Research and development of marine biodegradable plastics with degradation initiation switch function

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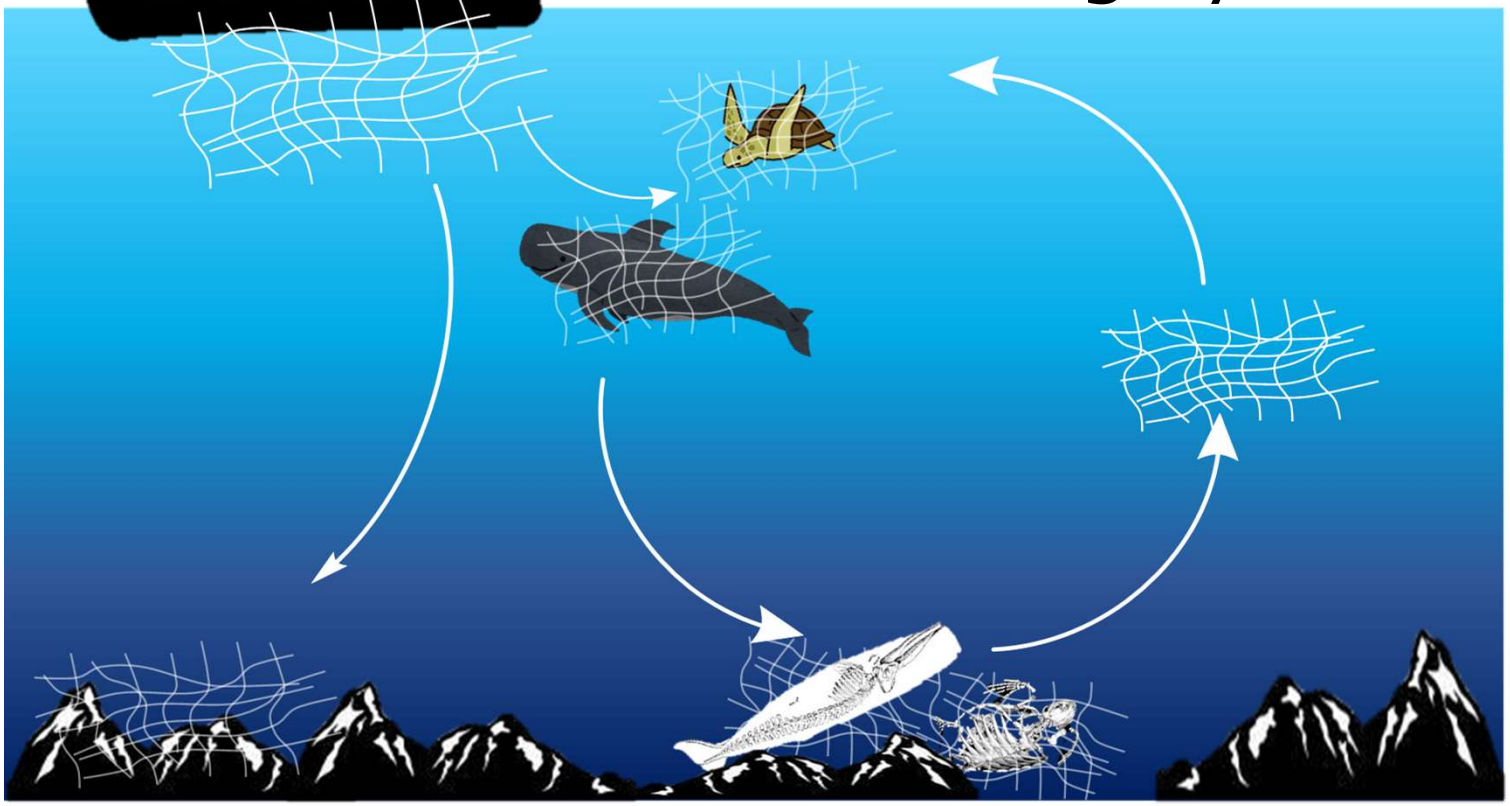
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Necessity of Biodegradable Fibers and Microbeads

Ghost fishing cycle



Sea turtle caught in fishing nets (Japan)

- About 50% of marine polluted plastics are fishing nets and fishing lines

Foresight Future of the Sea : A report from the Government Chief Scientific Adviser

- Need to develop fibers that decompose in the ocean
  →**Biodegradable plastics** has attracted significant attention

Plastic fibers generated from washing (Diameter = about 10 microns, 1/5 of a hair) (Invisible damage)

140,000 fibers released from one 6kg wash
(Napper & Thompson, 2016)

Non-biodegradable Microbeads

another microplastic issue

Daily facial cleanser, toothpaste, etc.

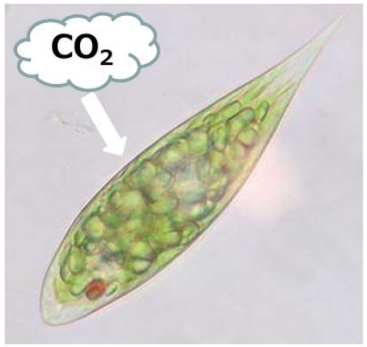
Final target (for fiscal 2029)

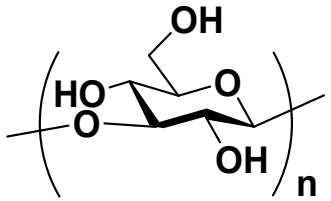
1. New polysaccharide ester derivatives and enzyme-encapsulated biodegradable plastics that have a biodegradation performance of about 90% in 6 months in seawater at 30 ˚C after activating of pH-switching or wear-switching function will be developed. In addition, we will establish a mass synthesis method, process them into fibers and injection-molded products.

