Effect of a stabilizing absorbable fiber population on electrospun PGLA

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Statement of Purpose: Synthetic absorbable polymers are routinely used as medical implants, scaffolds for tissue engineering and drug delivery devices. Since the emergence and acceptance of the absorbable suture Vicryl™(PGLA 90:10), much work has been performed with this material due to its long history, well known degradation mechanism, non-toxic by-products, as well as its availability in multiple FDA-approved medical devices. Recently, the electrospinning method has generated significant interest in medical device applications as this process can produce micro-fibrous materials with a topography similar to the native extracellular matrix[1-3]. During the electrospinning process, fiber formation occurs on the order of milliseconds, inhibiting polymer crystallization, yielding an unstable material that can undergo morphological and mechanical property changes when exposed to heat[1-2].

This prompted Poly-Med to continue its 12-year history of developing electrospun constructs to generate a thermally-stabilized PGLA 90:10 construct, which allows for sterilization and improves storage stability of this commonly used copolymer. The following demonstrates the benefit of inclusion of a thermally stable absorbable fiber population and its effects on minimizing thermally induced shrinkage and maintaining mechanical properties of electrospun PGLA (90:10).

Methods: Poly(glycolide-co-lactide) (PGLA, 90:10) and poly-dioxanone (PDO) were procured from PURAC and EVONIC respectively. PGLA and PDO solutions were prepared by dissolving in HFIP (Dupont) and electrospinning on a custom electrospinning apparatus using an electric field of 1.75 kV/cm. PGLA and PDO solutions were deposited from an array of separate needles at varying flow rates to generate materials at the following ratios (PGLA:PDO): 2:0, 2:1, 1:1, 1:2, 0:2. Electrospun samples were assessed for morphology, tensile mechanics, free shrinkage, and crystallization.

Results: Electrospun materials were fabricated with varying proportions of either PGLA or PDO. All samples exhibited a fibrous morphology with submicron fiber diameters <1μm) (Figure 1). Inclusion of increasing

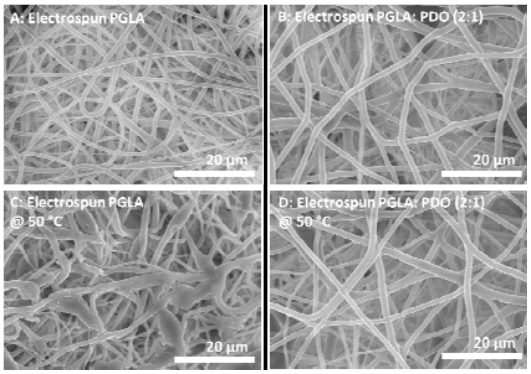

Figure 1A-D: Electron microscopy images of PGLA fiber networks without and with PDO (ratio 2:1) fibers before (A-B) and after being exposed to 50°C (C-D).

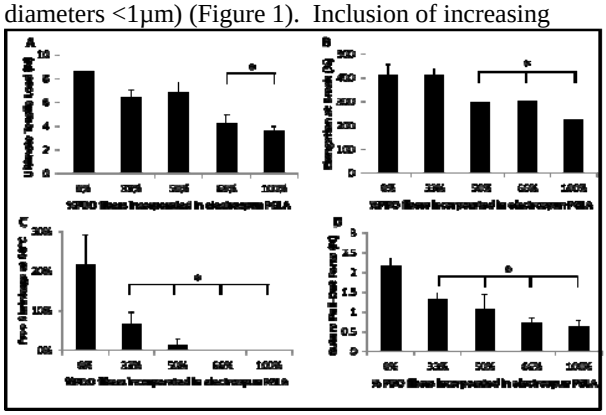

Figure 2A-D: Physical and mechanical properties of electrospun PGLA with varying ratios of PDO fibers. N = 3 per group; * indicates significant difference compared to control PGLA group.

PDO amounts resulted in a thermally stable fabric (Figure 1D) as neat PGLA materials displayed a contraction in pore size and disordered fiber morphology resultant of crystallization within the fiber (Figure 1C). Incorporation of PDO into PGLA at all loading levels, led to a maintenance of both fiber morphology and pore size (Figure 1D). Free shrinkage of electrospun PGLA without PDO possessed an average contraction of 22±8% while inclusion of PDO at 33% loading content significantly lowered this to 6±3% (Figure 2A). At PDO levels of >50%, free shrinkage decreased to less than 2%. Mechanical analysis indicated that incorporation of PDO decreased the ultimate tensile load and elongation at high content levels (>50%) while suture pull-out was lowered at all loading levels (>33%). It was determined that inclusion of 33% PDO exhibited the optimal mechanical properties while minimizing thermal shrinkage. DSC analysis indicated that thermally treated samples had a reduction in crystallization peak (data not shown).

Conclusions: We have demonstrated that inclusion of a stabilizing absorbable fiber population of PDO within electrospun PGLA (90:10) materials can minimize thermally induced heat shrinkage while maintaining mechanical properties. This work determined that the addition of PDO at 33% preserved fiber and pore dimensions and reduced free shrinkage. We foresee the use of varying fiber populations as a means to not only produce robust, thermally stable electrospun materials, but to also influence the long term mechanical performance producing temporal properties in regards to mechanics, resorption, and biological response.

References:

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