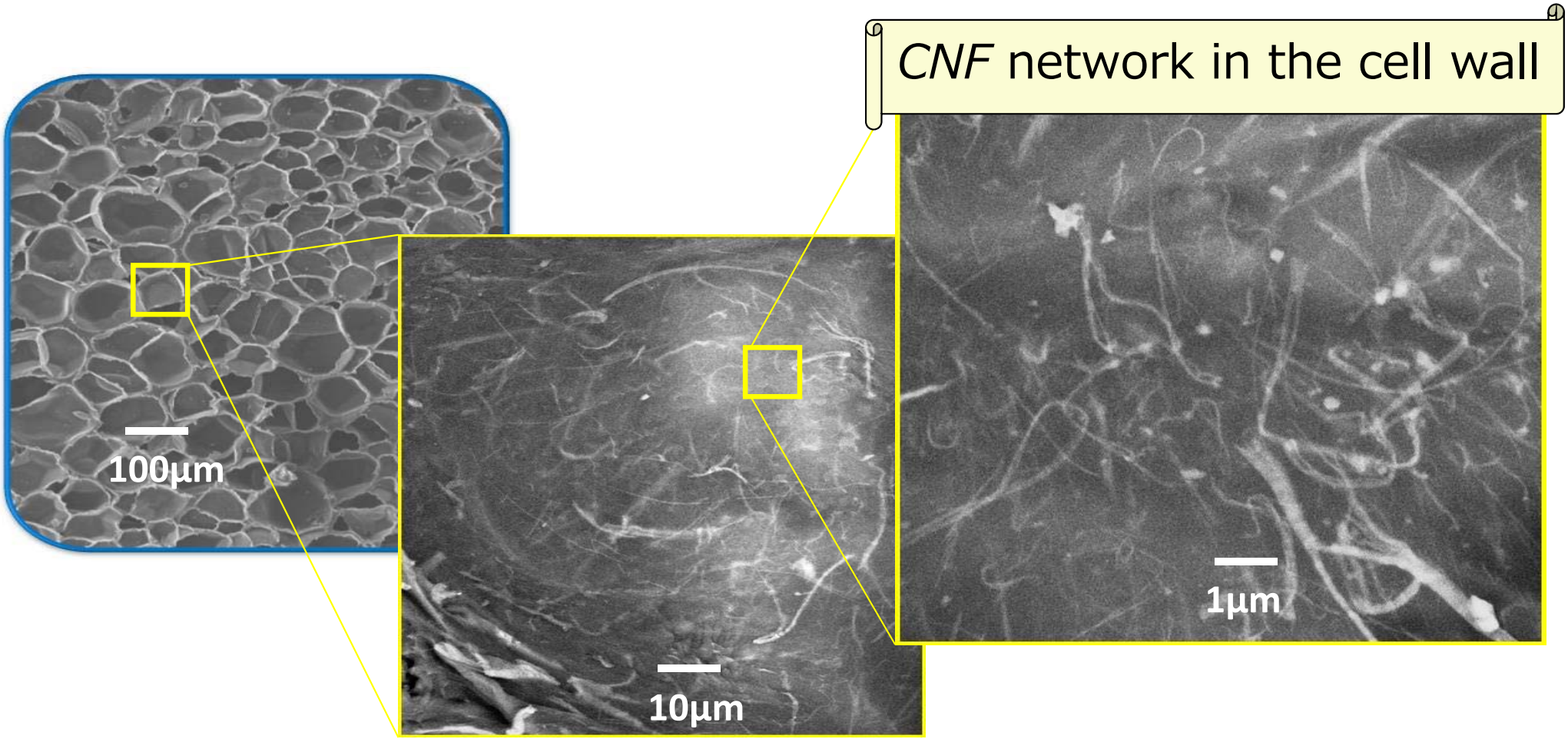




CNF→High Extensional Viscosity

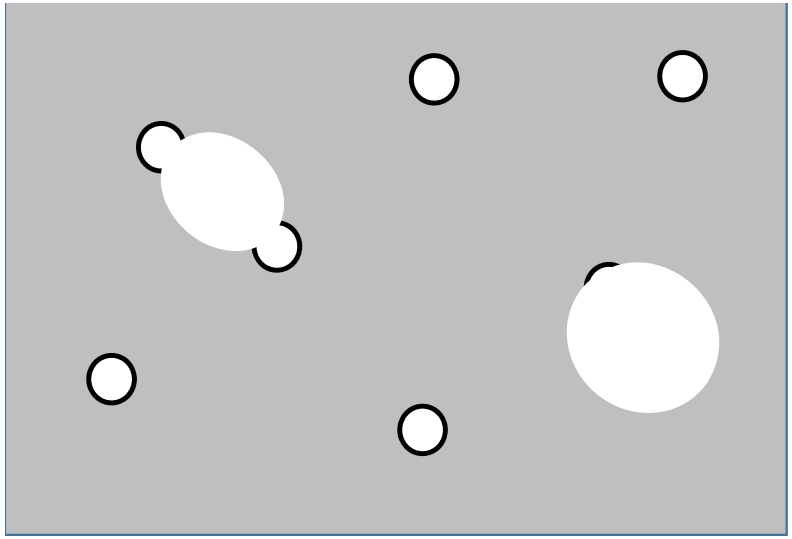
Suppression of expanding cell size
Preventing cell wall breakage
Narrow cell size distribution

