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)

R & D goals in 2029

Microbial production of new marine biodegradable base materials using biomass and carbon dioxide as main raw materials on a pilot scale

Our group

Development of PHA materials

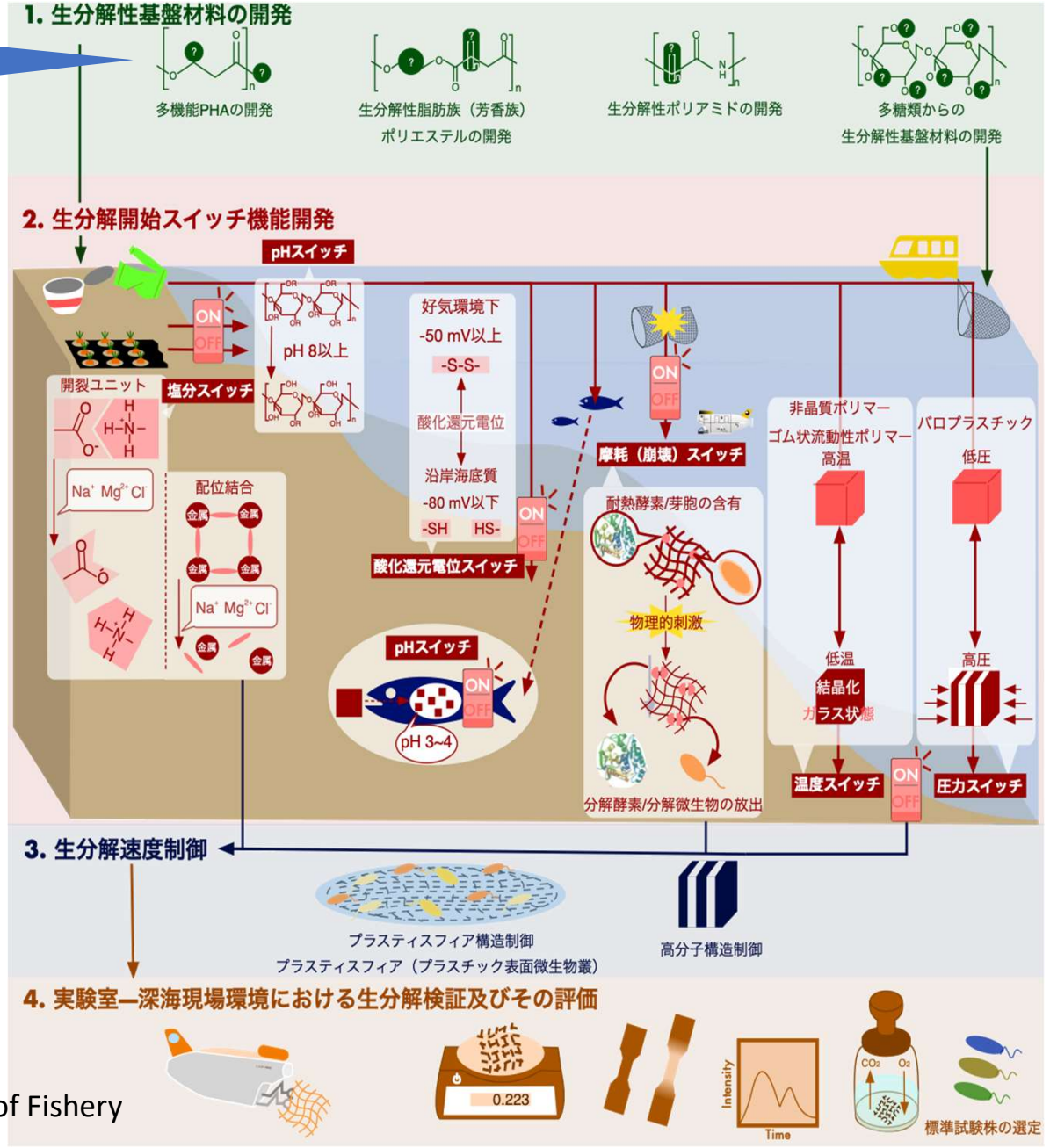
Synthesis

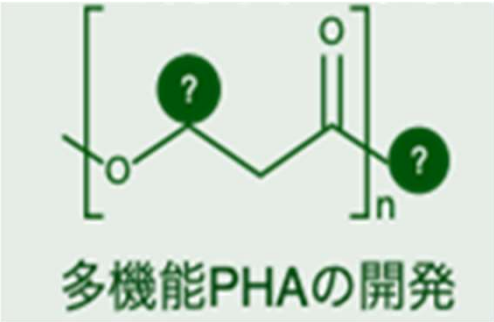
Providing materials to other groups

Collaborator
Hokkaido University
Tokyo Univ. of Agriculture
Kinki University

Biodegradation using deep sea water

Collaborator
Shizuoka Prefectural Research Institute of Fishery

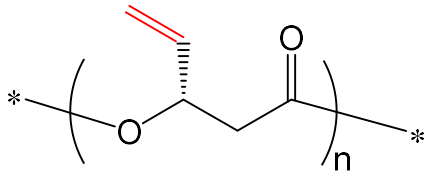