2. New lignin-based biodegradable plastics that have a biodegradation performance of about 90% in 6 months in seawater at 30 ˚C will be developed. In addition, we will establish a mass synthesis method, process them into fibers and injection-molded products.

3. New polysaccharide ester derivatives and enzyme-encapsulated biodegradable plastics that have a biodegradation performance of about 10% in 6 months in seawater at 4 ˚C after activating of pH-switching or wear-switching function will be developed. In addition, we will establish a mass synthesis method, process them into fibers and injection-molded products.

Marine biodegradable plastics produced from polysaccharides





paramylon

Extraction
Thermo-processing

- estrerification
- new processing procedure

Injection molding

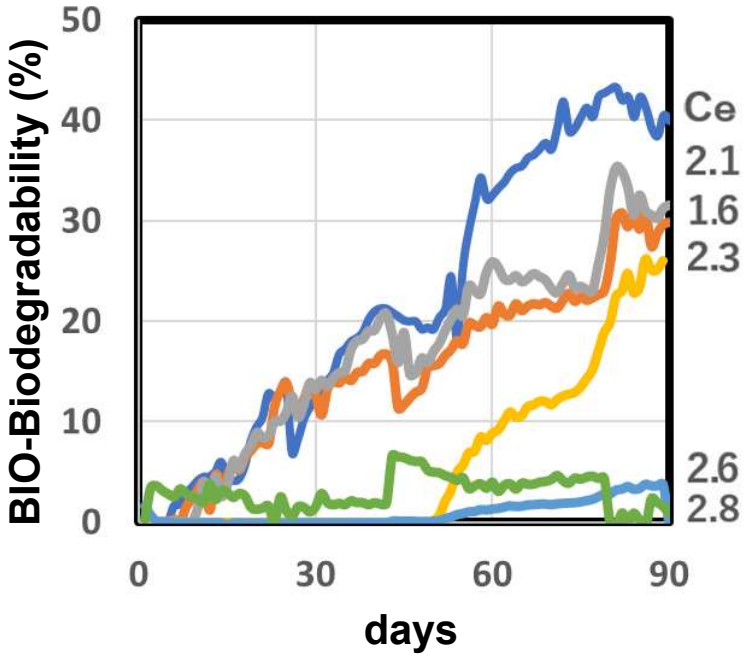
- Resistant to acids and alkalis
- Better impact strength > PP

Melt-spun fibers

- processable without additives
- high-strength

BOD Biodegradation test

- Using Seawater from Tokyo Bay
- Successful development of new high-performance materials with controlled marine degradability from polysaccharides

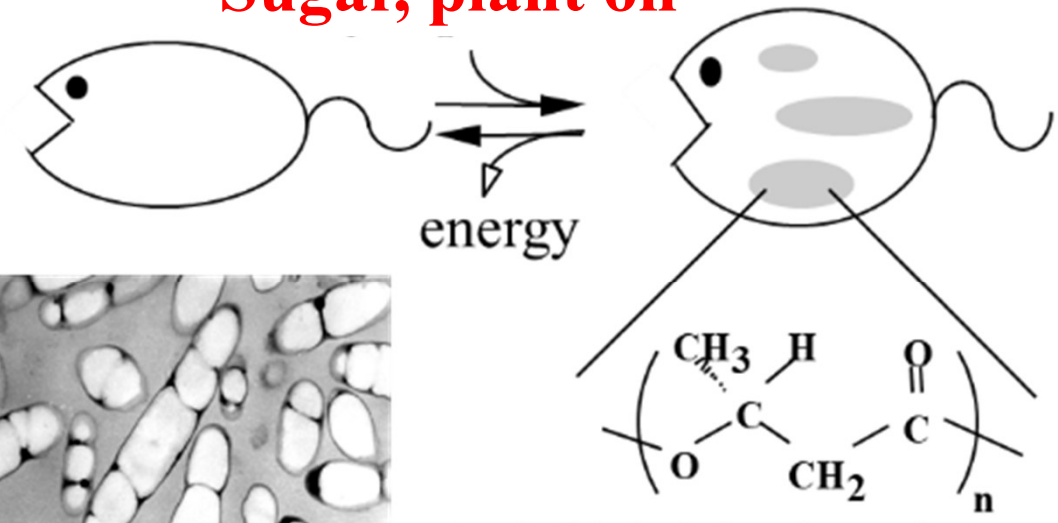


Excellent biodegradability

Non-biodegradability

Polyhydroxyalkanoate (PHA)

Sugar, plant oil

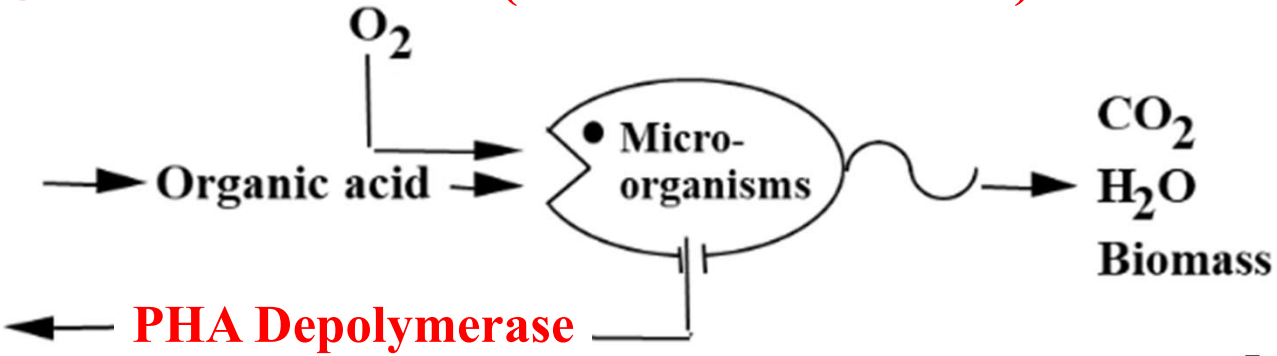


Poly[(*R*)-3-hydroxybutyrate]

