Compliant, Long-lasting, Absorbable Monofilament Sutures of Polyaxial Copolyesters

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Introduction: For various soft tissue applications of synthetic absorbable monofilament sutures, it is desired that the suture be compliant (low modulus) to improve the knotting characteristics and reduce the modulus mismatch between the implant and tissue which can be traumatic and cause an increased inflammatory response. Additionally, the demand for such compliant sutures which exhibit more than 50 percent *in vivo* breaking strength retention (BSR) after 6 weeks has increased with increases in the population of geriatric and diabetic patients. Soft and pliable absorbable polymers are most often made of linear block or segmented copolymers consisting of soft amorphous (B) and hard crystalline (A) blocks/segments in A-B-A or $(A\text{-}B)_n$ arrangements. The B-blocks are usually composed of flexible chains having a glass transition below room temperature giving rise to the soft characteristics of the copolymer, while the A-blocks are usually composed of rigid crystallizable chains providing the physical integrity and mechanical strength. A new approach towards achieving compliant monofilament sutures entailing the preparation of polyaxial copolymers with reduced average crystallite sizes through the use of amorphous polyaxial polymeric initiators was disclosed recently[1]. A similar approach towards achieving a compliant, long-lasting absorbable monofilament suture was pursued using a low-melting polyaxial polymeric initiator to prepare polyaxial copolyesters composed of a low-melting core end-grafted with high *l*-lactide crystallizable blocks. This report addresses the preparation, characterization, and use of such polyaxial copolyesters in the preparation of compliant, long-lasting, absorbable monofilament sutures.

Materials and Methods:

• Polymer and Suture Preparation: Compliant, absorbable polyaxial copolyesters were prepared by the end-grafting of a low-melting polyaxial polymeric initiator (PPI) with an *l*-lactide-rich comonomer mixture in the presence of stannous octanoate as a catalyst. The copolyesters were devolatilized to remove any residual monomer, melt extruded into monofilaments, drawn/oriented, and coated with ε-caprolactone/glycolide copolymer as described earlier[2]. The mechanical properties of the monofilaments were evaluated using an MTS Synergie 200 Universal Tester.

• Evaluation of *In Vitro* and *In Vivo* Suture Properties: The percent *in vitro* BSR was evaluated by determining the breaking strength of the sutures after incubation in a 7.4 pH phosphate buffer at 37°C for predetermined time periods. The percent *in vivo* BSR was evaluated similarly after subcutaneous implantation in Sprague-Dawley rats for predetermined time periods. The sutures were either sterilized by ethylene oxide or sanitized with isopropyl alcohol prior to implantation.

Results and Discussion: The properties of three typical PPIs and corresponding polyaxial copolyesters are given in Table I. The data demonstrate that the PPIs are capable of crystallizing prior to their end-grafting with the *l*-lactide-rich comonomer mixture. However, the degree of crystallization of the PPIs in the monofilaments will depend on the monofilament processing conditions. The data also demonstrate that the *l*-lactide-rich blocks are capable of forming crystallites with melting temperatures typical of *l*-lactide-rich copolymers resulting in levels of crystallinity sufficient to achieve high strength sutures while maintaining a high degree of compliance. The data given in Table II demonstrate the ability of converting the polyaxial copolyesters into compliant monofilament sutures with clinically acceptable breaking strengths and prolonged *in vitro* and *in vivo* BSR profiles. The relatively low modulus, atypical of high *l*-lactide copolymers, is believed to be the result of the reduced average crystallite size associated with the polyaxial geometry of the molecular chains as well as the relatively soft nature of the PPI. The prolonged BSR profiles, indicated by both *in vitro* and *in vivo* BSR greater than 50% after 8 weeks, can be attributed to the slow rate of hydrolysis characteristic of high lactide copolymers.

Table I. Properties of Three Typical PPIs and Corresponding Polyaxial Copolyesters

PPI / Copolyester	A	B	C
Thermal Data			
T_m, °C	48 / 172	47 / 178	47 / 175
ΔH, J/g	43 / 45	34 / 50	39 / 43
Inherent Viscosity, dL/g	- / 2.07	- / 2.29	- / 2.09

Table II. Monofilament Suture Mechanical Properties

USP size	4-0	3-0	2-0	0	1
Initial Properties					
Max Load, N	12.5	22.5	29.6	53.9	53.9
Knot Max Load, N	10.2	20.5	28.5	49.9	53.9
Modulus, Kpsi	310	279	283	264	243
Elongation, %	64	87	90	99	104
In Vitro BSR @ Week					
8	88	74	-	67	78
12	61	53	-	45	55
In Vivo BSR @ Week					
6	102	90	65	82	91
8	91	85	57	82	80
12	70	59	-	52	58

Conclusions: Polyaxial copolyesters have been prepared and shown to be capable of being converted to compliant, absorbable monofilament sutures with clinically acceptable breaking strengths and prolonged *in vivo* breaking strength retention profiles.

References:

1. Shalaby, S.W. U.S. Pat. 6,462,169 (2002).
2. Shalaby, S.W. U.S. Pat. 5,773,563 (1998).