Composite Bilayers Fabricated from Electrospun Silk Fibers and poly(dimethyl siloxane) for Vascular Graft Applications

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Introduction

While synthetic polymers have been extensively studied as substitutes in vascular engineering, they currently fall short of meeting the biological challenges at the blood–material interface. Various tissue engineering strategies have emerged to address these flaws and increase long-term patency of vascular grafts. By using grafts with an intimal surface of Eri silk fibers and reinforced with poly(dimethyl siloxane) we hope to address this challenge.

Figure 1. Comparison of various silk types, including: bombyx, eri, tussah, and muga; image source: https://www.treenwaysilks.com/kc-aboutsilk.php

Materials & Methods

Electrospinning Parameters for Fiber Production

- Eri silk was dissolved in 1,1,1,3,3,3-hexafluro-2-propanol (HFIP) to obtain a 12% w/w solution.
- 20 cm distance, 23 cm lateral motion, 0.8 mL/h flow rate, 16 kV

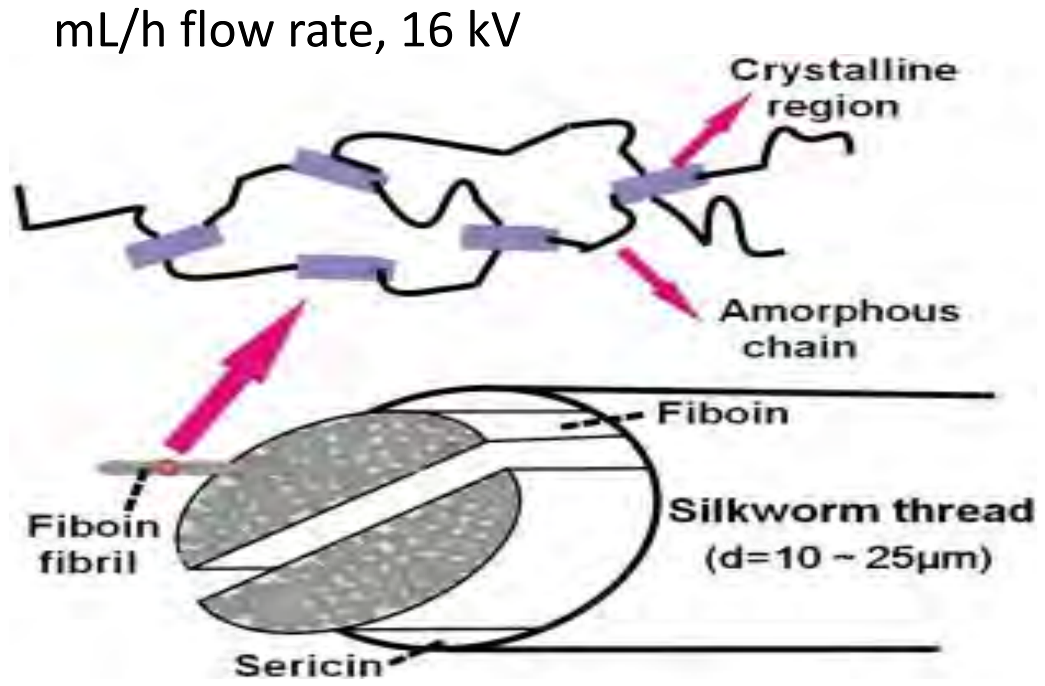


Figure 2. (above) Schematic representation of the sericin shell around the fibroin core. This sericin core must be removed before further downstream processing.