Tm (˚C)	174
Tg (˚C)	4
Tensile strength (MPa)	15
Elongation to break (%)	5
Young's modulus (GPa)	0.5

Primary degradation (Enzymatic degradation)

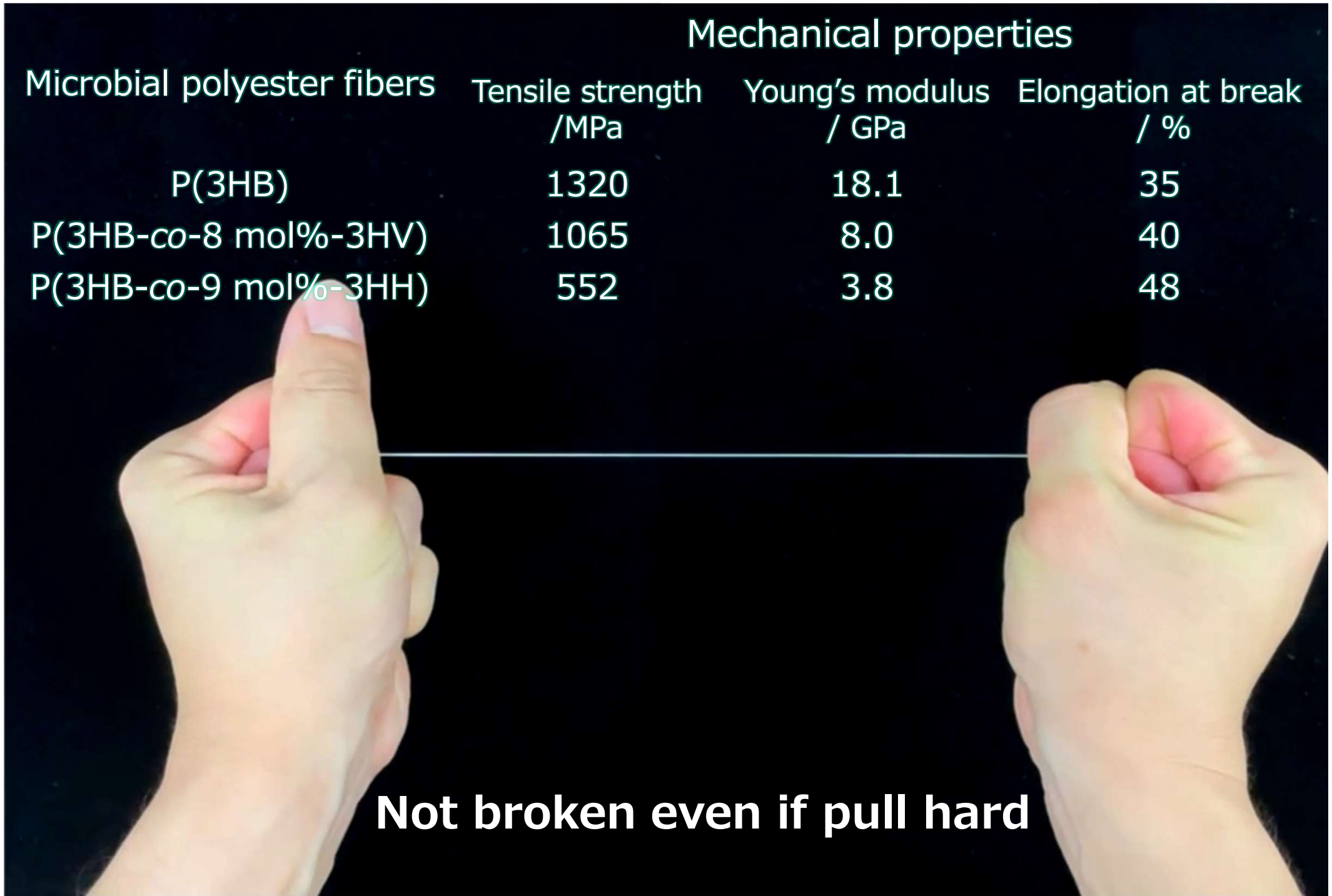
Ultimate degradation (Microbial metabolism)