SEM Image ～ CNF Network in the Cell Wall ～

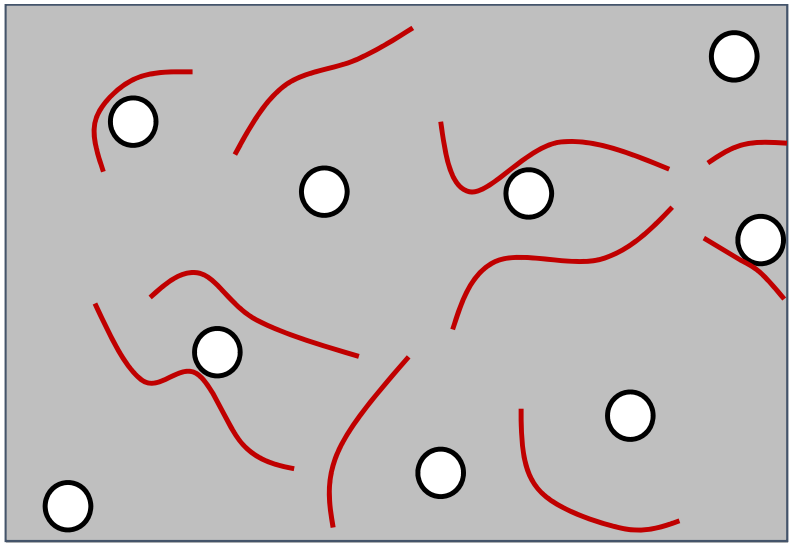


Effect of CNF on the morphology of foam

PE foam

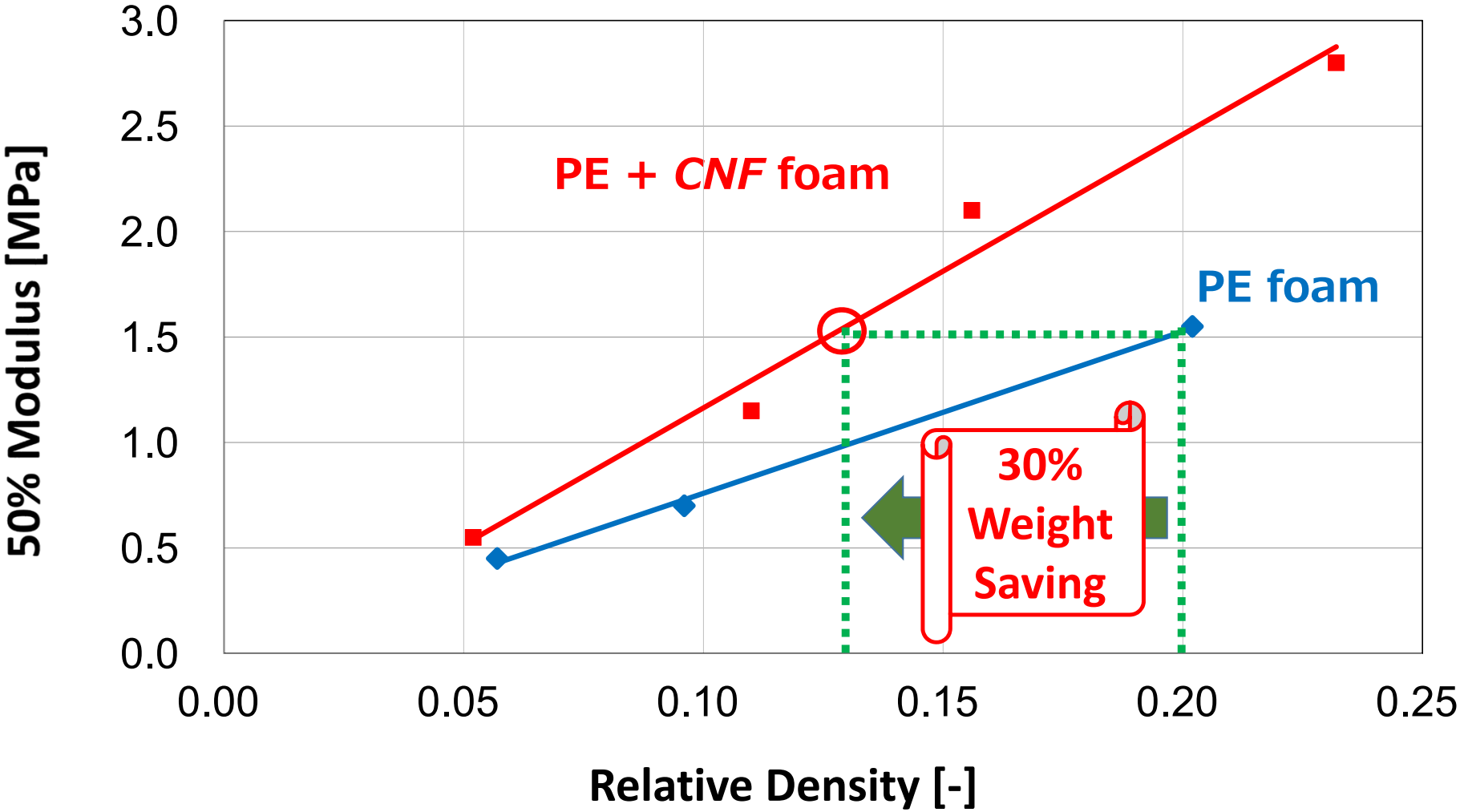


PE + *CNF* foam

