Modulation of the Properties of p-Dioxanone Copolymeric Monofilament Sutures

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Statement of Purpose: Since the successful development of poly-p-dioxanone for moderately absorbing monofilament sutures and ligating clips in the 1970s, there have been a number of studies on p-dioxanone copolymers which did not result in successful medical products.[1-4] The limited progress in the development of p-dioxanone copolymers into new monofilament sutures with special attributes and Poly-Med's recent interest in amphiphilic polyether-esters and polyaxial segmented copolyesters as precursors of unique monofilaments prompted the pursuit of the study subject of this communication.[5,6] Accordingly, this study investigates p-dioxanone-based polyaxial polyesters and polyether-esters and their conversion into monofilament sutures with modulated strength retention profiles.

Methods: Polyethylene glycols (PEGs) with molecular weights between 14,000 and 20,000 daltons were used as polymeric initiators in ring opening polymerization with the intention of decreasing the strength retention profile of homopolymer poly-p-dioxanone (PPD) monofilament suture. The reactions yielded amphiphilic copolymers (USD) with slightly different compositions.
In order to increase the strength retention profile of PPD, multiple p-dioxanone-based polyaxial copolymers were synthesized using both a trimethylene carbonate (TMC) to PDO molar ratio of 95:5 as well as a L-Lactide to PDO ratio of 94:6 in the prepolymers. The prepolymer was then extended by grafted PDO. The reactions yielded polyaxial copolymers (PDX) with different core compositions.
Monofilaments were prepared using a melt extrusion process. Extrudates were heated and drawn to reduce diameter and increase tensile strength by increasing orientation in the axial direction. After orientation, monofilaments were heat treated using a series of annealing and relaxation schemes to increase dimensional stability. Tensile testing was performed using a grip separation of 70 mm and a strain rate of 2.33 mm/s (obtained from USP monograph for testing of absorbable sutures). *In vitro* break strength ratios (BSR) were measured after incubation in phosphate buffer (pH 7.2) at a temperature of 37°C for various time periods.

Results: Compared to Ethicon's homopolymer polydioxanone suture (PDS II®) of similar size which has a BSR of 60%, USD monofilament sutures have a lower BSR ranging from 12-44% at 6 weeks. USD monofilament sutures have predominantly lower strength retention than that of PDS II® suture at 2 and 4 weeks as well. USD monofilament sutures have initial strengths from 43-94 kpsi compared to PDS II® suture strength of 81 kpsi.
Two PDX monofilament sutures have consistently higher BSRs, up to 79% at 6 weeks, when compared to PDS II® suture. Three PDX monofilament sutures have strength retentions greater than PDS II® suture at 2 and 4 weeks. PDX monofilament sutures have initial strengths ranging from 68-81 kpsi. USD and PDX monofilament suture initial strengths and BSRs are tabulated in Table I.

Table I: Comparison of Mechanical Properties

Polymer Name	Diam (mm)	Initial Strength (Kpsi)	*In vitro* BSR at 7.2 pH, 37°C (%)		
			2 Weeks	4 Weeks	6 Weeks
USD1	0.24	94	62	35	12
USD2	0.29	71	36	16	12
USD3	0.37	43	74	61	44
USD4	0.34	80	89	62	28
Ethicon PDS II®	0.33	81	80	70	60
PDX1	0.36	73	86	83	72
PDX2	0.27	80	70	44	31
PDX4	0.28	81	98	92	79
PDX5	0.29	68	69	35	13
PDX6	0.32	75	-	75	60

Conclusions: Using PEG as an initiator, an amphiphilic p-dioxanone copolymer, USD, was synthesized and processed into suture material that has strength retention as low as 20% of PDS II® at 6 weeks *in vitro*. Initial strengths of USD monofilament sutures that are comparable or stronger than that of PDS II® suture can be achieved using the appropriate copolymer composition. In contrast, a poly-axial p-dioxanone copolymer PDX was synthesized and processed into suture material that has strength retention as high as 130% of PDS II® suture. Initial strengths of most PDX copolymers are slightly weaker or the same as PDS II® suture. The successful modulation of poly-p-dioxanone monofilament properties, most importantly the strength retention profile, was achieved during the development of p-dioxanone copolymers. Further development of the processing conditions of the monofilaments could optimize the mechanical properties and yield more desirable results.

References:

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