Fabrication of a scaffold from novel tropoelastin-collagen electrospun yarn for skin tissue regeneration

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Statement of Purpose: As the largest organ of the body, the skin's primary function is to serve as a protective barrier against the invasion of harmful substances from the external environment. Therefore, the loss of integrity of skin due to physical or thermal damage can result in wounds affecting local and systemic tissue [1]. Collagen and elastin networks build up most of the extracellular matrix in skin tissue. As the precursor of elastin, tropoelastin (TE) is the main (>90%) component of elastin (Figure1) [2]. It has been reported that the existence of elastin and collagen-based scaffolds results in a decrease in stiffness, modulation of collagen degradation, enhancement of angiogenesis and elastin fiber formation. Therefore, an ideal dermal substitute would be expected to incorporate the mechanical and cell signaling properties of both collagen and elastin to better mimic the native composition and function of human skin [3]. Consequently, this study uses textile technologies, such as knitting, to provide the tools for the fabrication of 3D micro- and macro-scale structures to be used as tissue engineering scaffolds.

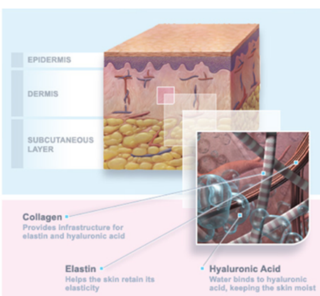

Figure1 Composition of dermis containing collagen, elastin and hyaluronic acid

Methods: Blended tropoelastin-collagen yarns are obtained using an electrospinning technique. Tropoelastin and collagen polymers are dissolved in HFIP at 4°C for 16 hours in 10:90, 20:80 and 0:100 (control) ratios to generate 10% w/v solutions. Then the tropoelastin-collagen mixture is pumped through two 18-gauge needles. The two nozzles connected separately to positive and negative charges are placed on the two sides of the rotating funnel collector. Under high voltage, nanofibers are produced and deposited on the rotating funnel forming a web. A plastic pipette is used to slowly draw the web into a continuous yarn. To design the scaffold for tissue repair, it is proposed to knit a rib structure on a Shima Seiki double needle bed weft knitting machine. The schematic illustration of the basic setup for electro-spinning of the nanofiber yarn is shown in Figure 2.

Results: The structure of the highly aligned electrospun twisted yarn will be visualized under SEM analysis and the anticipated morphology of nanofibrous yarn is shown in Figure 3. Previous studies have shown that the strength of

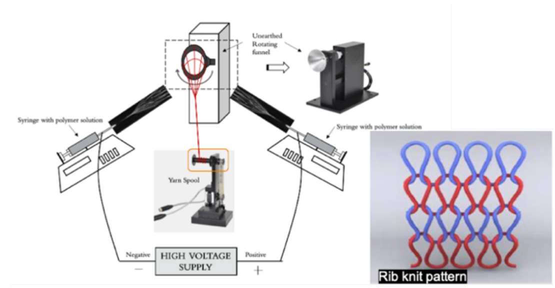

Figure 2 Schematic illustration of the basic setup for electrospinning nanofiber yarns and knitting pattern

electrospun human tropoelastin web had UTS values of 0.34 ± 0.14 MPa in the circumferential direction and 0.38 ± 0.05 MPa in the longitudinal direction (K.A. McKenna et al., 2012). The introduction of collagen into tropoelastin electrospinning to increase the mechanical performance has been demonstrated by A. C. Ford et al, who found that the low elastic modulus of cross-linked tropoelastin (0.057 MPa) increased to 0.37 MPa with a 1:1 tropoelastin-collagen blend[5].

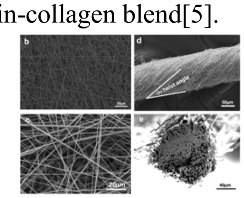

Figure 3 Anticipated result for the electrospun yarn morphology

Conclusions: The blended yarn exhibits both relatively higher Young's modulus and elastic modulus, which provides sufficient tensile resistance for fabrication of weft knitted scaffolds. The elastic modulus of the scaffold for skin tissue regeneration can be significantly improved due to the existence of tropoelastin and a knitted structure with stretchable loops.

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