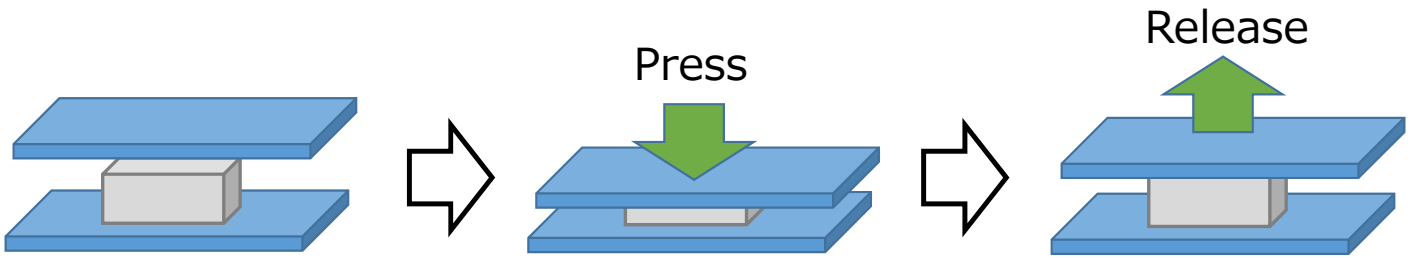


	PE foam	PE + *CNF* foam
Bubble nucleation	Spontaneous	Resin/ CNF interface
Cell density	Low	High
Cell size distribution	Wide(Wall breakage, void formation)	Narrow

