tmd LAB

Shape Memory Polymer

INNOSELF®

Innovative materials for a smart world

The world's leading technology of TMD LAB

TMD LAB is an R&D-based company with a long history of developing polycaprolactone(PCL)-based shape memory polymer(SMP) technology. TMD LAB presents new solutions to various industries including biomedical, multi-dimensional printing, textile, and engineering part by upgrading pre-used materials to functional shape memory polymers.

The founder, professor Hak-Joon Sung, developed the fundamental technology of SMP since 2009 when he was a professor in Vanderbilt University in the U.S. He has been upgrading the material to establish a broad range of property spectrum.

Now, TMD LAB is ready to present our signature material PCL-based SMP to the world where there is unmet need.

TMD LAB Headquarters (in Seoul)

Production / R&D Facility

Mass Production Equipment

Mass Synthesis Equipment

Synthetic Lab

Drying Room

Processing Room

Washing Room

Bio Lab

Physics and Chemistry Lab

INNOSELF®

Shape Memory Polymer (SMP) is a polymeric materials that has an ability to be transformed to a pre-designed shape when a certain type of stimulus (temperature, light, etc.) is applied.

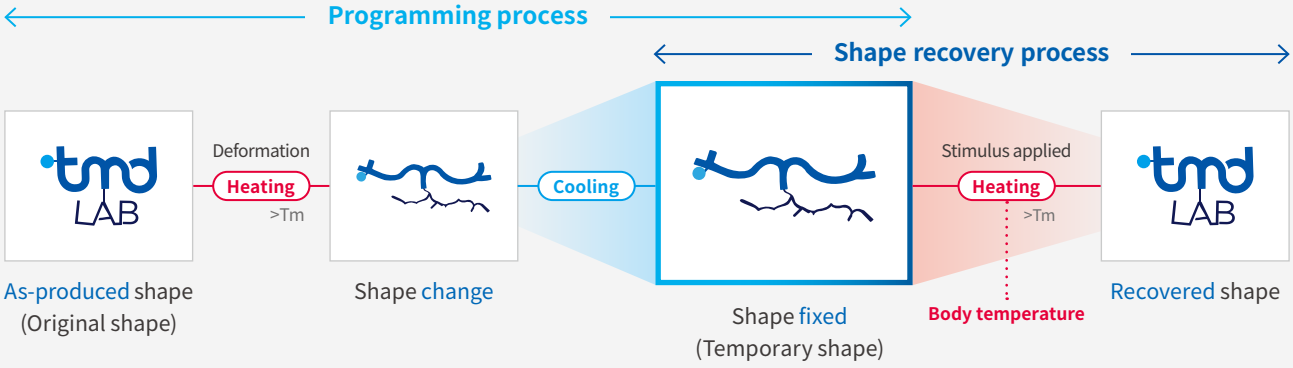
TMD LAB's SMP, called INNOSELF®, is the only SMP that has lowered the melting point to body temperature among commercialized SMP. As an implantable medical device, INNOSELF® is beneficial for minimal invasive insertion into a body due to its auto-transformation ability triggered by body temperature.

What is INNOSELF®?

Polycaprolactone (PCL) + **Various polymers**
- Silicone
- Poly (Glycidyl Methacrylate) (PGMA)
- Polylactic acid (PLA)
- Polyether ether ketone (PEEK)

▶▶ INNOSELF®

INNOSELF® Programming



INNOSELF® History

1 **1st** generation
Foundation of tunability and upgrade

2 **2nd** generation
Establishing mass synthesis

3 **3rd** generation
Tunable shape recovery temperature & mechanical properties

4 **4th** generation
Variation of chain structure from linear to multi-arms for more tunable properties

5 **5th** generation
Blending and copolymerization with other medical materials (silicone, PLLA, etc.)

Biocompatibility

- INNOSELF® is PCL-based biocompatible materials.
- PCL (Polycaprolactone) is FDA-approved for usage in the human body.
- Stable and biocompatible for long-term use. (Excellent tissue affinity)
- Suitable for medical device applications.

Polycaprolactone

Drug delivery device

Suture

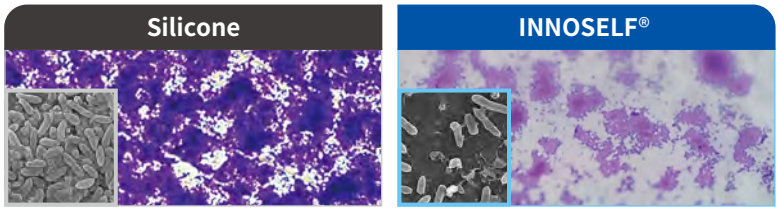
Adhesion barrier

* PCL has been widely used in the human body as (for example) a drug delivery device, suture, or adhesion barrier.

