Research and development of marine degradable multi-lock biopolymers from inedible biomass

Presenter : Satoshi Kato (Mitsubishi Chemical)
PM: Kozo Ito Professor, Graduate School of Frontier Sciences, The University of Tokyo
PJ participating organizations: The University of Tokyo, Mitsubishi Chemical Corporation, Bridgestone Corporation, Teijin Limited, Kureha Co.
Kyushu University, Nagoya University, Tokai National University Organization, Yamagata University
Research Institute of Innovative Technology for the Earth, National Institute of Advanced Industrial Science and
National Institute of Advanced Industrial Science and Technology, Ehime University, Tokyo Institute of Technology

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MS Ito PJ

【Objective】 We are developing a bioplastic that incorporates a multi-locking mechanism into aliphatic polyesters produced from inedible resources, and that biodegrades rapidly in seawater after unlocking by multiple external stimuli. In addition, we aim to strengthen the biodegradable plastic while maintaining good biodegradability through dynamic cross-linking, introduction of supramolecules, and optimization of the higher-order structure.

A trade-off between tear strength and marine biodegradability

To break this trade-off relationship, a biodegradable multi-locking mechanism is introduced.

Objectives

(i) Incorporate marine biodegradable resin and multi-lock mechanism.

(ii) To improve the toughness of the system, focusing on the improvement of tear strength.

(iii) To achieve these goals without compromising marine biodegradability.

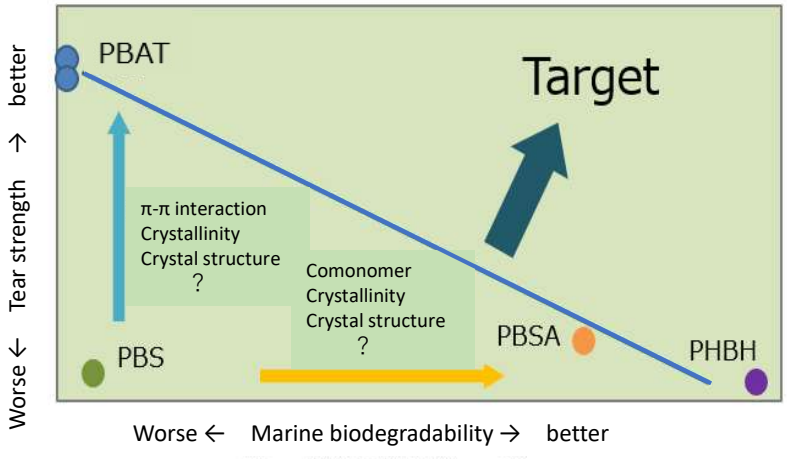


Fig 1: Physical properties and marine degradability

Intermediate goal ~ final goal

●FY2022 Intermediate Objective: Proof of concept of multi-locking mechanism
- More than 3-fold difference in degradation rate between single and multiple external stimuli

● FY2024 Interim Objective: Achieve both multi-locking mechanism and toughness
- Degradation rate more than 10 times different between one and multiple external stimuli.
- 5 times or greater tear strength compared to existing aliphatic polyesters

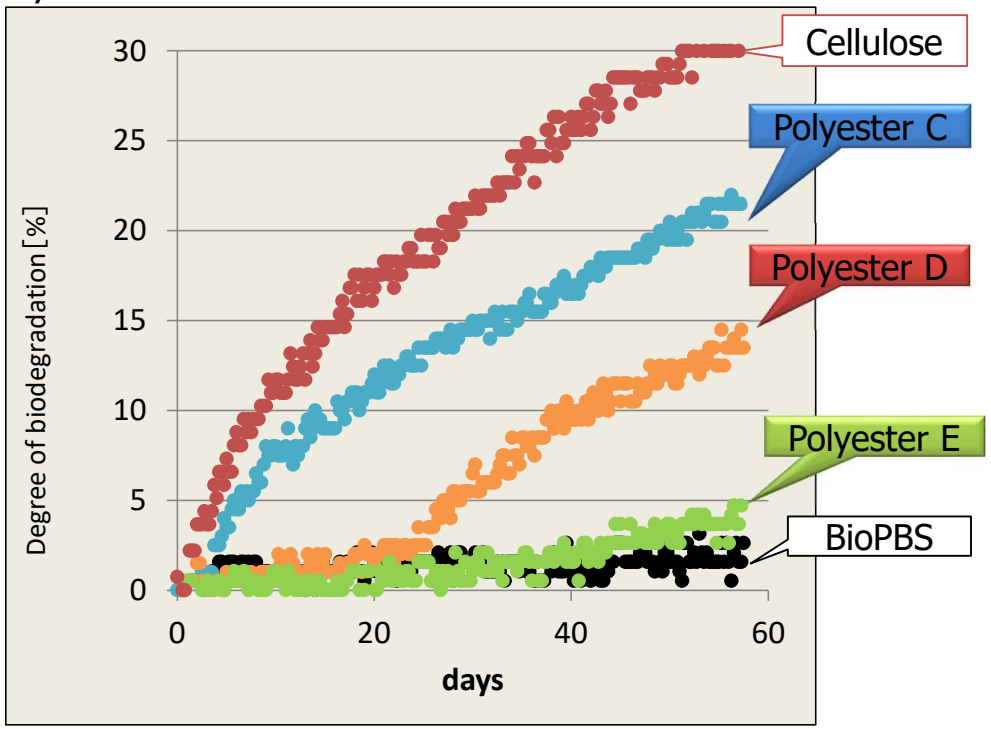
● FY2027 Intermediate goal: Bench-scale demonstration
- Demonstrate feasibility of production at a scale of 20 kg or more