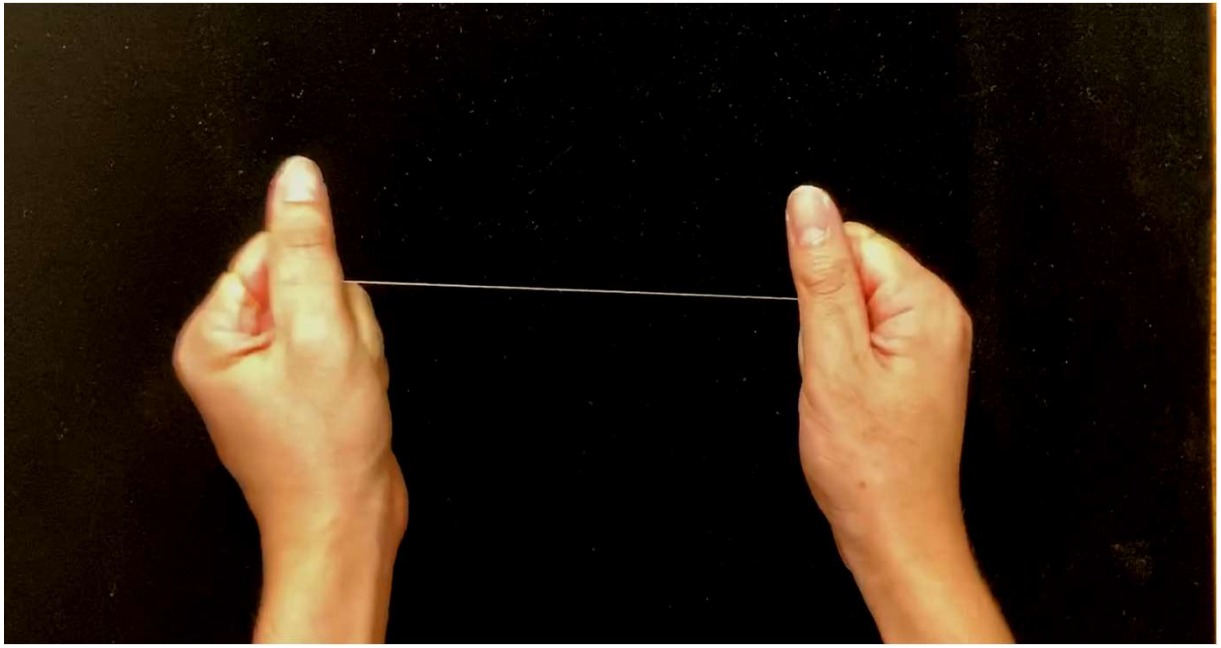
Polyhydroxyalkanoate (PHA)

PHA strong fibers

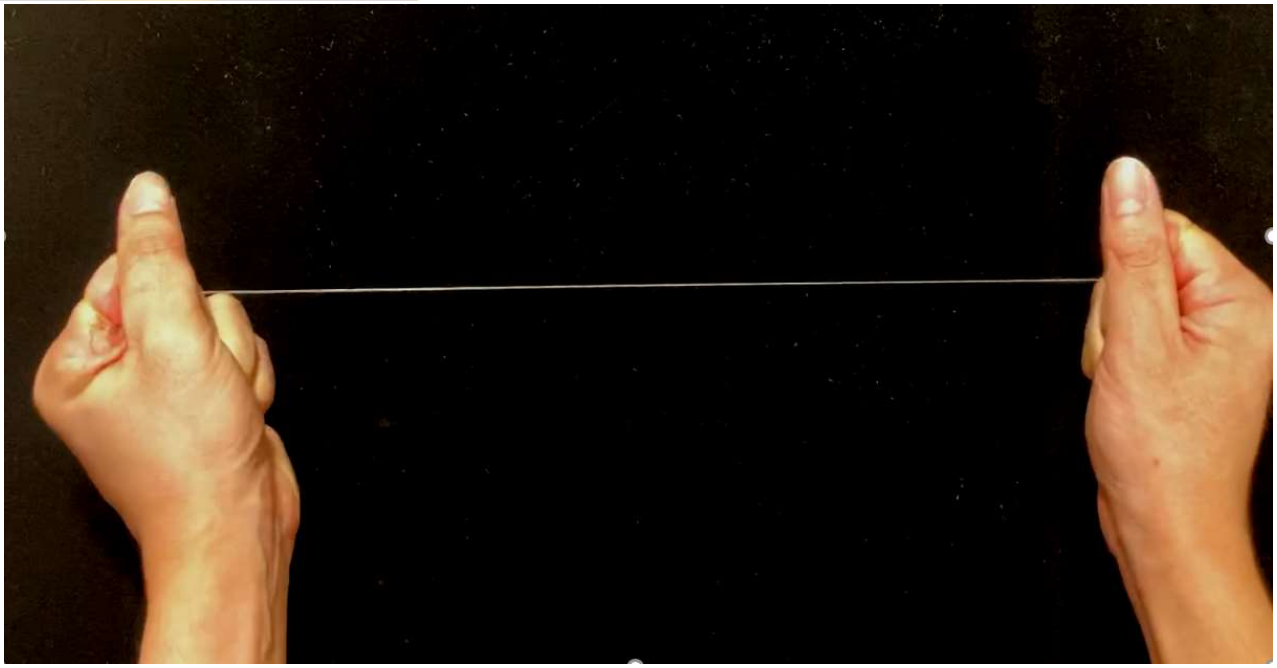
Microbial polyester fibers	Mechanical properties		
	Tensile strength /MPa	Young's modulus / GPa	Elongation at break / %
P(3HB)	1320	18.1	35
P(3HB-*co*-8 mol%-3HV)	1065	8.0	40
P(3HB-*co*-9 mol%-3HH)	552	3.8	48



