Effects of Particulate Integration and Mandrel Size on the Structure and Mechanical Anisotropy of Electrospun Constructs

Nicholas J Amoroso[1,4], William R Wagner[1-4], and Michael S. Sacks[1,4]
[1]Department of Bioengineering, [2]Department of Surgery, [3]Department of Chemical Engineering and [4]The McGowan Institute, University of Pittsburgh, Pittsburgh, PA 15219, USA

Introduction

Concurrent electrospinning of polymer fibers while electrospraying living cells has been recently introduced to provide the ability to rapidly fabricate highly cellularized engineered tissue constructs. [1] To date, this technique has not been closely studied to evaluate its effects on the mechanical properties and structure of these constructs. Here we present a detailed analysis of the effect of cell and particulate micro-integration on the construct microstructure and mechanical anisotropy.

Materials and Methods

Electrospun constructs were fabricated using an experimental setup similar to that described previously [1]. Briefly, poly(ester urethane)urea (PEUU) was electrospun onto one of two steel cylindrical mandrels rotated at similar tangential velocities. Concurrently, a known concentration of polystyrene microspheres, vascular smooth muscle cells, or sterile media was electrostatically sprayed onto the mandrel in a perpendicular orientation to the polymer. Constructs were then sectioned and mechanically tested using a biaxial testing device described previously. [2]

Results

In **Fig. 1** a cross-section of a microsphere integrated construct shows the microstructure surrounding the microspheres. Polystyrene microspheres were utilized as rigid bodies in order to elucidate an upper to the effect of particulate inclusion. Unexpectedly, we observed that decreasing mandrel diameter produced reversed mechanical anisotropy (Fig. 2) at the same tangential velocity. This effect is maintained with the inclusion of particulates(Fig. 3).

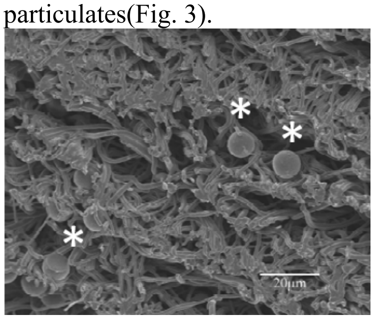

Fig. 1 Cross-section of a microsphere (indicated by *) integrated construct.

Discussion and Conclusions

We have demonstrated that a change in the mandrel geometry can induce high levels of mechanical anisotropy in a scaffold at very low tangential velocities that would not normally induce these behaviors.[2] Presumably, this effect results from changes in polymer fiber architecture due to bending to conform to a smaller diameter mandrel, and has the greatest effect on the preferred fiber direction. Moreover, the levels of anisotropy are comparable to those induced by high mandrel rotational velocities [2], and may allow for the development of mechanically anisotropic cellular infiltrated elastomeric scaffolds without rapid mandrel speeds.

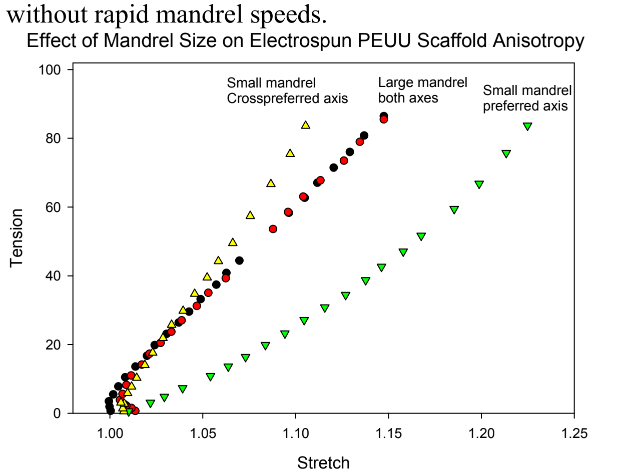

Fig. 2 Biaxial mechanical results depicting the change in the preferred direction following decreased mandrel size

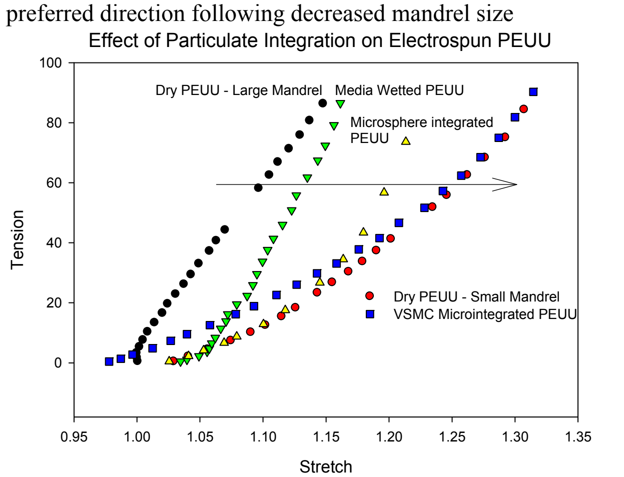

Fig. 3 Biaxial mechanical results depicting the change in the preferred direction following particulate integration.

References:

1. Stankus J.J. et. al. Biomaterials 27, 735, 2006.
2. T. Courtney, M.S. Sacks, J. Stankus, J. Guan, and W.R. Wagner, Biomaterials, Vol. 27, pp. 3631-3638, 2006.

Acknowledgements

Special thanks to the Center for Biological Imaging at the University of Pittsburgh, specifically Jonathan Franks for his help with SEM imaging. Funding source NIH grant HL68816.