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Biodegradable and biocompatible polymers produced by sustainable integrated bioprocess

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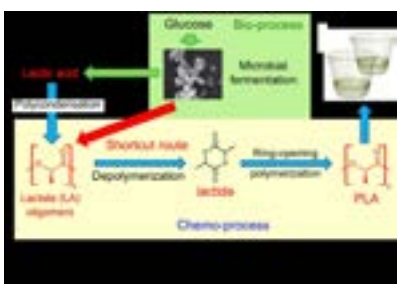
Natural polyesters, polyhydroxyalkanoates (PHAs), are synthesized and accumulated as energy storage in microbial cells. Physical properties of PHAs are tunable ranging from rigid to elastic, depending on the arrangement of monomer units in the polymer. Biodegradability and biocompatibility of PHA have inspired studies on the use of the polymers in biomedical applications, for example, as scaffolds in tissue engineering. The typical polyester available for this application is polylactide (PLA). Conventionally PLA can be synthesized via heavy metal-catalyzed ring-opening polymerization of lactide derived from fermented lactic acid (LA). In 2008, we firstly succeeded in incorporating D-form of LA (D-LA) into the 3-hydroxybutyrate (3HB) polymeric backbone in the Escherichia coli-based microbial factory carrying a newly developed D-LA-polymerizing enzyme (LPE). LPE was one of the artificially evolved PHA synthases through our long-term enzyme engineering study. Discovery of LPE prompted us to further create the unnatural monomer-contained PHA members other than LA-based polymers. Using LPE-based toolbox author expects to synthesize the chiral copolymers with diverse monomer constituents, owing to the extremely high enantio-selectivity and broad substrate specificity. In this symposium, author will talk about the overview of biosynthesis, properties and biodegradability of LPE-catalyzed polymers. We have currently attempted to develop the consolidated bioprocess for production of the target polymers from renewable feedstocks. Several case studies will be also presented with some processing products. So far author has been thinking about the possibility of "secretion" of polymerized ester-products by microbial platform. This should be a promising issue to overcome the cell volume limitation in the large amount of production of microbial polymers. Fortunately, we met to the "secretion" of low-molecular-weight D-LA-based polymers [or D-LA-based oligomers (D-LAOs)]. As a second topic, author will talk about the first observation of microbial secretion of D-LAOs and its advanced microbial secretion platform through the chain transfer reaction and modified cultivation conditions. Furthermore, synthesis of lactate (LA)-based poly (ester-urethane) using hydroxyl-terminated LA-based oligomers from a microbial secretion system will be presented.



Recent Publications

1. Taguchi S et al. (2008) A microbial factory for lactate-based polyesters using lactate-polymerizing enzyme. Proceedings of the National Academy of Sciences of the United States of America 105:17323-17327.
2. Matsumoto K and Taguchi S (2013) Enzyme and metabolic engineering for the production of novel biopolymers: crossover of biological and chemical process. Current Opinion in Biotechnology 24:1054-1060.
3. Salamanca-Cardona L et al. (2016) Consolidated bioprocessing of poly(lactate-co-3-hydroxybutyrate) from xylan as a sole feedstock by genetically-engineered Escherichia coli. Journal of Biotechnology and Bioengineering 122:406-411.
4. Utsunomia C et al. (2017) Microbial secretion of D-lactate-based oligomers. ACS Sustainable Chemistry & Engineering 5:2360-2367.
5. Utsunomia C et al. (2017) Synthesis of lactate-(LA)-based poly(ester-urethane) using hydroxyl-terminated LA-based oligomers from a microbial secretion system. Journal of Polymer Research 24:167-171.

Biography

Seiichi Taguchi is a Professor of Biomolecular Chemistry in Tokyo University of Agriculture. He received a PhD in Molecular Biology in 1991 from The University of Tokyo. After that, he joined the Faculty of Bioscience and Engineering as an Assistant Professor at the Tokyo University of Science. During the period, he was a Visiting Scientist of Louis Pasteur University. After spending the decade, he joined the Polymer Chemistry Lab in RIKEN Institute as a Senior Research Scientist. He moved to Meiji University as an Associate Professor in 2002 and was promoted to Professor of Hokkaido University in 2004, and shifted to the present position in 2017. He has received several awards such as Prizes for Science and Technology, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (MECST). He has published over 180 original research papers and over 30 books to his name.

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