Electrospun Bio-derived Polysaccharides and Proteins for Wound Healing Applications

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INNOVATION SCHOLARS

Background

- Proliferation and remodeling are the last stages of the wound healing process.
- Healing progresses on the cellular level, during these stages with the restoration of vascular function and formation of new skin & connective tissue.
- The vascular system is restored due to a combination of cell migration and replication.
- In the late proliferation phase, granulation tissue forms, filling wound gaps with a **scaffold**.
- Remodeling begins shortly after, building upon the scaffolding base.
- Dextran, a biocompatible polysaccharide, is frequently used in tissue engineering and wound healing research.
- Natural proteins and polysaccharides have demonstrated effectiveness in medical applications
- Fish skin grafts have been used to treat burns and diabetic foot ulcers, showing significant benefits in supporting wound healing.
- **Project Goal: To engineer a patch with dextran that will support adhesion and movement of cells throughout the proliferation and remodeling phases of wound healing.**

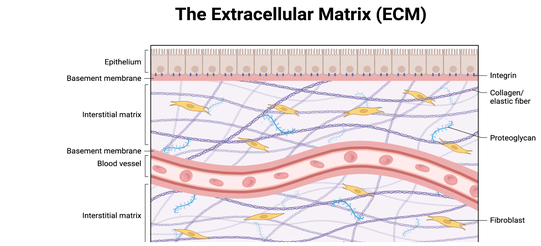

Figure 1: The extracellular matrix as a scaffold for cell adhesion and growth

Materials and Methods

Patches were prepared by chemically modifying dextran into dextran methacrylate (DexMA) and solubilizing this solution in an ethanol/water mix. Once thoroughly **vortexed** and **sonicated**, the solution was moved into a dark room where a light sensitive photoinitiator (LAP) was added. The final solution was then electrospun using a blunt tip needle and a 5mL syringe, dried, and carefully peeled off the collector plate. The sheet was cut up and cured under a UV light to activate the photo initiator, increasing the mechanical strength of the patches.

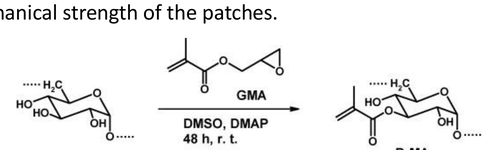

Figure 2: Dextran methacrylate synthesis.

Materials and Equipment:
- Bryson 8300 Ultrasonic cleaning bath
- Gamma High Voltage ES30P-20W
- New Era Pump System Inc.
- Stainless steel collector plate

Electrospinning Configuration

Optimized spinning parameters:
- 30% vol ethanol in DI water
- 25 weight% Dex-MA (88%)
- 11 cm distance between syringe tip and plate
- .28 mL/hr syringe flow rate
- 14 kilovolt applied voltage
- 20-gauge syringe

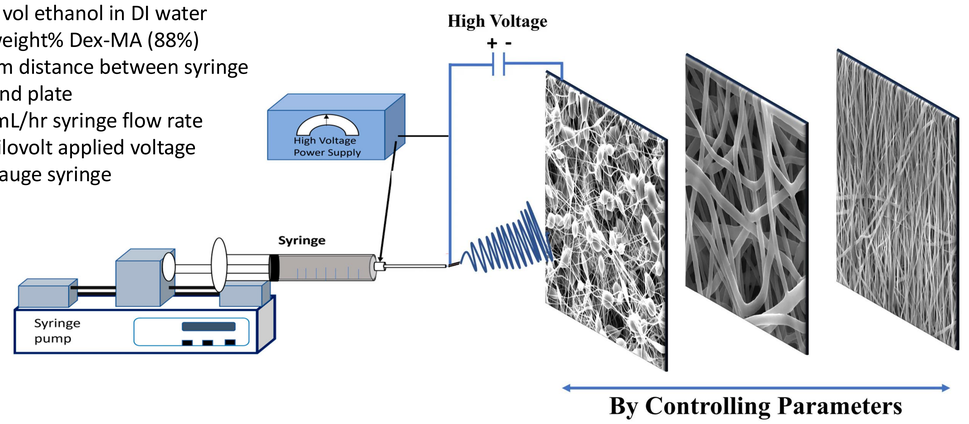

Figure 3: Parameters such as mass flow rate, applied voltage, and syringe gauge influence nanofiber properties.