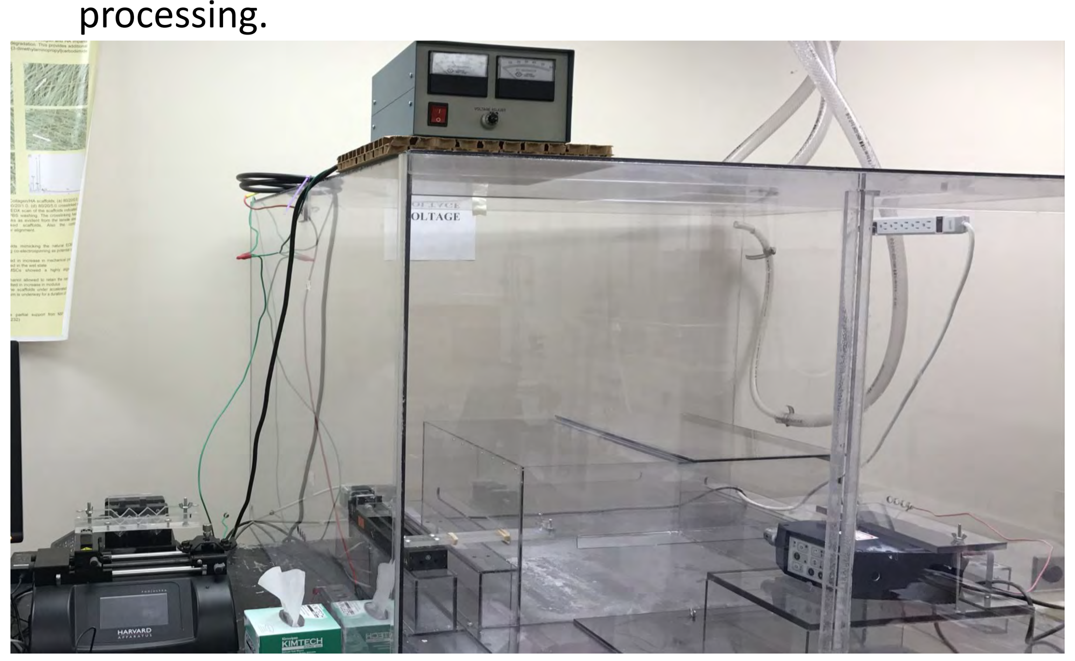


Figure 3. Electrospinning instrument featuring custom code (Python) to control syringe pumps, and lateral actuator. High Voltage supply is regulated DC.