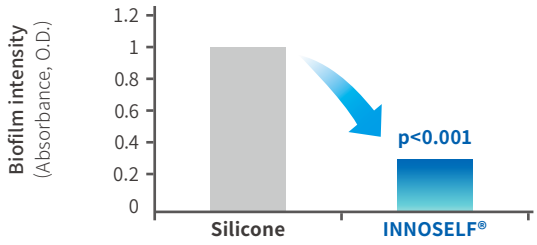
Anti-Biofilm

- A material capable of biofilm suppression.
- 74% biofilm suppression effect compared to silicone in biofilm test using bacteria.
- 52% biofilm suppression effect compared to EVA in biofilm test using patient bile.

Silicone vs INNOSELF®



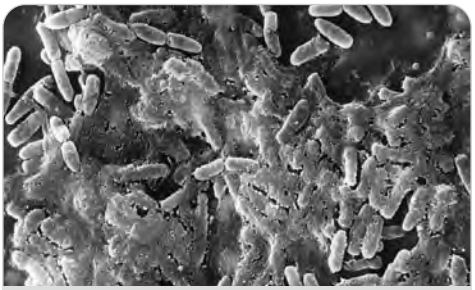
[Biofilm test using bacteria]



Biofilm suppression effect by **74%** compared to **Silicone**

Biofilm Infection

- Constitute several clinical challenges, including chronic inflammation, impaired wound healing, and rapid antibiotic resistance.

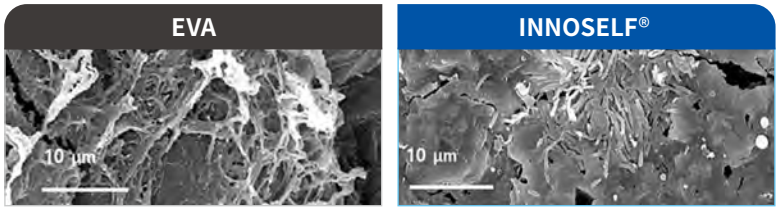


Pseudomonas aeruginosa

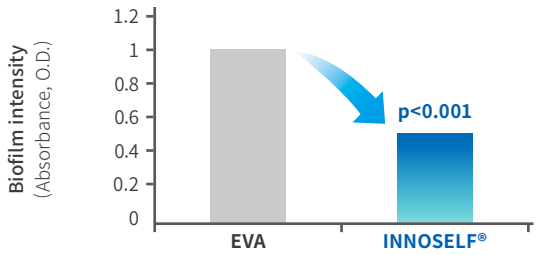
* Antimicrob Agents Chemother. 1995 Oct; 39(10) : 2262–2268

EVA vs INNOSELF®

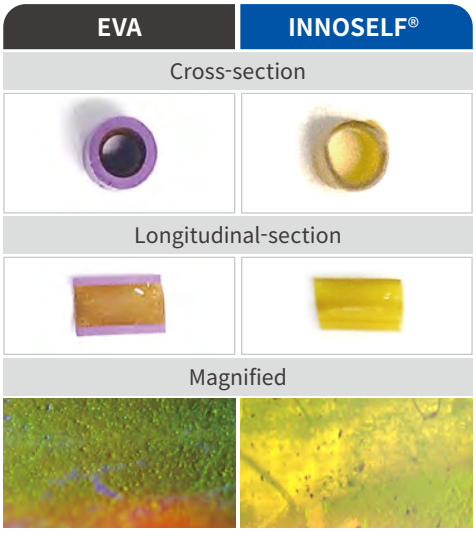
- Plastic stent occlusion : colonization of various bacteria and protein adsorption, etc.
- Stent replacement is required every 3 ~ 6 months.