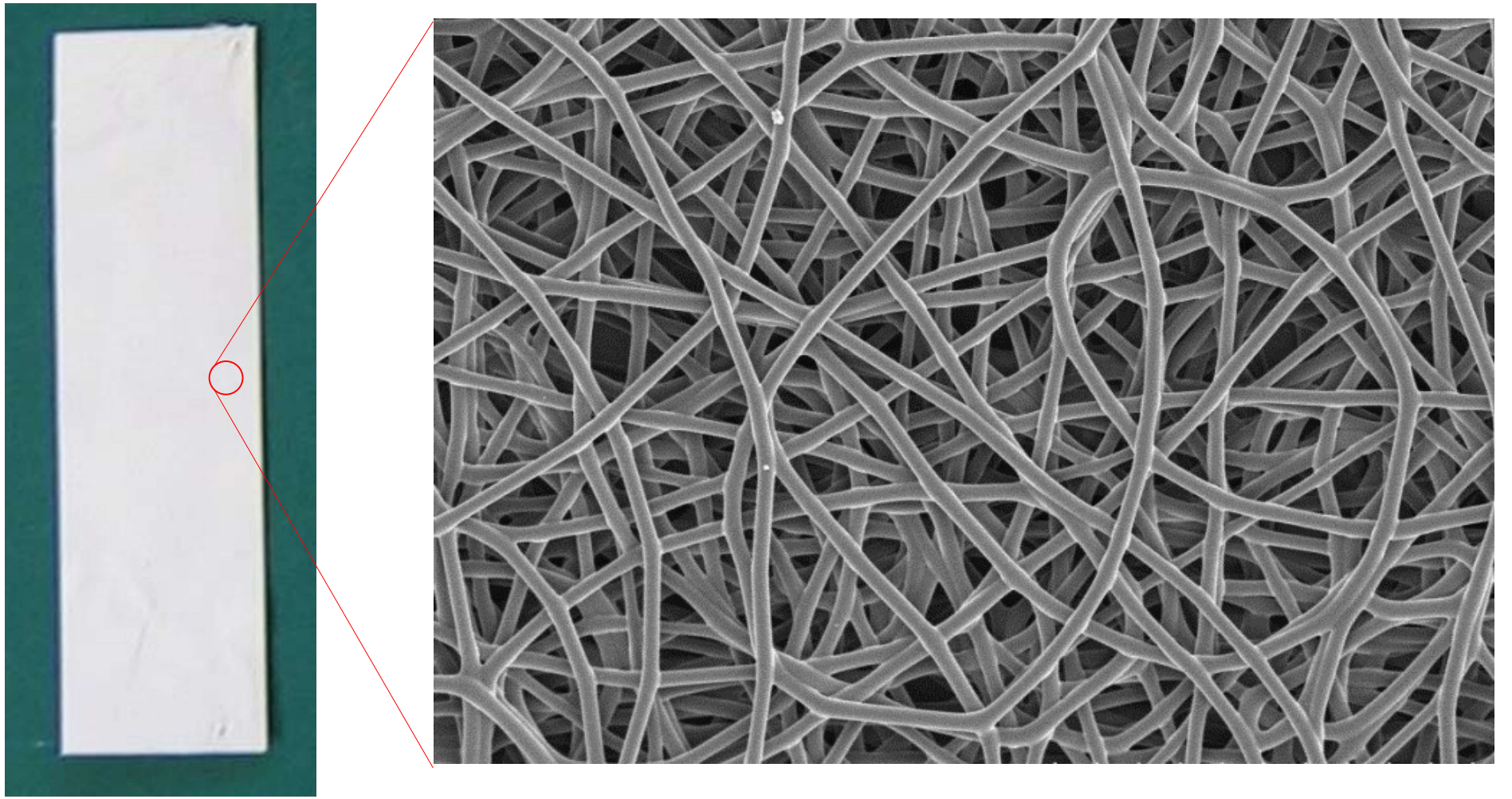
PHA elastic fiber with high strength



Fiber that stretches and shrinks 2 to 3 times and does not break



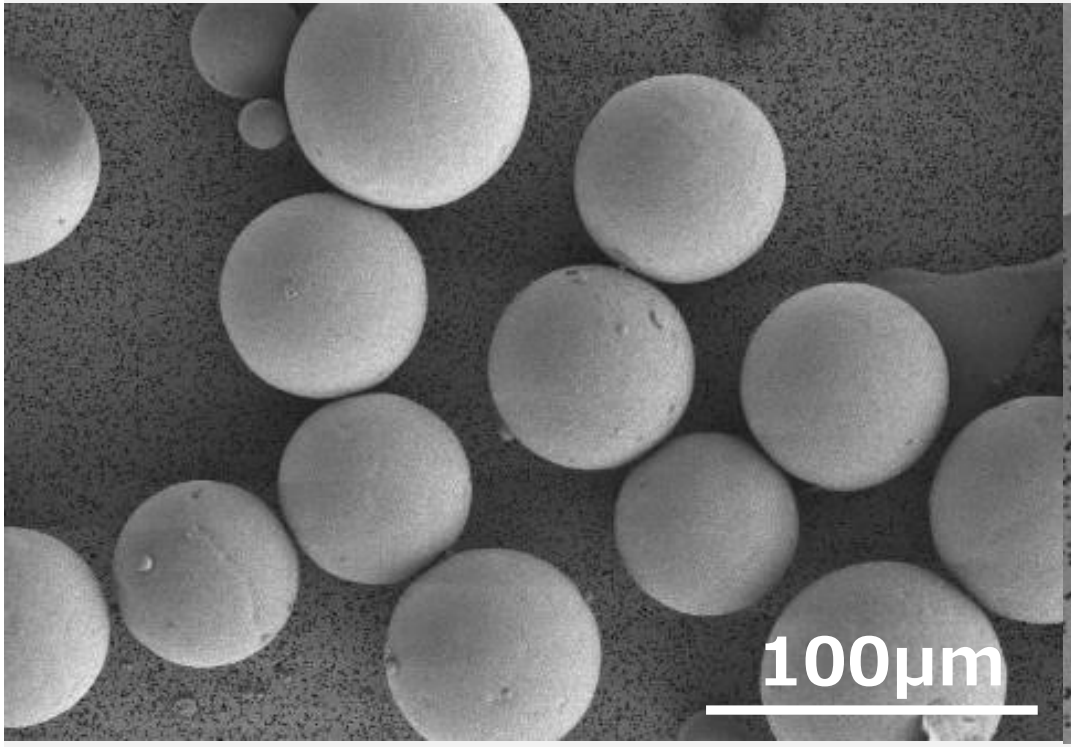
Ultrafine fiber mats with nano ordered diameters