Results & Discussion

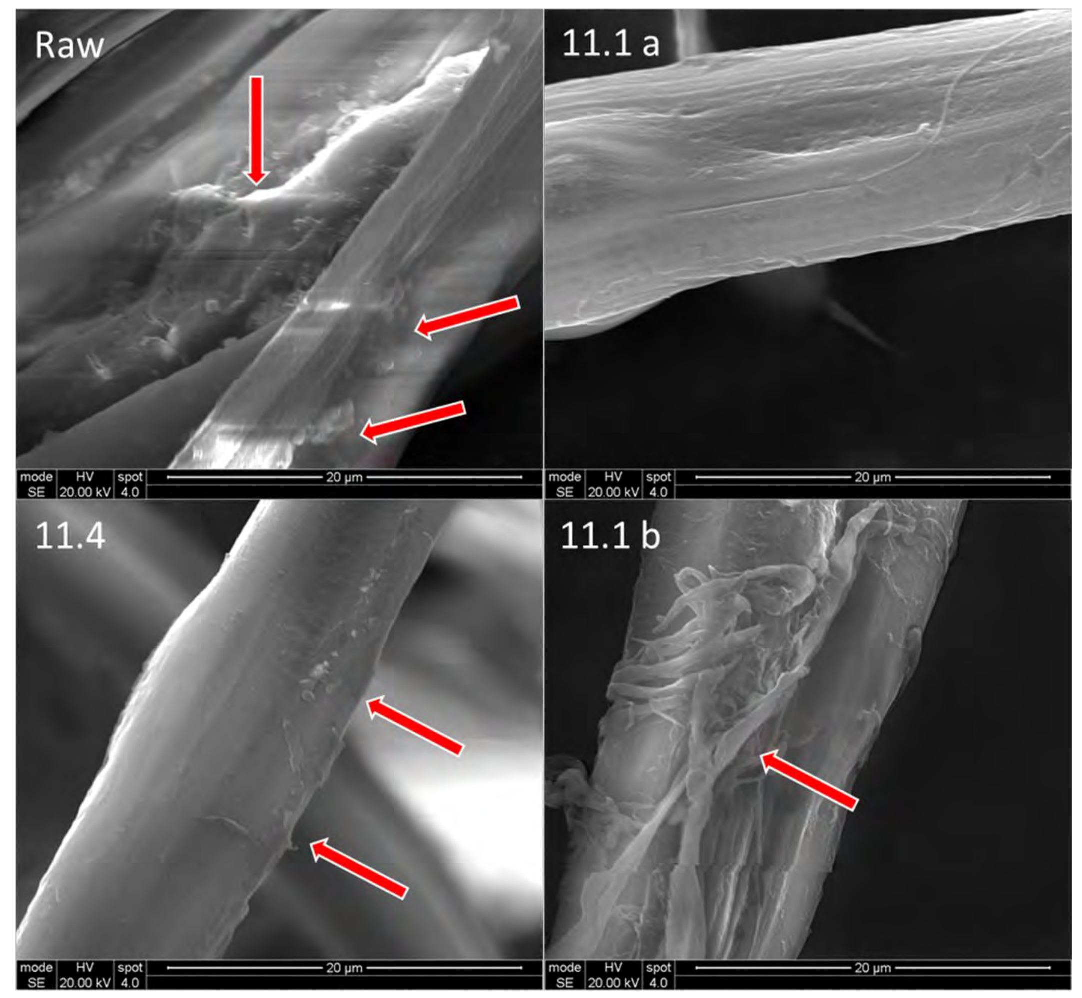


Figure 3. Scanning electron micrographs (SEM) of alkaline treated silk fibers. Treatments were conducted at pH 11.4 and 11.1