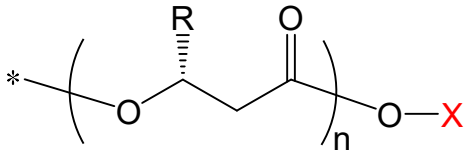
Development of multifunctional microbial polyester

1. PHA with terminal functional group / side chain unsaturated bond

Sole carbon source / Precursor → Microbe →



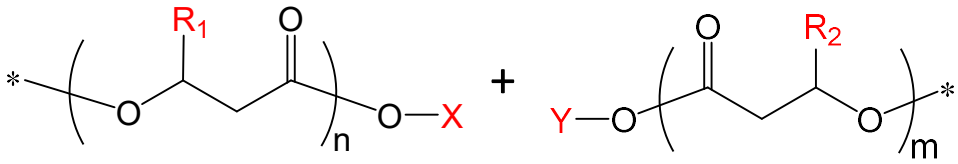
Unsaturated side chain



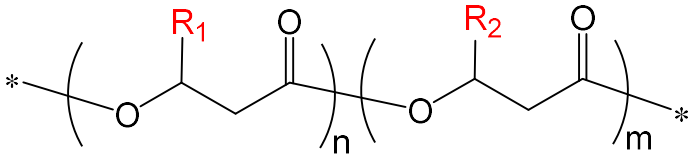
Terminal functionalization

Installing switch function

2. New PHA base material



Chemical synthesis

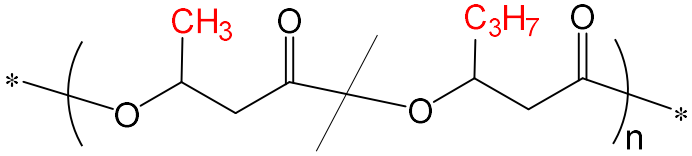


Biosynthesis

High toughness

3. Efficient synthesis method for new PHA from CO_2

Carbon dioxide（CO_2） → Microbe →

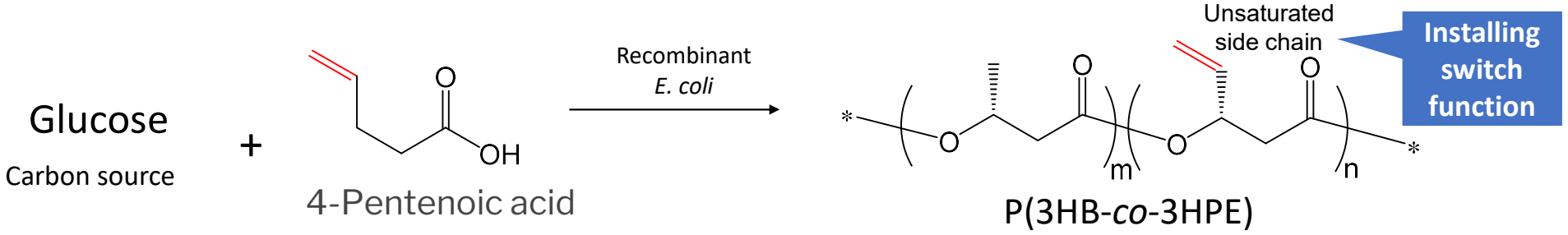


P(3HB-*co*-3HHx) etc.