Scanning Electron Micrographs of Electrospun Dex-MA

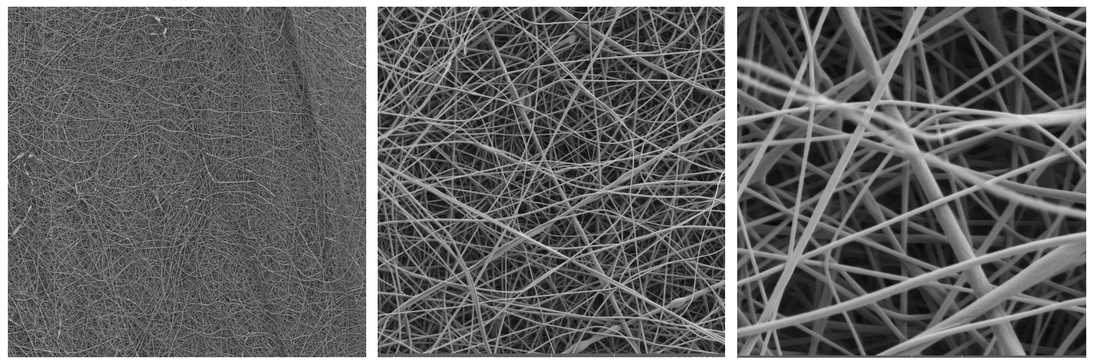

Figure 4: Scanning Electron Microscope Images of Dextran Methacrylate at 500x, 5kx, and 20kx magnification.

Cell Culture Confocal Microscopy

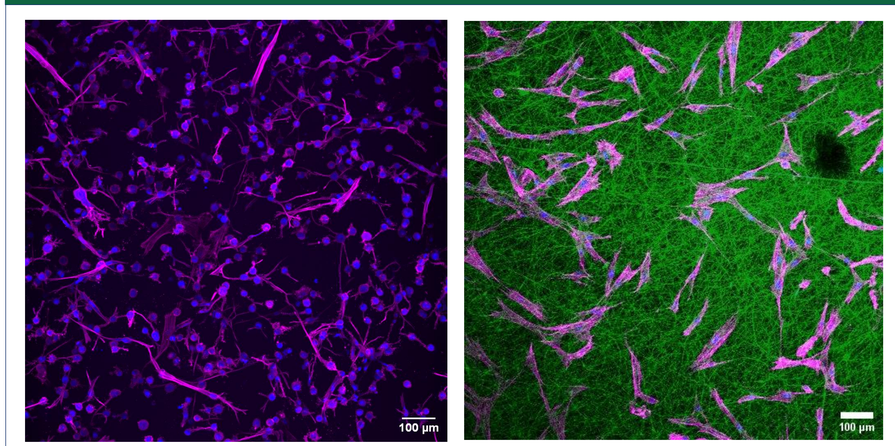

Figure 5: Human dermal fibroblast adhesion on standard-fabrication Dex-MA hydrogel (left) compared with increased adhesion and cell spreading (right). Actin filaments are stained with phalloidin (purple), and nuclei are stained with DAPI (blue). Dextran exhibits green autofluorescence.

Future Directions

Fucoidan Addition:
- Biocompatible polysaccharide derived from brown algae
- Expresses bacteriostatic properties, limiting the possibility of infection

Integration of Naturally Derived Proteins:
- Using biocompatible properties of salmon-derived fibrinogen to enhance biological functionality

Investigation of Material Properties:
- Evaluating the patch's elastic modulus to determine how much it can compress or stretch without impacting the connection to skin

Patch Adhesion:
- Potentially adding an adhesive cover to secure the patch to the skin, adding a hygroscopic material to improve moisture retention

Figure 6: Fibrinogen protein, found in ECM

Conclusions

The limiting factor in scalability is the need for further optimization the of the spinning process. The primary issue with current parameters is that the solvent evaporates too quickly, creating a build up at the tip of the syringe that grows over time, requiring frequent pausing of spinning to wipe the syringe tip off. To fix this, adjustments in water to ethanol ratio with respect to ambient humidity must be investigated. Patient-ready bandages would require sterilization, which may be achieved via ethylene oxide sterilization before aseptic processing and packaging.

Figure 7: Standard Industrial Ethylene Oxide Sterilizer (left) and Industrial Electrospinner (right)

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