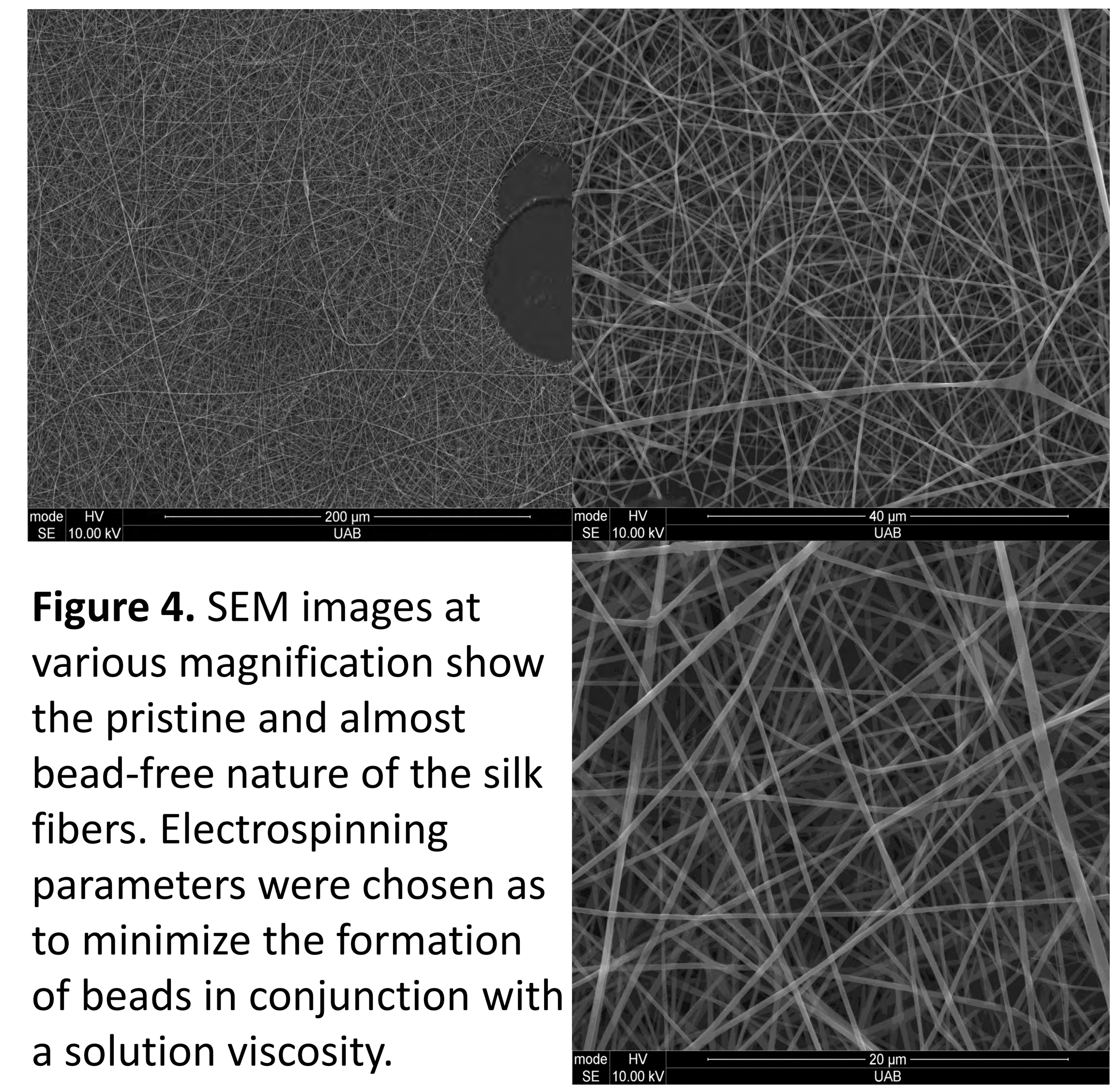


Figure 4. SEM images at various magnification show the pristine and almost bead-free nature of the silk fibers. Electrospinning parameters were chosen as to minimize the formation of beads in conjunction with a solution viscosity.