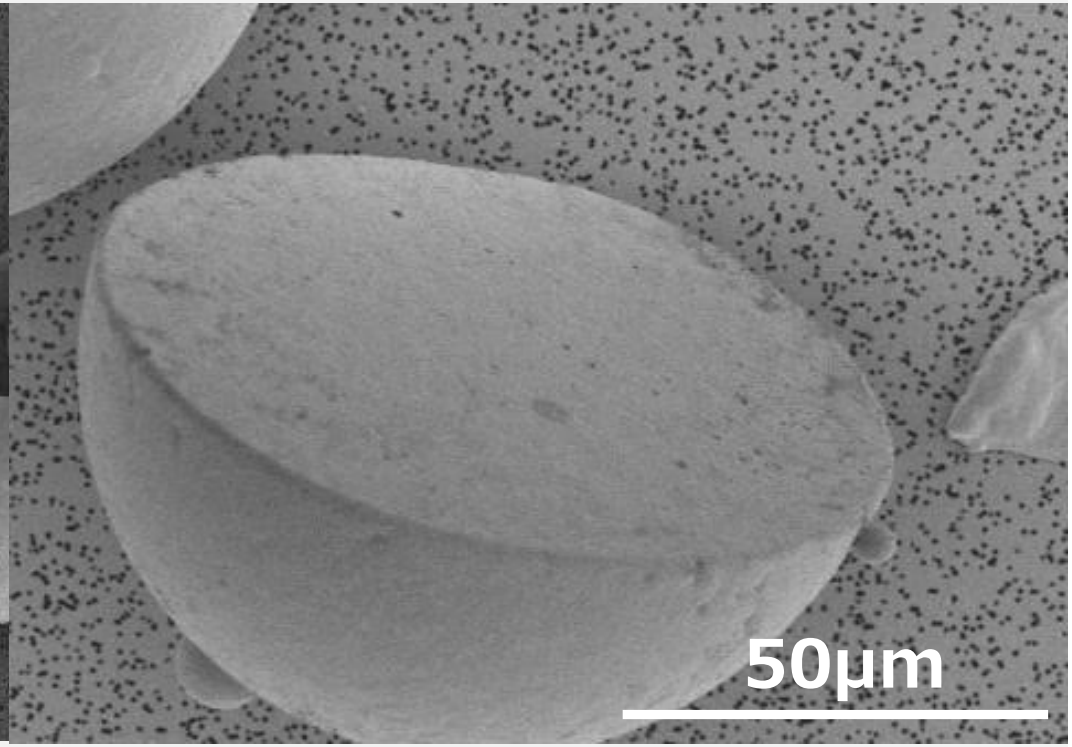


Masks and Air-Filters for removing pollen and viruses

SEM observation of P(3HB) microbeads

55-108㎛ diameter P(3HB) microbeads

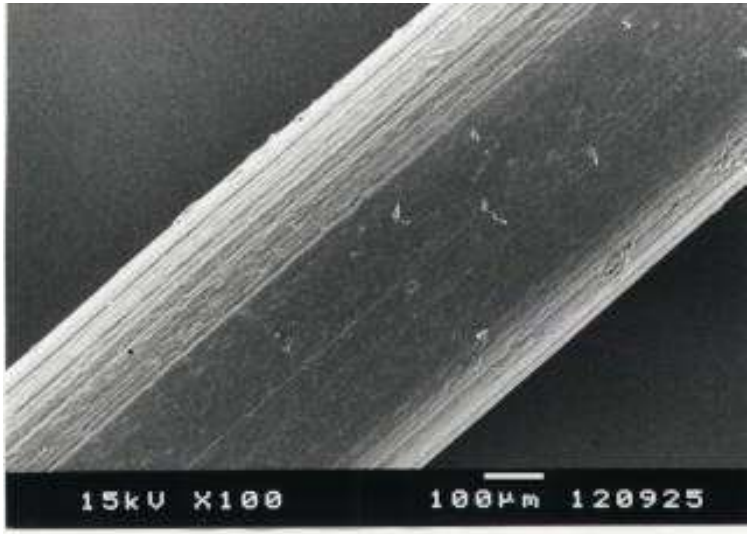


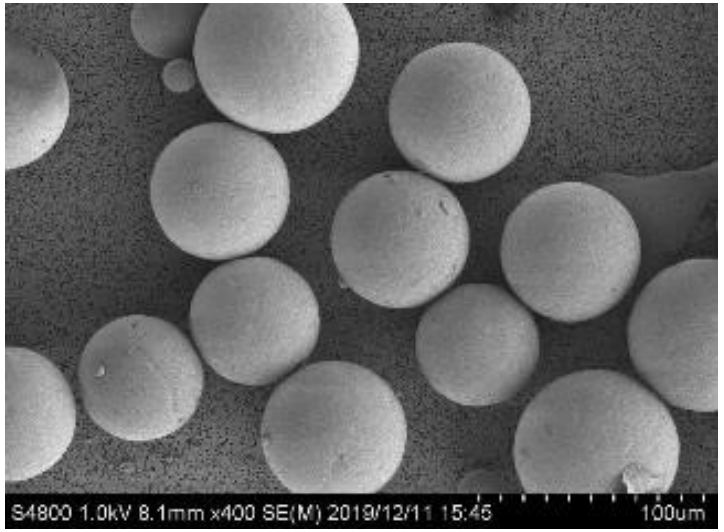


✓ P(3HB) microbeads are dense and spherical

Biodegradation of fibers and microbeads

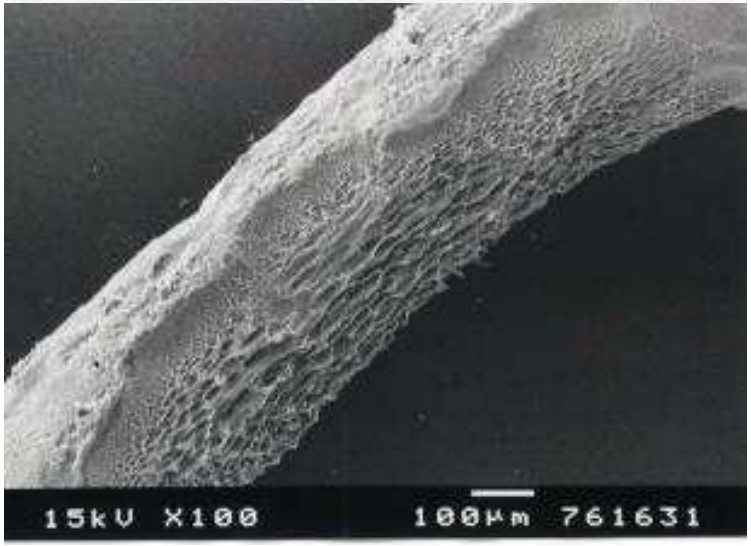
Before

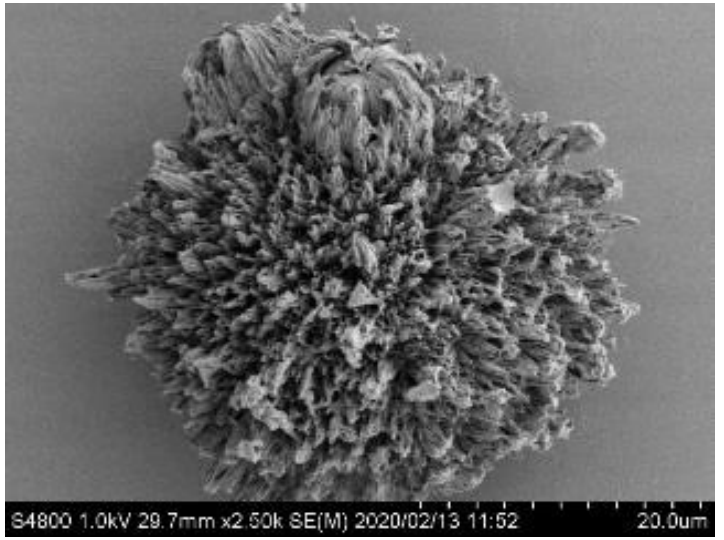




Before

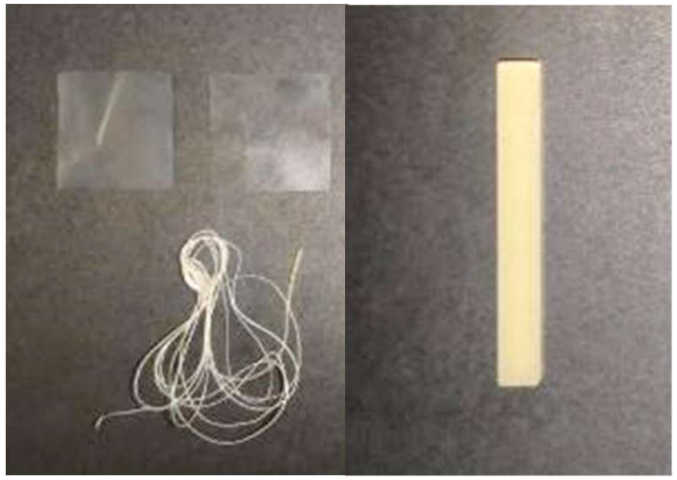
After
21 days





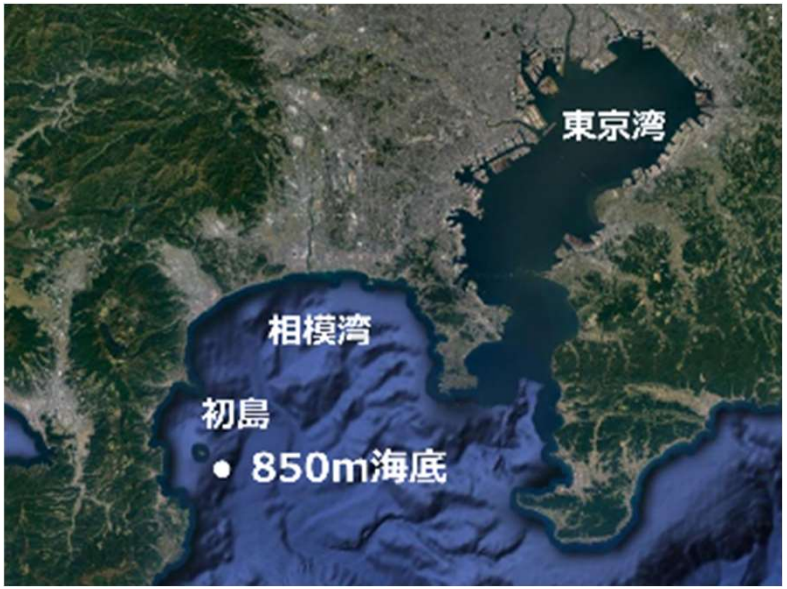
After
1 days

Biodegradation test in deep sea



Biodegradable Plastics