CO_2 direct utilization

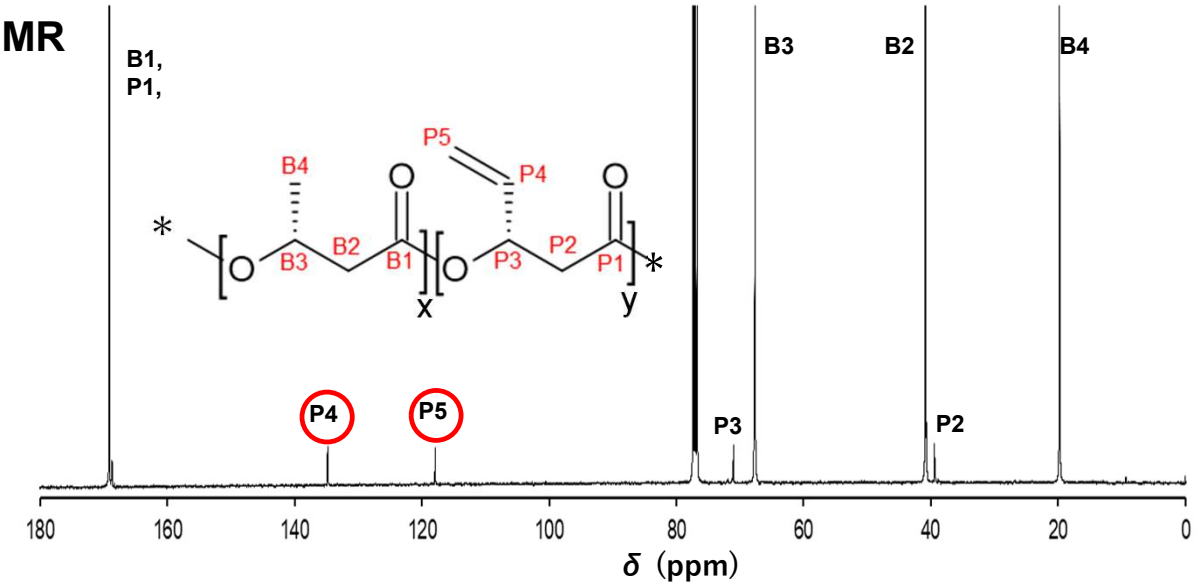
Main achievements at the moment ①

Base Materials for Installing Switching Functions



Culture Condition： LB medium + 4-Pentenoic acid + Glucose + Inducer (IPTG) , 30℃, 72 h

Flask culture (2L)



