4-9 Promising Biodegradable Plastic for Industrial Applications

— OFF-ON Control of Biodegradability in Polymer with Radiation and Chemical Modifications —

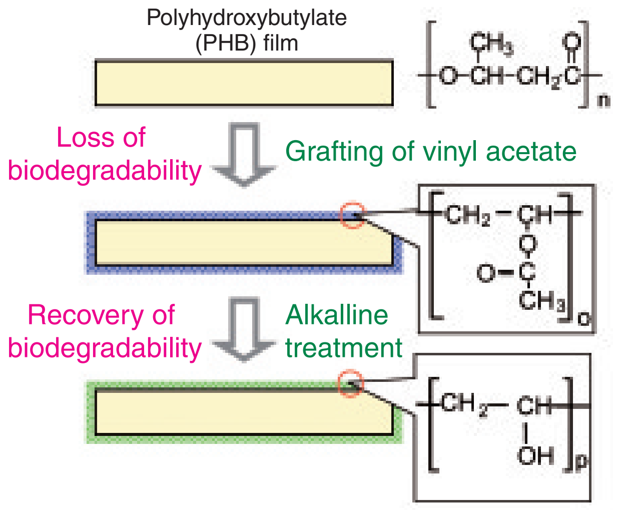

Fig.4-21 OFF-ON control of biodegradability in PHB by graft polymerization
Biodegradability of PHB film was suppressed by surface grafting of vinyl acetate (VAc). Alkaline hydrolysis converts grafted VAc to biodegradable polyvinyl alcohol. As a result, VAc-grafted PHB recovers its intrinsic biodegradability. This technique can provide a polymer, which is not degraded during use but which when discarded becomes degradable after alkaline treatment.

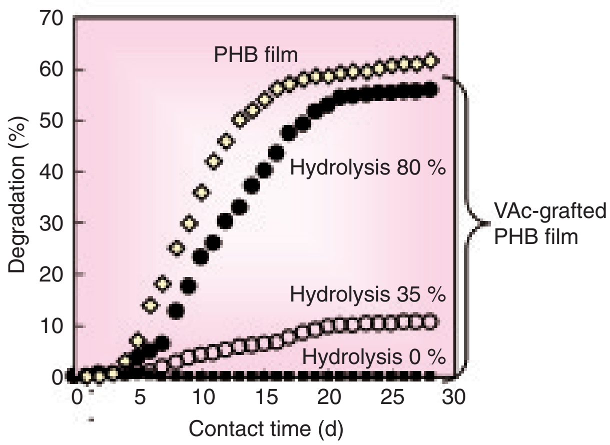

Fig.4-22 Effect of hydrolysis on biodegradation of PHB film grafted by VAc
VAc-grafted PHB did not show any biodegradation. Hydrolysis of VAc-grafted PHB with alkaline treatment induced biodegradation. The increment of hydrolysis increased the biodegradation of VAc-grafted PHB. Biodegradability of VAc-grafted PHB after 80% hydrolysis was equivalent to that of PHB alone.

Biodegradable plastic is attractive as an environment-friendly polymer, which is finally decomposed, to water and carbon dioxide in the ground. In Japan, 6,000 tons of biodegradable plastic, 10% of world consumption, is used annually. Polyhydroxybutylate (PHB) is biodegradable polyester, which is accumulated in the bodies of microorganisms. Though its mechanical strength is the same as that of polypropylene, PHB was rapidly degraded by native microorganisms even in anaerobic conditions. Thus, it has the ideal features of a biodegradable polymer, maintaining its mechanical strength like non-biodegradable plastic during use and having its biodegradability induced after disposal by chemical treatment.

Graft polymerization can introduce a polymer chain onto a trunk polymer, as in grafting for trees. In radiation-induced grafting, the active sites in the trunk polymer are produced with electron beams (EB) and γ-rays and reacted with a polymerizable reagent, so that the graft chain propagates. When vinyl acetate (VAc) was grafted on EB-irradiated PHB film, a layer composed of polymeric VAc chains covered the PHB film as shown in Fig.4-21. Although PHB is biodegradable polymer, its biodegradability was lost by the overlay of non-biodegradable poly-VAc , which became 15% of PHB weight. Fig.4-22 shows the biochemical oxygen demand (BOD) of PHB film and VAc-grafted PHB films after various degrees of hydrolysis by alkaline treatment. The VAc-grafted PHB film did not exhibit any biodegradation at all. However, alkaline treatment hydrolyzes the grafted poly-VAc on the surface layer of PHB, changing the poly-VAc to biodegradable polyvinyl alcohol. As a result, VAc-grafted PHB recovered its biodegradability after alkaline hydrolysis. Hydrolysis of 80% of the poly-VAc resulted in the same level of biodegradability as that of the original PHB. Hence, the combination of graft polymerization and alkaline hydrolysis could realize the OFF - ON control of biodegradability. This technique will be applicable to a variety of biodegradable polymers in the future.

Reference

Wada, Y., Tamada, M. et al., Biodegradability of Poly(3-hydroxybutyrate) Film Grafted with Vinyl Acetate: Effect of Grafting and Saponification, Radiation Physics and Chemistry, vol.76, 2007, p.1075-1083.