Chamber filled with biodegradable plastics



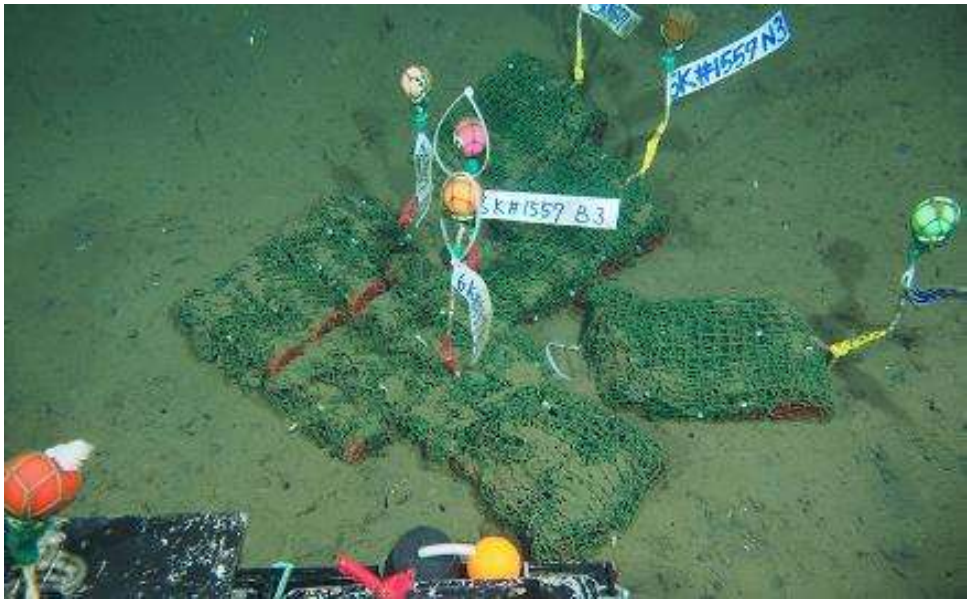
Installed 850m off Hatsushima Island, Shizuoka Prefecture

SHINKAI6500

Joint research with JAMSTEC

Deep-sea status and recovery of biodegradable plastics

Joint research with JAMSTEC



Samples after 4 months of installation

Recovery using a robotic arm

Recovery of samples and deep sea water

Collection of seabed soil

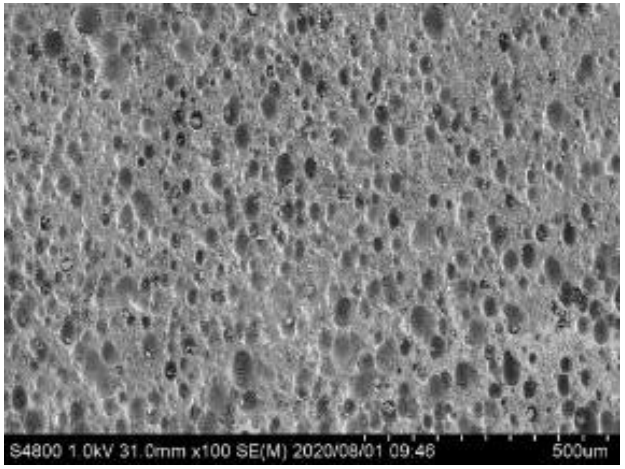
Biodegradation of PHA at shore

	length (mm)	wide (mm)	thickness (mm)	weight (g)
0 M	30.0	10.0	4.0	1.30
12 M	25.5	7.5	2.2	0.39
Reduction rate	15%	24%	45%	70%

Size