Extraction

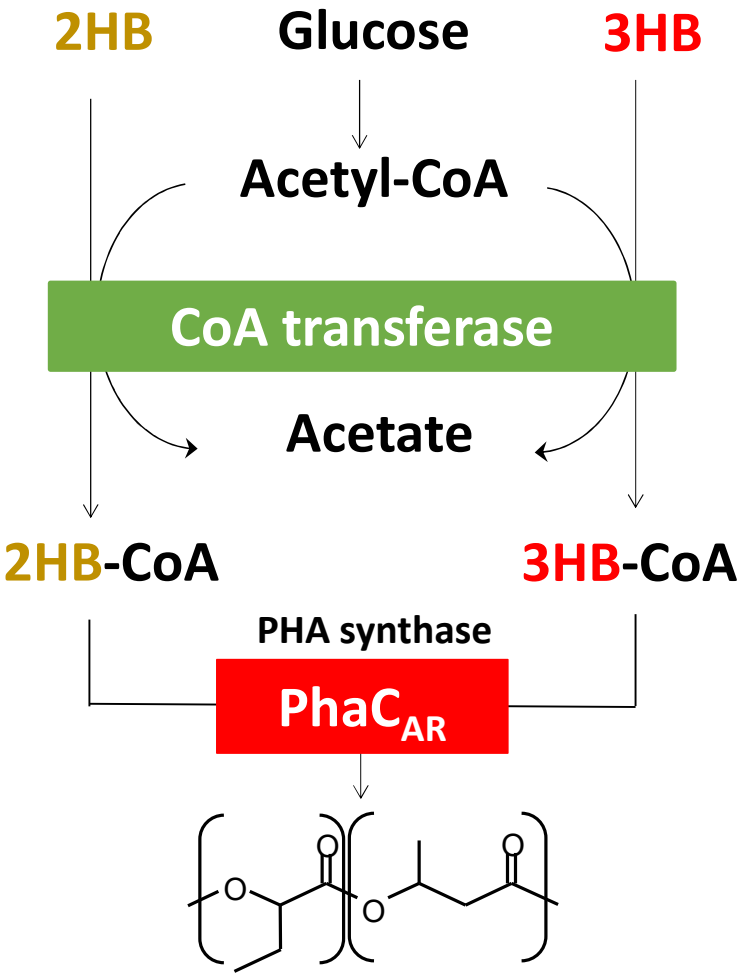
Synthesize 120 g of 3H4PE polymer

→ To install switch function

Main achievements at the moment ②

Development of New PHA Base Material (high toughness material)

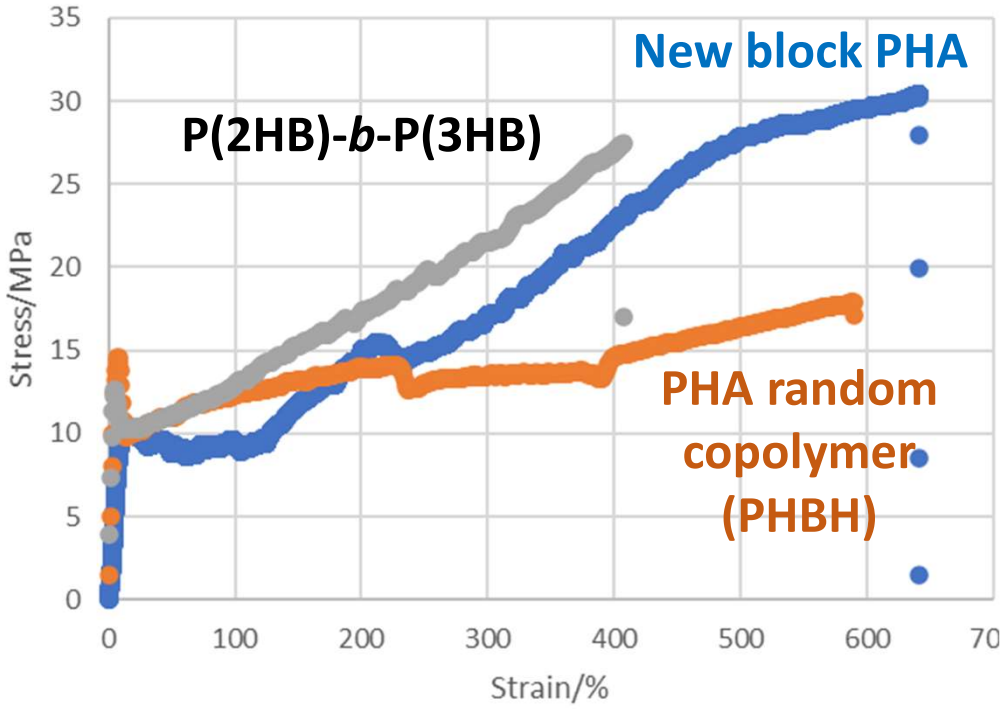
Block Copolymer Biosynthesis



P(2HB)-*b*-P(3HB)