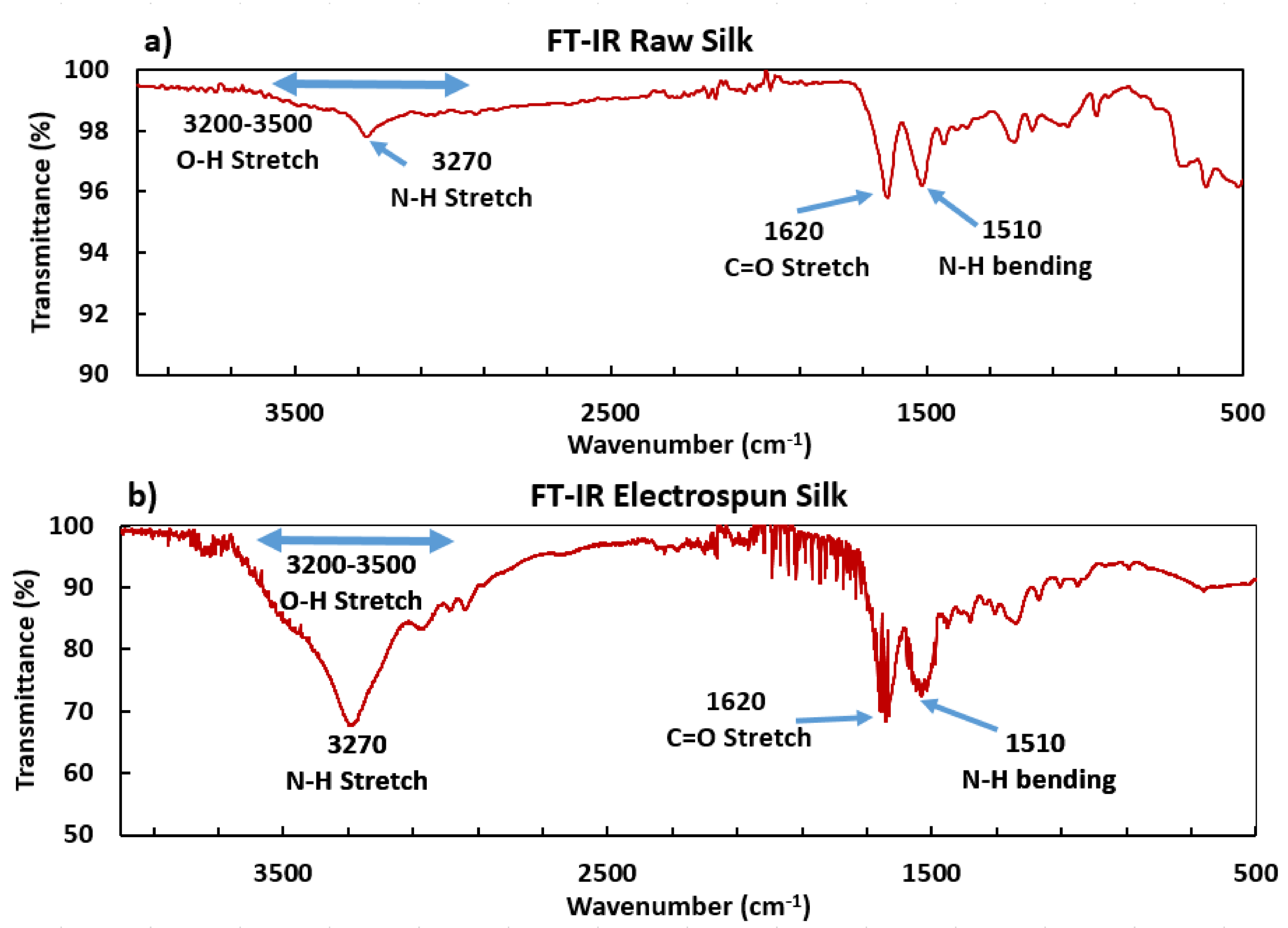


Figure 5. Fourier Transform Infrared Spectroscopy (FTIR) of the silk before processing (a) and after processing/electrospinning (b). The expected peaks at 3270, 1620, and 1510, are for N-H stretch, C=O stretch, and N-H bending respectively. The broad 3200-3500 peak is associated with O-H stretching.

