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Introduction

The quantitative analysis of the structure of the biopolymer fibrin has many implications in wound healing.⁵ The ability to obtain data about the thickness of fibrin strands in an unbiased empirical fashion will further the understanding of the effect of this aspect on elements of wound healing. Specifically, diameter, or thickness, of the fibrin strand affects the rate of degradation or fibrinolysis of the protein in blood clots.⁴ This degradation of fibrin and the subsequent replacement by collagen determines how the skin will heal and scar.² This project aims to demonstrate an iterative mathematical method that serves to estimate the thickness of fibrin strands based on the Carr-Hermans Method.

Governing Equations

$$\tau(\lambda) = \frac{88}{15} n \frac{dn^2}{dc} c \lambda^{-3} \mu \left[1 - \frac{23}{77} \pi^2 n^2 d^2 \lambda^{-2} \right]$$

where $\tau(\lambda)$ is the turbidity as a function of wavelength, λ . $\frac{dn}{dc}$ is the specific refractive index increment, n is the refractive index, c is the concentration of fibrin, μ is the mass to length ratio, and d is the diameter of the fiber.

Equation 1¹

Equation 1 is the original mathematical representation of the Carr-Hermans method,³ The equation is based on experimental data, and is typically used to estimate the mass length ratio, μ , or to develop Carr-Hermans plots comparing a selection of differently prepared samples.

Assumptions and Heuristics

- The fibrin strands are of a cylindrical geometry and infinitely long¹
- The mass length ratio can be defined as a function of the density of the sample and the cross-sectional area of the fiber, making μ a function of the fiber diameter

$$\mu \sim \rho A_x$$

where ρ is the density and A_x is the cross-sectional area of the cylindrical fiber.

- All other parameters in Equation 1 can be specified through experimentation
- Arbitrary data sets were developed in accordance with fundamental relationships defined by Carr and Hermans, turbidity was then calculated as follows:

$$\tau(\lambda) \propto \lambda^{-3}$$

- Tabulated values of n , $\frac{dn}{dc}$, and c for fibrin were used in conjunction with the wavelengths and their corresponding turbidities to solve for the diameter, repeated 100 times to obtain statistical data on theoretical fiber thickness

Current Data Acquisition

The most prevalent method of obtaining values for the thickness of fibrin strands involves fixing, dehydrating, drying, sputter coating, and imaging samples (figure 1). These images are then analyzed, and the fibers are measured using software, however there is no clear protocol on how to objectively select the specific strands or the locations on each strand that are measured.

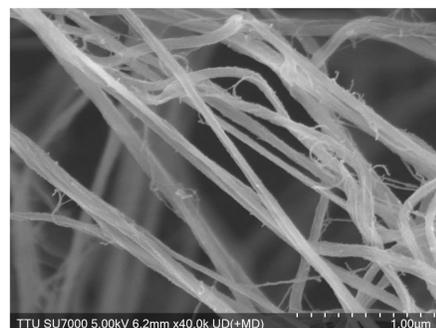
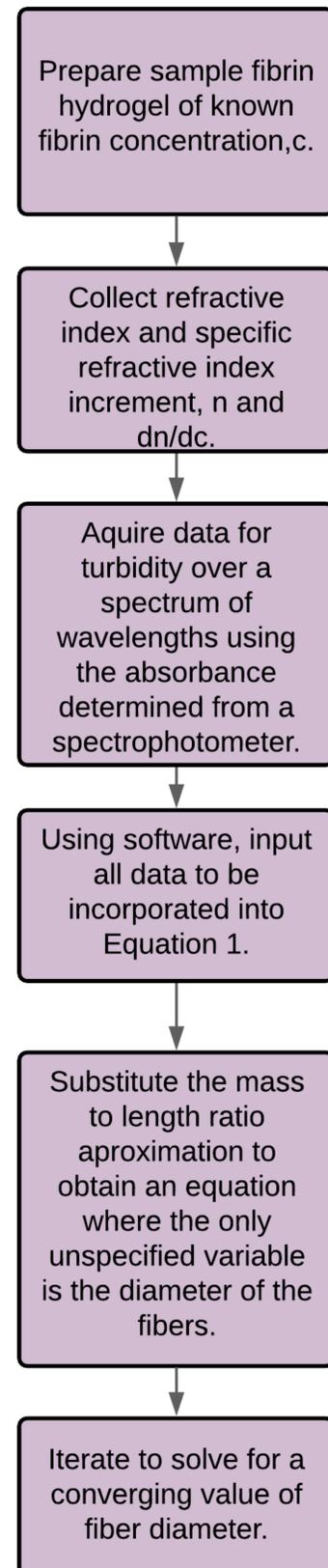


Figure 1 Image, courtesy of Jonathan Garvin, depicting fixed and dehydrated fibrin fibers using a Scanning Electron Microscope.

Procedure



Future Action

The theoretical calculations derived from arbitrary data yield results that would be expected given the nature of the fibrin structure. Next steps will involve the experimental collection of data and the comparison of that data versus the data acquired from current data acquisition methods. These trials should be replicated, and a statistical analysis should be employed in order to determine the accuracy that this method can produce values for fiber thickness.

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