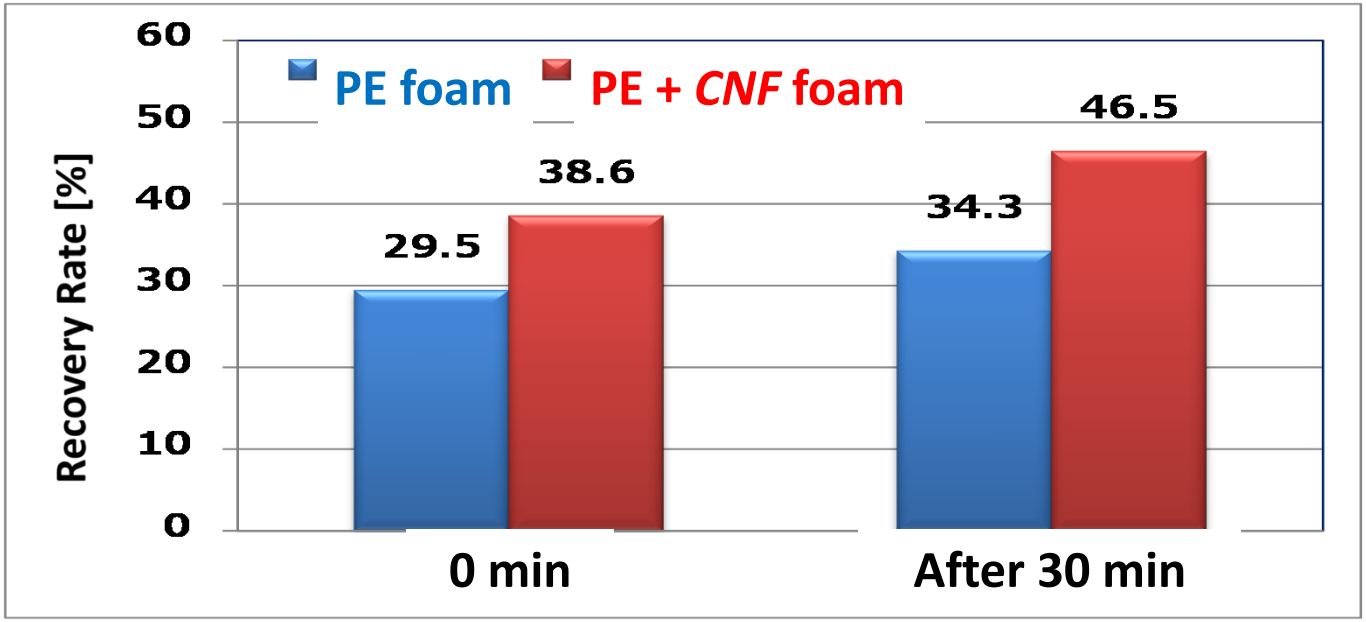
Tensile Property



Cushioning Property



<Press Condition>
- Press load : 0.6 MPa
- Time : 24 hour
- Temp : 25 ℃



Improvement in Recovery Rate ⇒ High Elasticity, Low Settling

Commercial Application

STARCEL® was used in the midsole(FlyteFoam Lyte) of running shoes GEL-KAYANO25, DYNAFLYTE3

55% Weight Saving, 20% Strength Increase, 7% Improvement of Durability

Conclusion

・*CNF* was applied in Chemical Foaming.

・Addition of *CNF* contributes high extensional viscosity.
acceleration of bubble nucleation.

⇨
- Suppression of expanding cell size
- Preventing cell wall breakage, coarse void formation
- Narrow cell size distribution
- Reinforcement of cell wall
- High elasticity, low settling
- Weight saving

・***STARCEL®*** was used in the midsole(FlyteFoam Lyte) of ASICS's running shoes GEL-KAYANO25, DYNAFLYTE3

Acknowledgements

Prof. Hiroyuki Yano
Prof. Fumiaki Nakatsubo
Prof. Masahiro Ohshima

Kazuo Kitagawa
Takeshi Semba
Akihiro Ito

METI
Ministry of Economy, Trade and Industry

MEXT
MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

MAFF
Ministry of Agriculture, Forestry and Fisheries

NEDO

asics

Thank you for your kind attention

PRESENTED BY:
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Technology Division
SEIKO PMC CORPORATION