

Copolymers from L-Lactide and PEG as Fast Resorbing Polymers with High Mechanical Strength

Anja Enderle, Berthold Buchholz

Boehringer Ingelheim Pharma GmbH & Co.KG
55216 Ingelheim, Germany

Statement of Purpose: Over the past few decades, biodegradable polyesters, such as poly(lactide) and its copolymers have been extensively studied for a wide variety of biomedical applications such as orthopedic fixation. They show controllable biodegradability, excellent biocompatibility, and high safety, but a low water uptake and therefore slow degradation resulting from their hydrophobic nature. For some application such as pediatric craniofacial surgery¹, materials are needed with high mechanical strength and faster degradation. The introduction of poly(ethyleneglycol) (PEG) into the hydrophobic polyesters leads to materials with the desired properties and very good biocompatibility². By varying the ratio of polyester to PEG, degradation and mechanical strength can be adjusted.

Methods:

Materials: PEG and monomethoxy-terminated PEG (PEG-MME) with molecular weights from 1000 to 6000 Dalton were purchased from Fluka and stannous octoate from Atochem.

Polymerization: Ring opening polymerization was used to synthesize AB-diblock or ABA triblock copolymers. Appropriate quantities of L-lactide and pre-dried PEG or PEG-MME were molten and a solution of stannous octoate in toluene was added. The catalyst concentration was 80 ppm Sn(II). The polymerization was conducted for 3 days at 120 °C.

Purification: The ground polymer was purified via extraction with supercritical CO₂.

Analytic: Degradation studies were performed at pH 7.4. The test specimens were immersed into phosphate buffer at 37 °C. After predetermined degradation intervals, the test specimens were rinsed with demineralized water and vacuum dried. The degradation was measured by monitoring the decrease in inherent viscosity (iV). The initial iV value is defined as 100 %.

The iV was measured in chloroform (0,1%) at 25 °C using an Ubbelohde-type viscometer.

The mechanical data were measured according to ASTM D 638.

Results / Discussion:

The degradation of the AB diblock copolymer with 1 % of PEG-MME 2000 is only marginally faster than the poly-l-lactide (60 % after 16 weeks). An increase in PEG-MME content to 5% leads to an iV after 16 weeks of 40 %. If an ABA triblock copolymer with PEG 6000 Dalton is used, it makes no difference, whether 1 % or 5 % of PEG are incorporated in the polymer. After 16 weeks the iV is 25 % compared to the initial value.

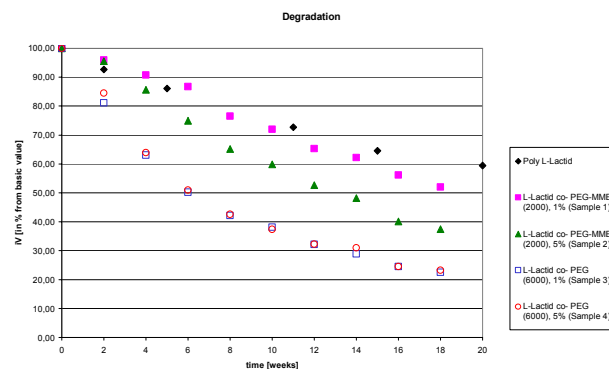


Figure 1: Degradation of different PEG containing Poly-l-lactides

The PEG copolymers can be processed by the same methods as poly-l-lactides, e.g. extrusion. Here, a low residual monomer content is very important to avoid degradation of the polymer during processing.

The tensile strength data presented in table 1 show, that the data from the PEG copolymers are comparable to those of Poly-l-lactide especially, if the PEG content is 1 % (sample 1 and 3).

Sample	iV [dl/g]	Tensile strength [MPa]
1	1,96	84
2	1,12	68
3	2,49	85
4	1,55	73
Poly-l-lactide	2,64	86

Table 1: Mechanical data of different PEG containing Poly-l-lactides

Conclusions:

The results of the degradation tests clearly demonstrate, that by varying the amount of PEG, the nature of the block structure (AB or ABA), and the molecular weight of the PEG the degradation can be adjusted. By introducing only little amount of PEG into the polyester, the mechanical strength is almost not influenced. Therefore ABA and AB block copolymers are very promising materials for a wide range of new applications, where implants with a faster resorption and suitable mechanical properties are desired.

References:

- ¹ S.Cohen, *Neurosurg Focus*, 16(3): Article 12, 2004.
- ² A. Kissel, *Advanced Drug Delivery Reviews*, 54, 2002.