# Models to Predict the Resorption Rate of Bioresorbable Textile Scaffolds

Chenxiang LI [1], Chirag GAJJAR [1], Sangwon CHUNG[1,2], Richard PAYNE [3] and Martin W. KING*[1,4]

[1]College of Textiles, North Carolina State University, Raleigh, NC 27695, USA, [2]Korea Institute of Science & Technology Evaluation & Planning, Seoul, South Korea, [3]Tengion Inc., 3929 Westpoint Blvd, Winston Salem, NC 27103, USA, [4]College of Textiles, Donghua University, Shanghai, 201620.

**Statement of Purpose**

Because aliphatic polyester polymers and fibers are bioresorbable, biocompatible and are hydrolyzed into non-toxic products, they are used extensively as suture materials, fixation devices, drug delivery systems and tissue engineering scaffolds. The biodegradation rate depends on i) the intrinsic properties of the polymer, ii) the geometric & morphological characteristics of the device and iii) the hydrolytic or enzymatic environmental conditions. Previous controlled *in vitro* experiments on sutures have demonstrated that the losses in strength and mass during manufacture and after implantation are to some extent predictable [1]. This is not the case, however, with more complex fibrous structures, such as bonded nonwoven webs. Hence the objective of this study has been to develop mathematical models of the resorption behavior of specific nonwoven materials containing aliphatic polyester fibers so as to predict their losses in strength and mass over time on exposure to typical humid manufacturing, cell culture and storage environments.

**Materials & Methods**

Two types of polylactic acid (PLA) hydroentangled nonwoven fabrics with different cross-sectional shaped fibers (round and grooved) were supplied by Allasso Industries Inc., Raleigh, NC. While the two webs had smilar fabric weights, the grooved fiber fabric had about 5 times the surface area of the round fiber fabric, which enhanced its liquid moisture transport through wicking [2]. Over a period of 3 week's the following three *in vitro* hydrolytic and enzymatic environments were controlled at 37°C; i) phosphate buffered saline (PBS) at pH 7.4, ii) a papain enzyme solution in EDTA and cysteine, and iii) a DMEM cell culture media in the presence of calf serum. After each week the PLA fabric samples were monitored for changes in mass, molecular weight (GPC), appearance (SEM), level of crystallinity (DSC), mechanical strength and surface chemistry (ATR-FTIR, XPS).

**Results & Discussion**

After exposure to PBS for 3 weeks, only the PLA web with round fibers showed a decrease in mass of 8%. The other samples showed no significant change in mass, nor did they show any change in molecular weight. Both round and grooved fiber samples experienced some loss in crystallinity as well as a loss of carbonyl stretching bands (FTIR) pointing to evidence of chain scission, particularly when exposed to the cell culture media. Increases in amide band absorption (FTIR) following the treatments with enzymes and cell culture media suggested that proteins were absorbed onto the fiber surface. This was confirmed by SEM and XPS analysis which showed 3-8% nitrogen content for both samples after 3 weeks.

Changes in mechanical properties were observed with both nonwoven fabrics. The round fiber web had a significantly lower strength after 3 weeks in PBS buffer, whereas the grooved fiber web had significantly greater strength and stiffness after 3 weeks of exposure to all 3 degradation environments (Figure 1).

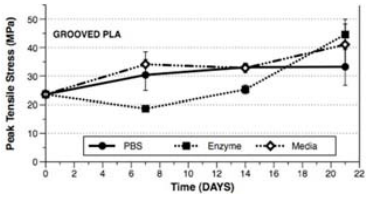


Figure 1: Increases in tensile strength of grooved fiber web during 3 weeks of incubation

**Conclusions & Further Work**

Since the PLA nonwoven web with grooved fibers had a higher surface area and was more hydrophilic than the round fiber web, its mechanical properties and structure were expected to change earlier. This hypothesis, however, was not confirmed. In fact the opposite conclusion must be drawn since the only significant loss in mass was observed when the round fibers were exposed to PBS at pH 7.4. In addition, the grooved fiber nonwoven structure actually gained tensile strength and initial modulus during exposure to enzyme and media cell culture conditions. It is believed that this phenomenon relies on the adsorption of proteins onto the fibers surface, which contributes to mechanical bonding between neighbouring fibers.

In order to distinguish between nonwoven fabric strength loss due to changes in surface friction as opposed to fiber strength loss and polymer degradation, we are planning additional *in vitro* resorption studies on both staple spun yarns and continuous filament yarns. The two yarn samples will enable the development of two separate mathematical models to explain fabric strength loss in terms of surface friction and polymer chemistry respectively. By combining these two basic models it will then be possible to integrate a single mathematical model for predicting the strength loss of needlepunched nonwoven textile materials made from resorbable aliphatic polyester fibers, e.g. polyglycolic acid (PGA).

**References**

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