Absorbable Solvent-Precipitated Foams and Applications Thereof

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Statement of Purpose: Growing interest in biocompatible scaffolds for tissue regeneration has led researchers to investigate bioresorbable polymers for the production of porous polymeric constructs and foams using a variety of methods[1-3]. The potential biomedical applications for porous polymeric foams include scaffolding for bone and cartilage regeneration, templates for organ generation, and time-release drug delivery systems. The benefit of porous bioresorbable materials is that they serve as templates for cell deposition in the short term, and then the polymeric scaffolding degrades slowly over a period of time (predetermined by composition) to leave behind the developed cellular architecture. In an attempt to produce microporous scaffolding for biomedical applications, Poly-Med has developed porous bioresorbable foams from a polyaxial co-polyester and polyethylene glycol (Avg Mn = 4600, abbrev. PEG 4600).

Methods: Homogeneous polymer solutions were prepared by dissolving polyaxial poly(L-lactide-*ran*-glycolide-*ran*-trimethylene carbonate) and PEG 4600 in acetone or methyl acetate to create a dilute solution. The solution was added to a glass crystallizing dish (100 x 50, Diameter x Height), followed by the immediate and careful addition of a non-solvent mixture to elicit precipitation. The resulting polymer-solvent system was allowed to dry at room temperature for 24 hours. Subsequently, foams were removed from crystallizing dishes and dried at RT in a vacuum oven for at least 48 hours to remove all traces of solvent. Dried foams were observed using optical microscopy (2.5x and 10x magnification) and scanning electron microscopy (100x to 4000x magnification) to determine pore structure, distribution and size within the foam interior. Density measurements were performed using the Arrhenius method. Volume displacement was measured by adding 0.5 gram to 1.5 gram samples to a graduated cylinder containing deionized water. The displaced water was also removed with Pasteur pipette and weighed as a duplicate measurement for volume of sample. From herein, foams prepared from acetone and methyl acetate will be abbreviated A-Foams and M-Foams, respectively.

Results: A-Foams and M-Foams demonstrated marked differences in porosity, overall density, and matrix surface smoothness. Based on SEM imaging at magnifications of 100x to 4000x, it appears that M-Foams contain fully interconnected pores, whereas A-Foams appear to be only semiporous. Two distinct pore types were found in A-Foams: large pores of approximately 10-20 µm in diameter that were distributed between the pervasive polymeric matrix, and a second smaller pore type (1-3 µm in diameter) distributed within the matrix scaffolding itself. M-foams, however, contained only one pore type of approximately 20-30 µm in diameter, and this pore type appeared to be evenly distributed throughout the foam. These differences in porosity coincide with the density variations between foams, as presented below in Table 1.

Table 1. Density values for A-Foams and M-Foams.

Foam Type	Density (g/mL)
A-Foam	0.35±0.01
M-Foam	0.27±0.01

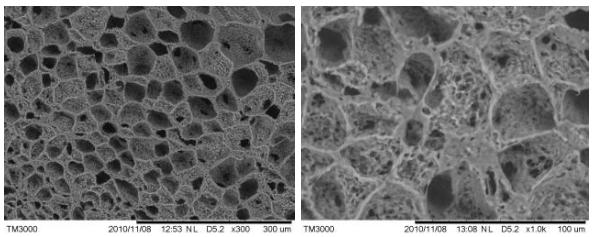

Figure 1. SEM images of the interior surface of A-foams viewed at 300x (left) and 1000x (right) magnification.

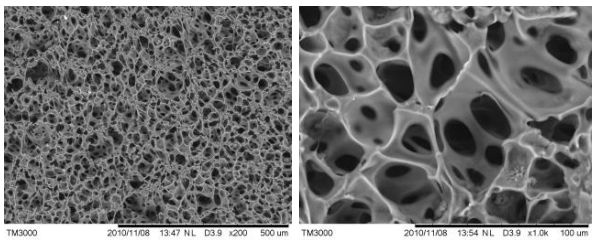

Figure 2. SEM images of the interior surface of M-foams viewed at 200x (left) and 1000x (right) magnification.

Conclusions: By using two different solvents systems to prepare foams from a polyaxial co-polyester and PEG 4600, we were able to affect the porosity, density, and matrix architecture. Semiporous A-Foams, with two distinct pore types and a rough matrix surface, were prepared using acetone as the dissolution solvent and had the highest density of the two foam types. Fully porous M-Foams, with a single pore type and a smooth matrix surface, were prepared using methyl acetate as the dissolution solvent. Thus, Poly-Med has found that porous and semiporous microcellular polymeric foams can be successfully prepared from bioresorbable polymers using a solvent-precipitation method, and this method can be tailored to affect pore size and density of the final material. In future studies we intend to increase pore sizes, to investigate pore distribution using modeling software, and we intend to study the ability of similar foams to elicit cell seeding within the foam architecture.

References:

1. Shalaby, S.W. et al, U.S. Patent 5,847,012 (1998).
2. Vyakarnam et al., U.S. Patent 6,306,424 B1 (2001).
3. Mikos, A.G., U.S. Patent 5,522,895 (1996).