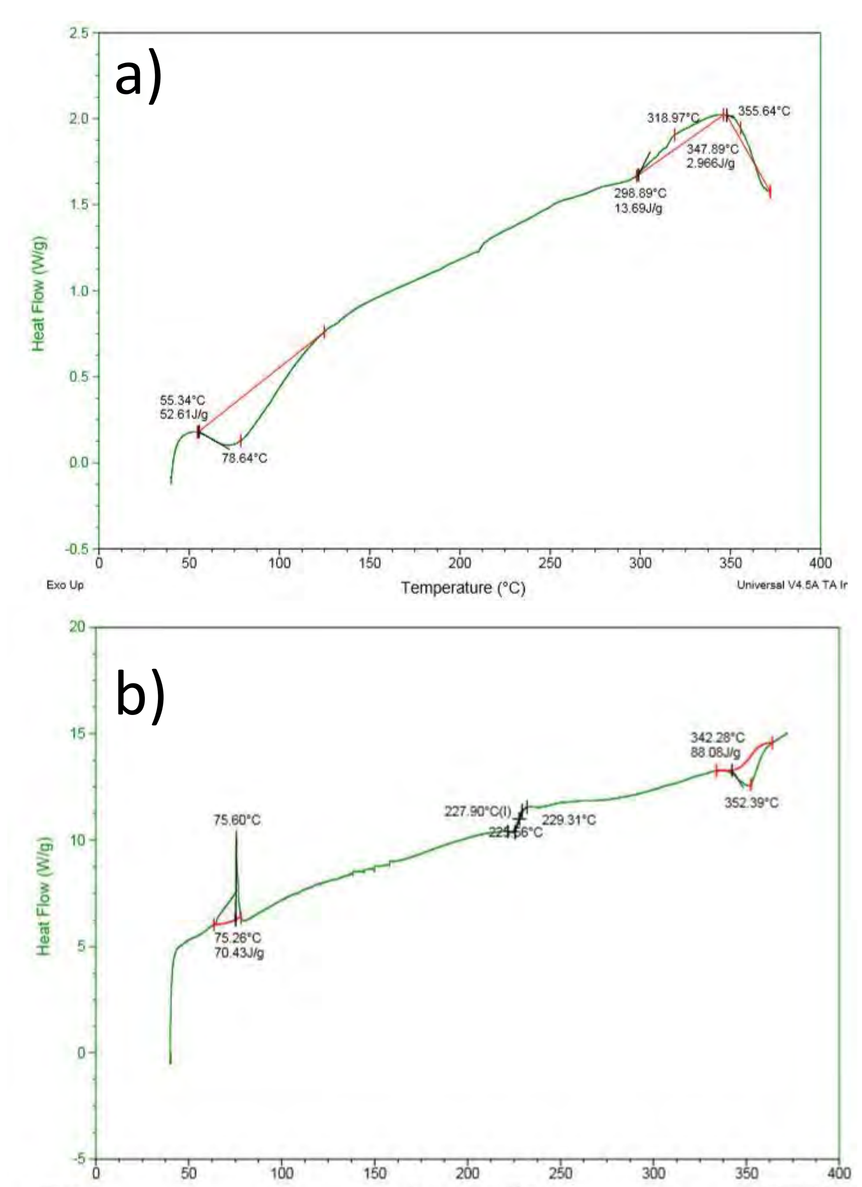


Figure 6. Differential Scanning Calorimetry (DSC) thermograms of raw silk (a) and electrospun silk (b) showing various thermal characteristics of melting, crystallization, and glass transition

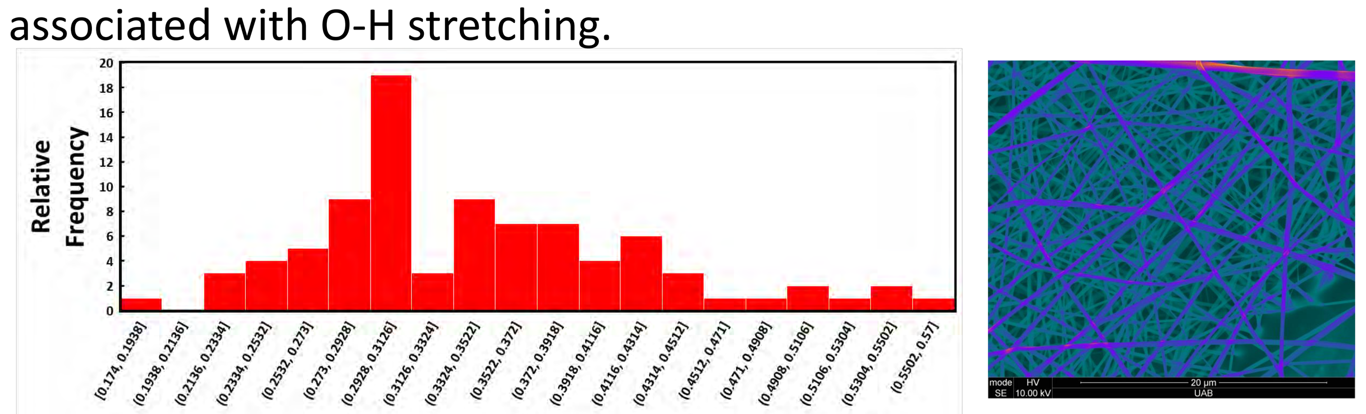


Figure 7. Fiber size distribution analysis. The SEM micrograph is shown in false color (ImageJ) to highlight the foreground fibers (blue) in contrast to background fibers (green); the blue fibers were analyzed for size distribution.

Composite PDMS Grafts

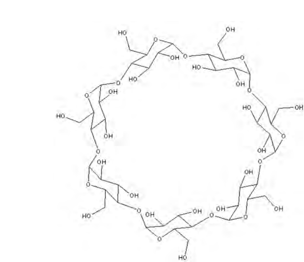
- Silk fibers alone were not mechanically sound
- Addition of PDMS shell improved properties.

Conclusion

- Silk provides an attractive candidate materials for vascular grafts; however, a reinforment phase (PDMS) is necessary.

Future Work

- Incorporation of cyclodextrin to deliver heparin
- Full mechanical characterization
- Process optimization



References

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- Zongqian Wang, et al.,Effect of silk degumming on the structure and properties of silk fibroin, The Journal of The Textile Institute, (2018).

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