Electrospun Silk Material Systems for Wound Healing

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Statement of Purpose: The functional properties of six distinct electrospun silk material groups were evaluated to assess conformational and biocompatible characteristics related to wound dressings. In a hydrated state, all six silk matrices exhibited absorption, water vapor transmission, oxygen permeation and enzymatic biodegradation suitable for full-thickness wound sites. Employing constrained drying techniques, silk concentration was a determinate factor influencing material structural properties related to the storage and distribution of such wound dressing systems. Subsequently, three electrospun silk models demonstrated ideal biomaterial properties with potential utility for wound dressings.

Methods: The most useful properties in a full thickness burn wound dressing include the ability to provide an impermeable barrier to bacterial pathogens, manage wound site edema and dehydration, and support time synchronized antibiotic, immunological, and tissue regeneration biotherapies. Capitalizing on the unique fiber morphology of variant electrospun silk/PEO blends, this research explored the conformational and biofunctional properties of six distinct PEO extracted silk material systems for potential utility as full thickness wound dressings. Employing constrained drying techniques, it was discovered that silk concentration played a major role in material structural properties including material thickness, fiber density, fiber orientation, phase dispersion and porosity. Through this drying technique, the S87, S82 and S76 silk percent material groups were transformed into flat pliable membrane-like conformations with minimal surface area loss which are ideal for a distributable wound dressing with a sustainable shelf-life.

Results: In order to maintain a stable homeostatic state, normal skin permeates body fluid at a rate of 204 $g \cdot m^{-2} \cdot day^{-1}$.[1] A full thickness granulating wound has an evaporative water loss of 5,138 $g \cdot m^{-2} \cdot day^{-1}$.[2] It has been determined that an ideal full thickness wound dressing should have a water transmissibility rate of 2,000–2,500 $g \cdot m^{-2} \cdot day^{-1}$ to permit adequate moisture level while preventing excessive dehydration.[2] Referencing the absorption, EWC and water vapor transmissibility properties in Table 5, the constrain-dried S87-S76 materials performed comparatively to proposed sponge-like natural chitosan wound dressings. Although the chitosan/poloxamer dressing candidate exhibited exceptional absorption and EWC properties, these tests were conducted with PBS (pH7.4) at 37° C. Additionally, the oxygen transmissibility disparities between the S87-S76 material systems and the asymmetric and bilayer chitosan materials were attributed to test conditions. OTRs for the chitosan derivatives were tested in dry conditions at 0% RH whereas dH_2O saturated silk materials were evaluated in a hydrated environment at 80% RH to emulate an exovasating wound environment. Until a clinical evaluation is performed, it is unknown whether the oxygen permeation trait of this biomaterial is sufficient to inhibit infection and promote thrombosis.

Since normal human skin regenerates in about 21 days, the goal of the biodegradation study was to evaluate the enzymatic degradation times of these silk materials in order to facilitate full-thickness wound epithelialization by employing a multi-layer wound dressing delivering time released biotherapies. Results revealed that after 14 days the S87-S76 matrices degraded 80% which compared favorably to the lysozyme exposed chitosan/poloxamer dressing which degraded 82% over the same time period. In contrast, the PLGA/PLLA (90/10) co-block polymer system only had a 20% degradation rate after 14 days in PBS. However, it is important to assess degradation rates in vivo, as enzyme levels will vary significantly, and it has been shown that silk biomaterials can degrade in weeks to years in vivo depending on material format, location and related variables.[3] Finally, although the constrain-dried S87-S76 material systems exhibited pore throat sizes below .3 μm^2, factoring in biodegradation, it is unclear how long these material systems will provide an impermeable barrier to gram negative bacilli and gram positive cocci sepsis initiating bacterial pathogens.

Conclusions: The goal of this study was to evaluate the physical and bio-functional properties of six electrospun silk material systems in order to create an effective full thickness wound dressing. Although the absorption, water vapor transmission, oxygen permeability, and biodegradability properties for all six S87, S82, S76, S67, S61 and S57 silk percent material systems were useful for wound dressing applications, after constrained drying techniques, only the S87, S85 and S76 models displayed conformational properties suitable for the handling and distribution of wound healing systems.

References:

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