In Vitro Degradation of Poly(*p*-dioxanone) Fibers: Effects of Size, Temperature and pH

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INTRODUCTION

Absorbable wound closure medical devices play important roles in surgical procedures. Unlike permanent implants, absorbable devices are designed to stay in the body for a temporary duration until tissue/wound healing is completed. An in-depth understanding of their degradation mechanism *in vitro* and *in vivo* is necessary to develop wound closure medical devices of superior performance. Two key degradation properties of an absorbable material are absorption (mass loss) and strength reduction during implantation. These properties are affected by many factors such as chemical composition, processing, molecular weight, morphology, pH, temperature and so on. To better understand degradation behaviors of filament biomaterials, a study was conducted to evaluate effects of size, temperature and pH on *in vitro* degradation of experimental poly(*p*-dioxanone) (PDO) fibers. This presentation reports our findings from the study.

MATERIALS AND METHODS

The experimental materials were three in-house prepared drawn PDO monofilament fibers. The filaments were annealed to give a crystallinity of ~45%, and Eto-sterilized. The initial properties of the samples are provided in Table 1. The fibers were cut into 15-cm long specimens, and placed into phosphate buffer solution of pH7.3 and pH3 at 37°C and 55°C, which generated 3 combined *in vitro* conditions. At each pre-determined time period, 8 specimens were removed from the *in vitro* bath and tensile-tested at room temperature immediately on an Instron tester and an appropriate load cell with gage length 25mm and crosshead speed 25mm/min. The molecular weight (Mw) was determined by gel permeation chromatography (GPC) analysis on Waters 2695, Wyatt Optilab rEx Refractometer, Wyatt HELEOS II Multi-angle Laser Light Scattering Detector, Columns-PL HFIPgel columns (2) with Mobile phase-HFIP with 0.01 M LiBr (0.2% H_2O). For morphology analysis, specimens were gold-coated and scanned under high vacuum at 5 kV using a JEOL JSM-5900LV scanning electron microscope.

RESULTS AND DISCUSSION

Fig 1 shows the changes of breaking strength retention (BSR) with *in vitro* time, fiber size, pH value and temperature. The BSR decreased with increasing exposure time. High temperature and low pH conditions significantly accelerated the degradation of the fibers with the former having larger acceleration factor. It seemed that large size fibers degraded slightly faster with increasing time. Similar trends were observed for Mw changes during *in vitro* degradation (Fig 2). By plotting BSR against Mw, a good relationship was found, as shown in Fig 3, and temperature and pH had no effect on this relationship, which can be described well by the formula[1], $BSR = a + b\ln Mw$, where *a* and *b* are constants. So, from this equation, BSR can be predicted from Mw for the fibers during *in vitro* degradation, or verse versa. Fig 4 illustrates SEM results in this study, which in most cases no significant changes in fiber morphology were observed.

SUMMARY

Effects of temperature, pH and sample size on *in vitro* degradation of three PDO fibers were investigated. High temperature and low pH conditions accelerated greatly the degradation of the materials. A good relationship exists between BSR and Mw for the polymer fibers during *in vitro* degradation. Fiber morphology showed limited changes during degradation.

REFERENCES

1. Biomaterials, 26, p4327 (2005).

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Table 1. Initial Properties of Experimental Fibers

Fiber	Diameter (mm)	Tension Strength (N)	Modulus (MPa)	Mw (g/mol)
1	0.201±0.007	23.40±0.51	1396±70	81490±777
2	0.347±0.005	52.99±2.06	1279±139	78703±541
3	0.452±0.007	81.19±1.80	1102±35	80373±1075

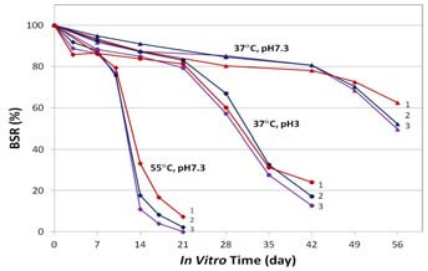

Fig 1. Changes of Tensile Strength during *In Vitro* Degradation

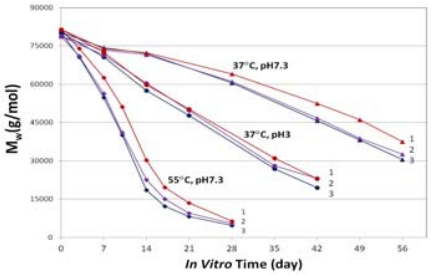

Fig 2. Changes of Molecular Weight during *In Vitro* Degradation

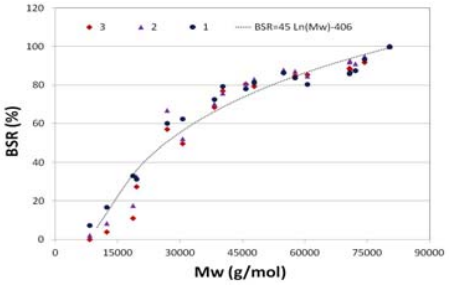

Fig 3. Illustration of Relationship between BSR and Mw

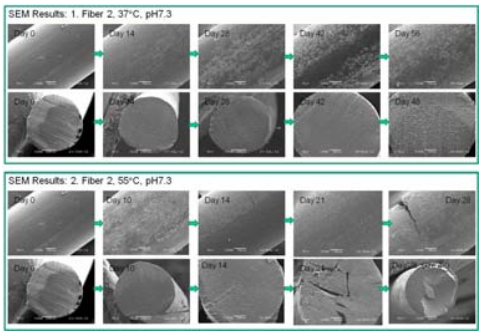

Fig 4. Morphological changes of Fibers during Degradation