● FY2029 Final Goal: Achieve the following in scale-up products
- Multi-locking mechanism, marine biodegradability after unlocking: BOD test in seawater (25°C), 40% degradation in 30 days
- Tear strength: 10 times higher than existing biopolymers
- Polymer production at bench scale

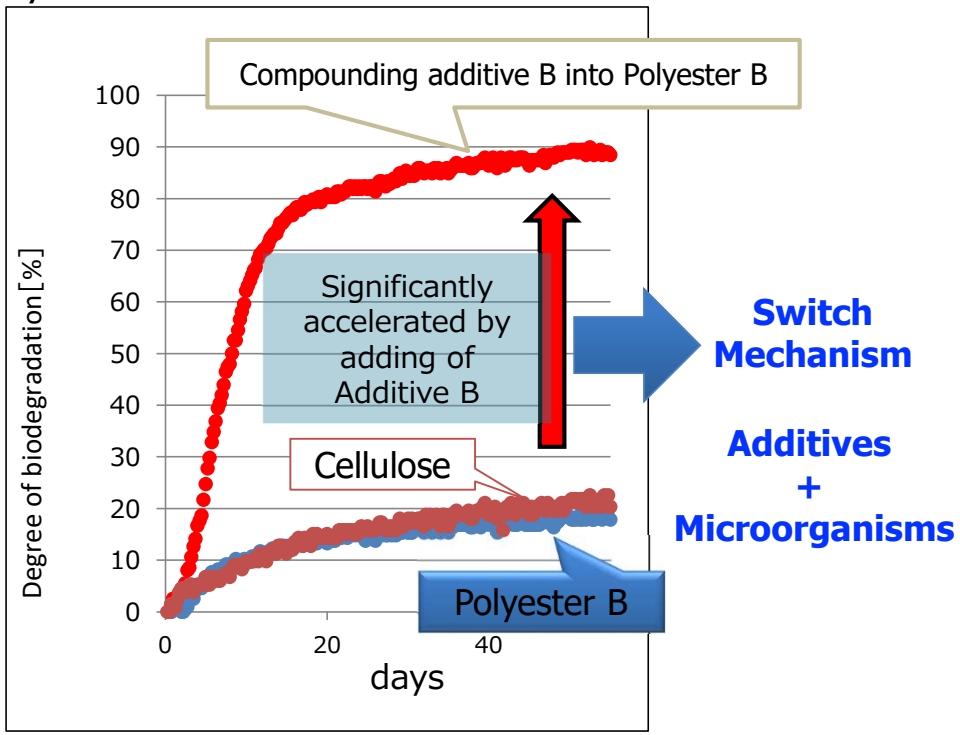
BioPBS : Methodology for improving marine biodegradability

