

THE SUMMARY OF Ph. D. DISSERTATION

Major Applied Chemistry		SURNAME, Firstname SUZUKI, Yoichi
Title Synthesis of Biodegradable Polymers by Enzyme-Catalyzed Polymerization and its Biotechnological Analysis		
Abstract Recently, biodegradable polymers have received much attention as environmentally friendly materials. Enzyme-catalyzed polymerization has been extensively studied as one of the synthetic method of the biodegradable polymers. Enzymes may become a powerful catalysis for stereo- and regioselective reaction. Therefore, the enzyme-catalyzed polymerization is expected to produce useful polymers that are often difficult to obtain by conventional chemical synthesis. In this thesis, in order to establish the precision enzyme-catalyzed polymerization, aliphatic polyester synthesis using enzymes were studied. PHB depolymerase is the enzyme which degrade bacterial poly(3-hydroxybutyrate) [P(3HB)] in environment. In the chapter two, preparation of P(3HB) by the ring-opening polymerization of β -butyrolactone (BL) using PHB depolymerase as the catalyst was achieved for the first time. (<i>R,S</i>)-BL was enantioselectively polymerized to give (<i>R</i>)-enriched P(3HB). The substrate-binding domain lacking PHB depolymerase exhibited better catalytic activities for the ring-opening polymerization of BL.		

The enzyme-catalyzed polymerization proceeds in nonaqueous media or under high reaction temperatures such as over 60 °C. To our knowledge, there are no reports giving direct proof that the catalytic amino acid residues of the hydrolase are involved in the enzyme-catalyzed polymerization under that reaction conditions. In the chapter three, the involvement of the catalytic amino acid residues of the PHB depolymerase in the enzyme-catalyzed ring-opening polymerization of BL could be demonstrated using three kinds of PHB depolymerase site-specific mutants.

In the chapter four, small-size (4-membered) and medium-size (5-, 6-, and 7-membered) achiral lactones as well as achiral macrolides (12- and 13-membered) were subjected to the ring-opening polymerization reaction using PHB depolymerase. The lactones showed various reactivities and none of them larger than 6-membered δ -valerolactone showed polymerization activity. On the other hand, there are several reports on the ring-opening polymerization of the large-size lactones using lipases. The different reactivity between PHB depolymerase and lipase can be explained on the basis of tertiary structural model of the active site of each enzyme.

In the chapter five, details of the ring-opening polymerization of BL using lipase were studied. It was found that yielded P(3HB) has linear and cyclic structures, and that (*R*)-BL was more quickly polymerized compared to (*R,S*)-BL in producing the P(3HB).

In this study, several kinds of biodegradable aliphatic polyesters have synthesized by enzyme-catalyzed ring-opening polymerization. It was revealed that the catalytic amino acid residues of the enzyme are responsible to the enzyme-catalyzed polymerization. The catalytic reactivities and the interactions between enzyme and substrate were discussed using tertiary structure model. These studies suggest that the enzyme engineering may establish the novel precision polymer synthesis.