[Biofilm test using patient bile]



Biofilm suppression effect by **52%** compared to **EVA**



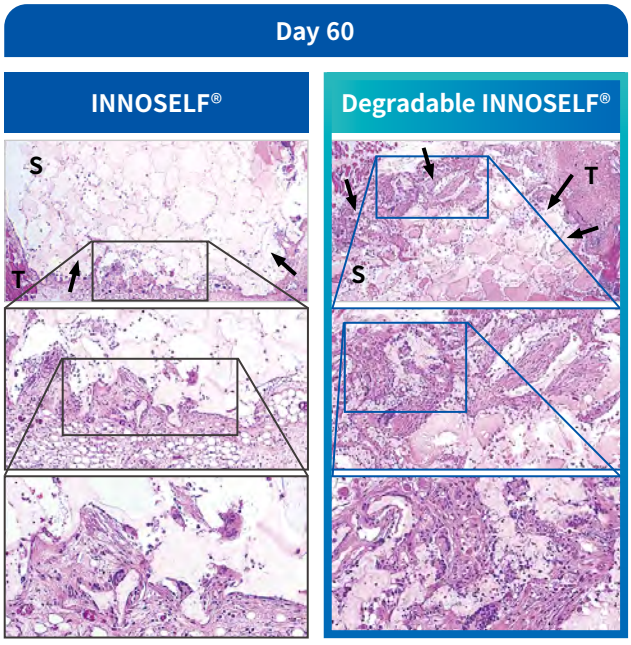
* EVA (Ethylene-Vinyl Acetate copolymer)

* Currently under joint research with the NIST (National Institute of Standards and Technology) about the mechanism of biofilm inhibition (2022).

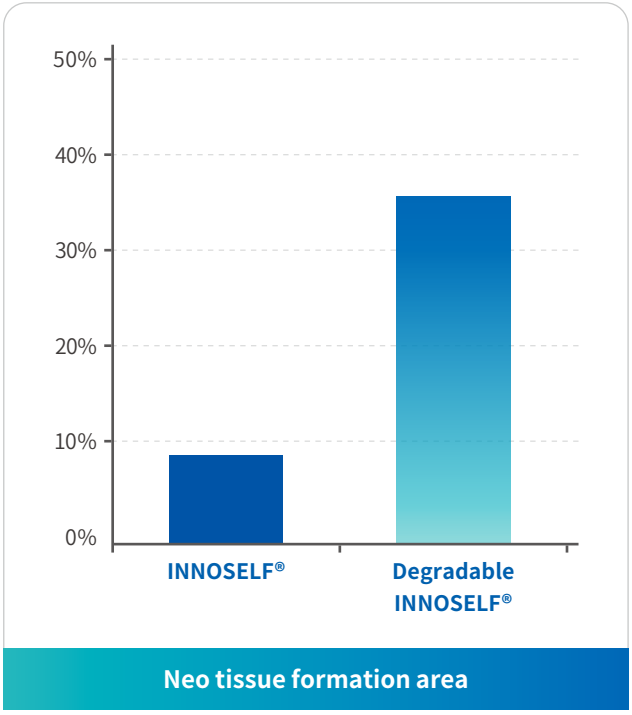
Biodegradability

- An eco-friendly biodegradable material.
- Diversity is ensured by the composition of two types of materials : biodegradable and non-biodegradable materials.
- *In-vivo* degradation test, confirmation of tissue and cell penetration after subcutaneous implantation. (non-inflammation condition)
- *In-vitro* degradation test, degradable up to 47% under slightly acidic conditions (pH 6.5 ~ 7.1) for 7 days.

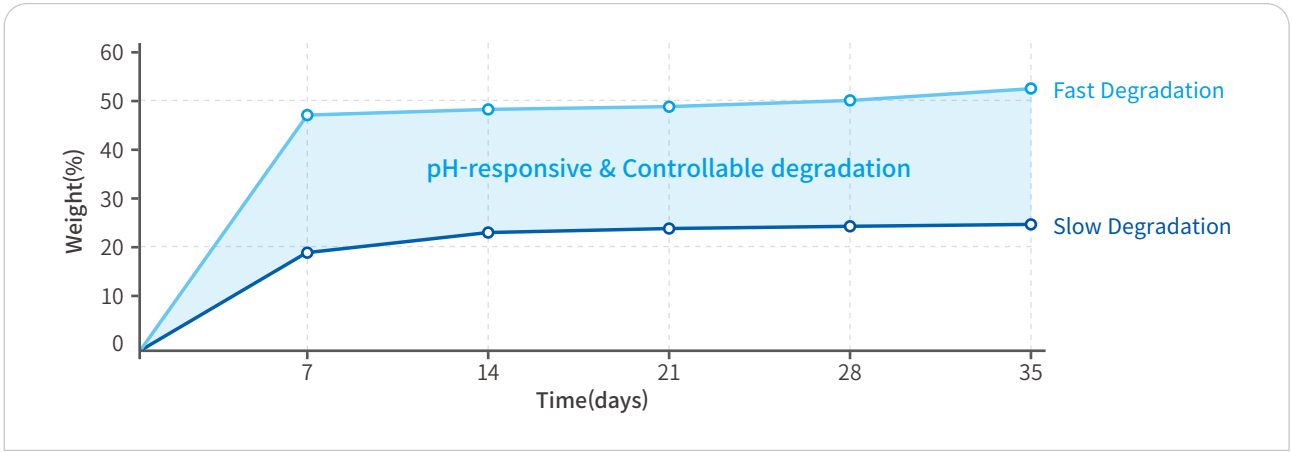
In-vivo Degradation Test



S : Scaffold | **T** : Tissue | **Arrow** : Direction of cell invasion
* Scale bar : 100 μm * Subcutaneous implantation for 60 days

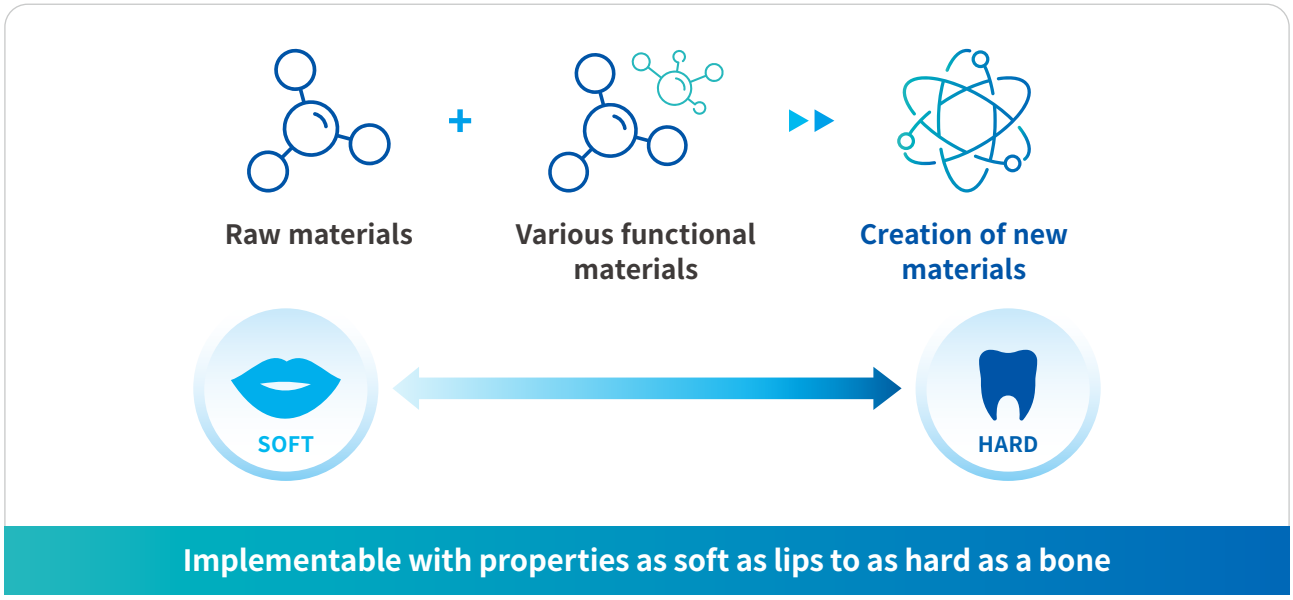


In-vitro Degradation Test

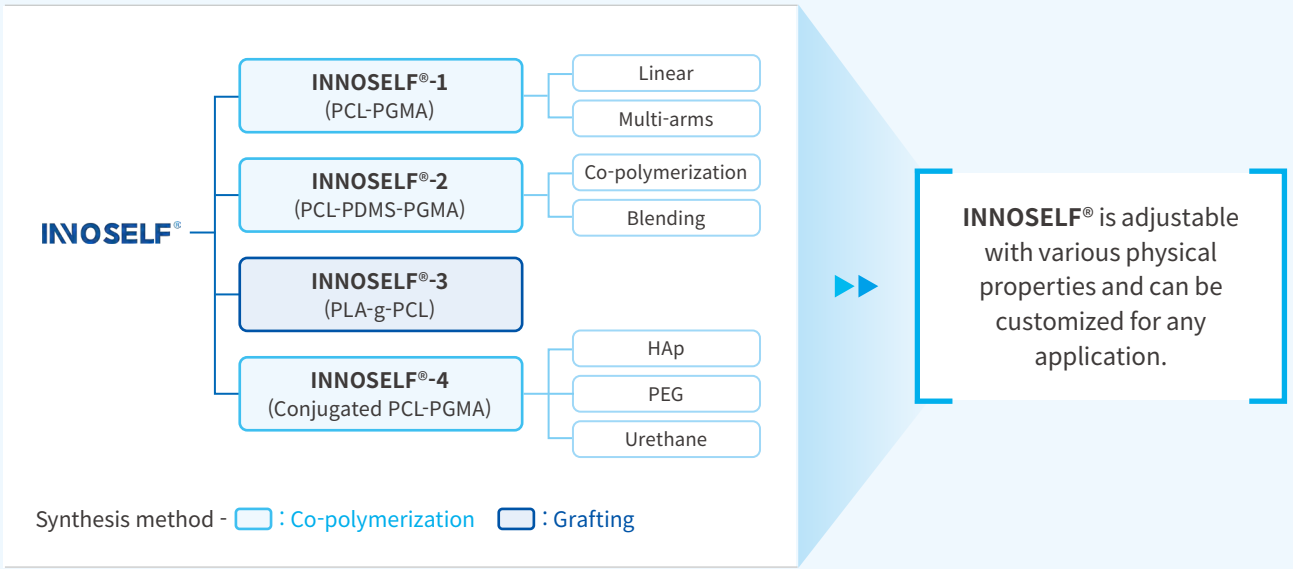


Versatility

- Customer-specific processing possible.
  (Shape restoration time adjustable & Wide range of physical properties)
- The temperature range (28°C ~ 49°C) adjustable for recovery of shape.
- The melting temperature, shape restoration speed, shape memory volume, and step-by-step shape restoration controllable.
- Building various physical spectrum through combination with PGMA, Silicone, PLA, etc.
- The various properties adjustable. (ex. strength, hardness, elasticity, and flexibility)
- Building various process methods. (extrusion, molding, 3D printing, etc.)



Implementable with properties as soft as lips to as hard as a bone



Benefit For Customers

You can upgrade or replace the material of your product with INNOSELF® for better outcomes.

Other Materials	Polyurethane	Silicone	EVA	PE	PTFE	Polyamide	

Limitation of Materials

- **No(or limited) shape memory function**
  - Not suitable for use in the body because of relatively high Tm.
- **Biofilm formation**
  - Biofilm forms and fiberize the tissues by bacteria and protein adsorption on the surface of the implanted product.

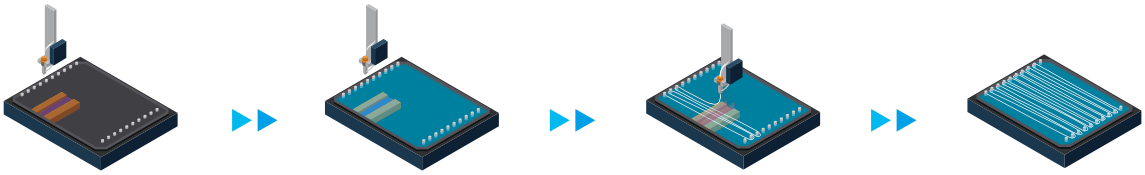
Solution of INNOSELF®

- **Shape memory ability in the body temperature**
  - INNOSELF® can be restored in the body temperature range (30°C to 42°C).
- **Biofilm suppression compared to silicone & EVA**
  - Biofilm forms significantly less by controlling the adsorption of bacteria and protein.
  - Suppression effect by 74% compared to silicone, 52% compared to EVA.
- **Wide range of physical properties**
  - INNOSELF® can deliver a wide range of materials to meet customer needs. (degradable / non-degradable, shape recovery speed and stimulation sources, mechanical properties, chemical properties, etc.)
- **Wide range of output type**
  - Polymers can be provided in powder, filament, pellet, resin, etc., depending on the manufacturing process and customer needs.

Other Materials	SMA (Shape Memory Alloy)
Limitation of Materials	• **Low energy efficiency – passive shape recovery** • **Complex thermo-mechanical behavior** • **Complex motion control - non-moldable** • **Expensive materials** • **Temperature dependent effect** • **Poor fatigue properties** • **Low operational speed** * Source : Micro and Nanosystems, 2016, 8, 79-91
Solution of INNOSELF®	• **Active shape recovery** • **Underpricing than SMA** • **Easy operation process than SMA** • **Higher tensile strength than SMA** • **Low density than SMA** • **Higher shape recovery rate (>90%)** • **Moldability**

Manufacturing Methods

- Extrusion Molding & Injection Molding
- Automatic Injection
- Molding
- Multi-D (FDM - Filament / DLP - Resin)



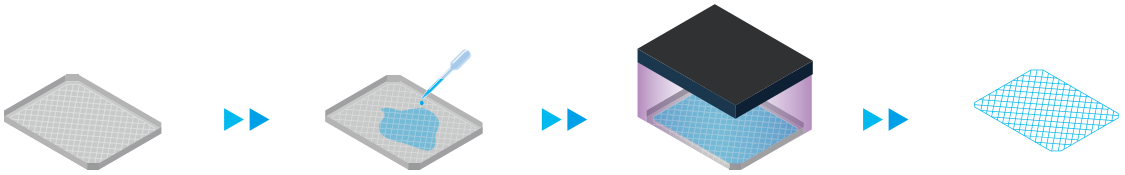
Turn on the automatic injection equipment

Fill the water tank with a liquid solution and install the nozzle and syringes

Operate the program and it starts extrusion and crosslinking simultaneously

Place the acquired specimen into water

Automatic Injection



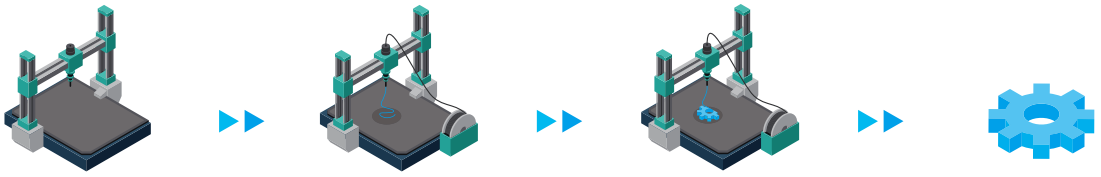
Prepare a mold

Spread a polymeric solution

Photocuring process

Specimen acquired

Molding



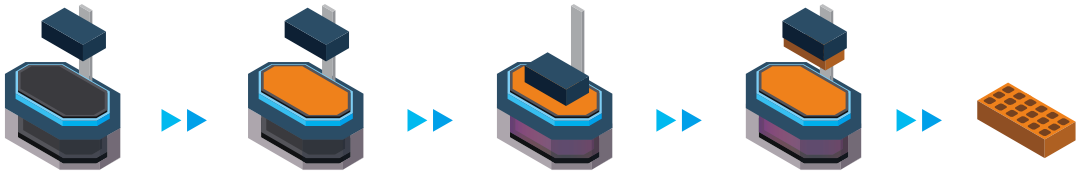
Fused Deposition Modeling (FDM)

Heated filament cools immediately when it is extruded into a liquid type

Repeat the same process until it is finished

Specimen acquired

Multi-D (FDM - Filament)



Digital Light Processing (DLP)

Fill the vat with resin

Photocuring process - creates the layer by curing and solidifying the resin

Repeat the same process until it is finished

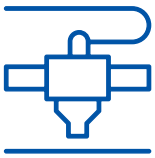
Specimen acquired

Multi-D (DLP - Resin)

Applications

Industry Area

Bio-Medical



Multi-Printing

Textile

Engineering

Output Types

Polymers

• Powder • Filament • Pellet • Resin

- We supply shape memory polymers in various forms such as powder, filament, pellets, and resin.

Semi-finished Products

• Sheets • Tube & Catheter • Suture • Coating Material • Medical Balloon

- We provide semi-finished products that can be combined and upgraded with the existing products manufactured by customer companies.

Finished Products

Eyes • Lacrimal Duct Stent • Punctal Plug • Glaucoma Device Supporting Tube

Bile • Biliary Stent

Cardio • External Vascular Wrapping Support

Microneedles • SMP Microneedles

Prosthetic Implants • Nose Implants • Breast Implants

- We provide finished products through joint R&D, OEM&ODM, licensing out, etc.

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Create a Smart world with Smart materials

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