MITSUBISHI CHEMICAL

Evaluation of marine biodegradability by BOD test



Evaluation of marine biodegradability by BOD test



- Copolymerization of new comonomer into BioPBS

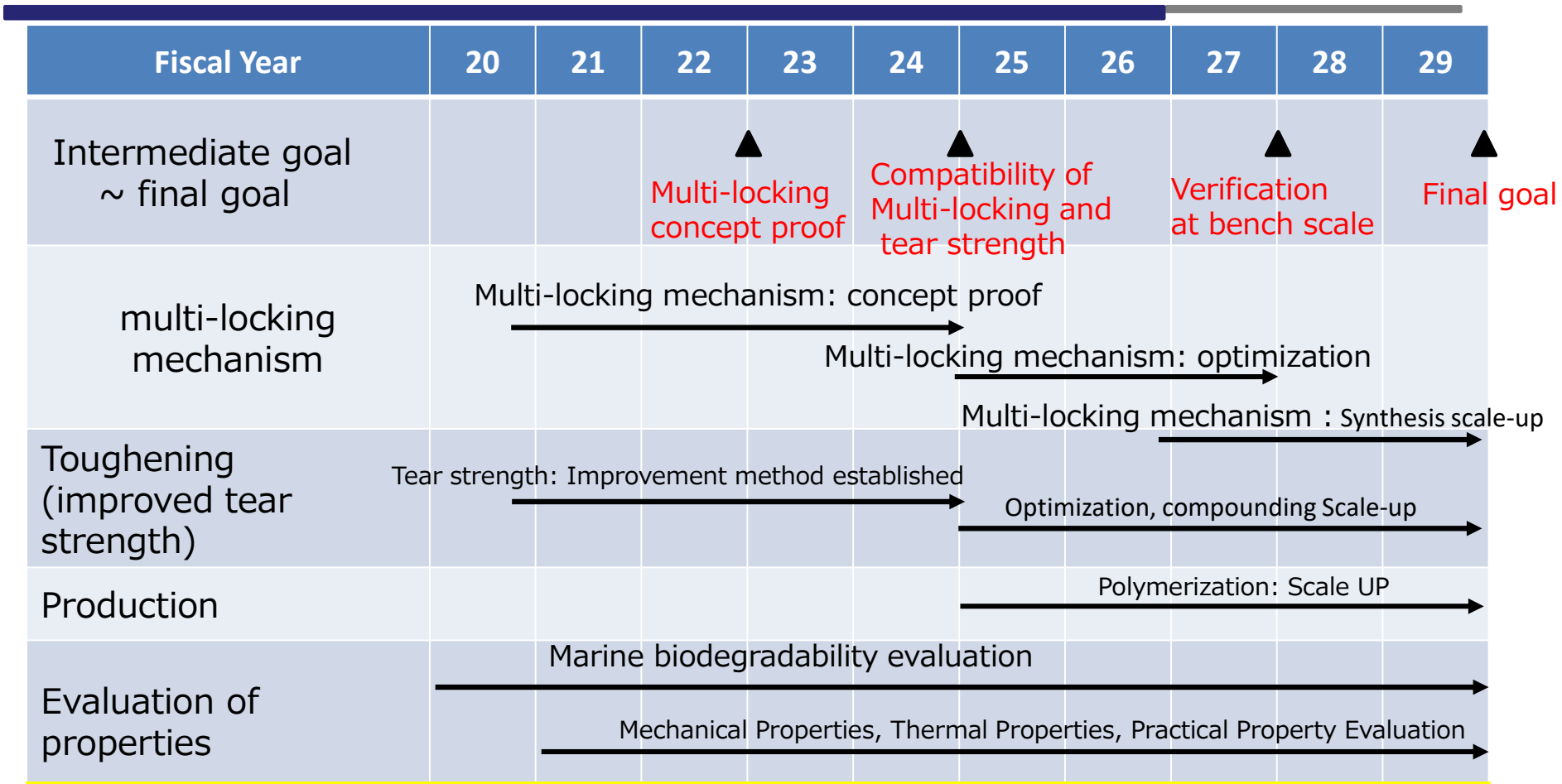
Biodegradability for marine ↑

- Coexistence of "certain additives" with marine biodegradable Polymer

Biodegradability for marine ↑

KAITEKI Value for Tomorrow
Mitsubishi Chemical Holdings Group

FY2020-FY2029



FY2022 Intermediate Objective: Proof of concept of multi-locking mechanism
- More than 3-fold difference in degradation rate between single and multiple external stimuli

Ultimate goals: (i) multi-locking mechanism, (ii) marine biodegradability, 40% degradation in 30 days at 25C, (iii) tear strength: 10 times higher than conventional products, (iv) polymer production at bench scale or higher.

Summary of progress in FY2021

- **FY2024 Interim Objective**: Achieve both multi-locking mechanism and toughness
  - Degradation rate more than 10 times different between one and multiple external stimuli.
  - 5 times or greater tear strength compared to existing aliphatic polyesters

Achievement level against target: Progress as planned

FY2021 Results

- The crystal structure change before and after tearing can be analyzed. (Prof. Sasaki, Kyoto Institute of Technology)
- In the PBS system, the toughening tendency by additives was confirmed. (Prof. Ishigami, Yamagata Univ.)
- Detection of crystal structure and hydrogen bonding state of copolymerized biodegradable resin. (Prof. Sato, Kobe Univ.)
- Analysis of higher-order structural change by weathering test and surface degradation by enzymes. Analysis of surface degradation by enzymes.(Prof.Takahara, Kyushu Univ.)
- Confirmation of surface structural change by enzymes. (Prof. Matsuno, Kyushu Univ.)
- The concept of multi-lock mechanism of carrier-supported biodegradation promoter model was confirmed. (MCC)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