Expandable block copolymer synthesis by combining various monomers

Mechanical Properties of New Block PHA

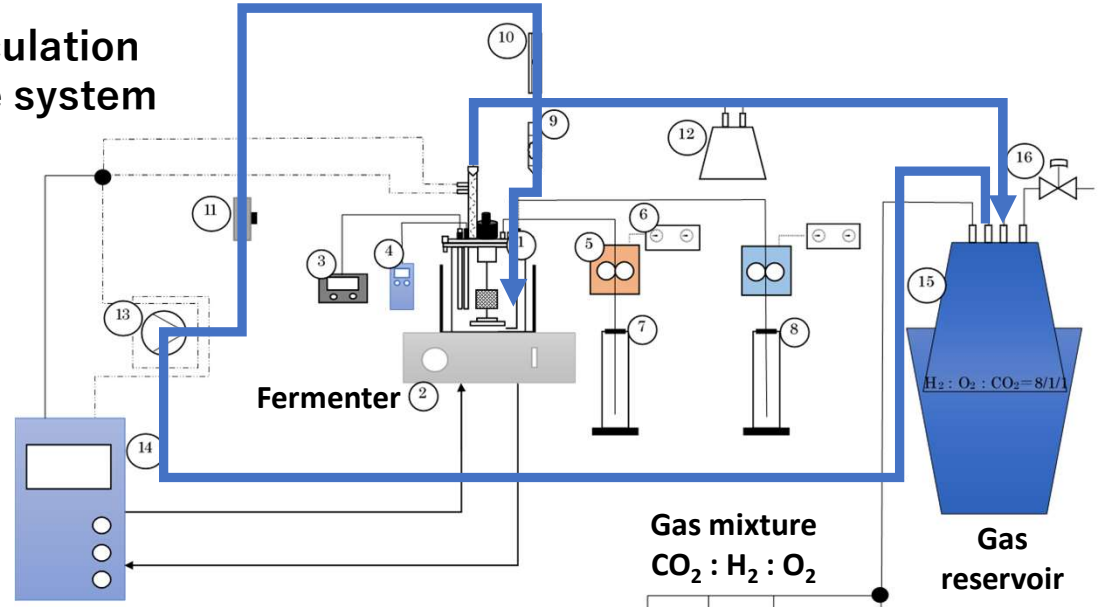


Using the polymer biosynthesis system shown on the left, we are exploring for block PHA that exhibits better mechanical properties. The new block PHA shown above has improved elongation at break over the previously reported block PHA [P(2HB)-*b*-P (3HB)]. In addition, the toughness was improved compared to the commercialized PHA (PHBH) (123 MJ/m^3).

Main achievements at the moment ③

Development of Efficient Synthesis Method for New PHA from CO_2

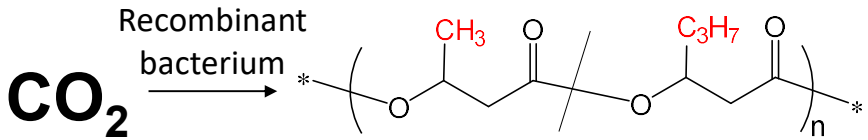
Closed circulation gas culture system



① 籠型攪拌翼付発酵槽
② スターラー付き恒温槽
③ pH コントローラ
④ DO コントローラ
⑤ ペリスタポンプ
⑥ 添加用ポンプへの On - Off タイマー
⑦ 消泡剤
⑧ 中和用アルカリ
⑨ 除菌フィルター
⑩ 流量計
⑪ ニードルバルブ
⑫ 廃液トラップ
⑬ 循環ポンプ
⑭ 発酵槽温調整用冷却水循環装置
⑮ 基質ガス貯槽
⑯ ガスサンプリング口
⑰ アナログマノメーター
⑱ ガスシリンダー
⑲ バキュームポンプ

Fermenter

CO_2 direct utilization



P(3HB-*co*-3HHx)
PHBH

Culture results of recombinant bacterium (after 204 h)

Dry cell wt. (g/L)	PHBH conc. (g/L)	PHBH content (wt%)	3HHx fraction (mol%)
61.4	51.5	83.9	5.4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