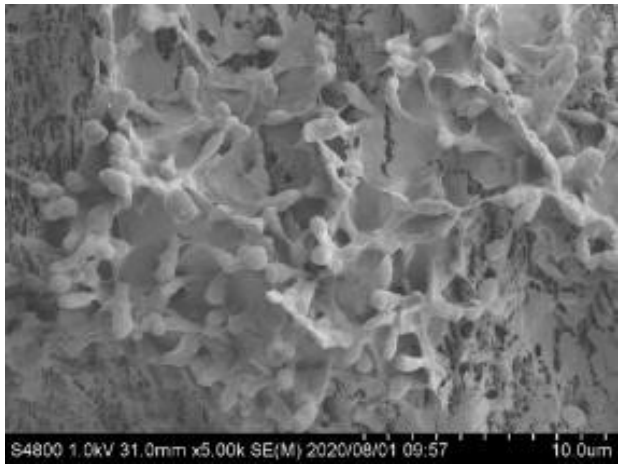
0 12M

Surface



0 12M

Degrading microorganisms



Based on the result of injection-molded product degraded for 12M at shore, if a plastic bag were made from our biodegradable plastic

Thickness of convenience store plastic bag＝30μm

Reduction of 1,800μm in 12M

30μm／1800μm×12M＝0.2M

This means that the plastic bag would decompose in about a week!

Necessary to verify the difference in the degree of biodegradation depending on the sea area.
Furthermore, necessary to compare the results with deep sea biodegradation tests.


MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM