Cellulosic Nanocomposite as a Potential Scaffold in Cardiovascular Tissue Engineering

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**Motivation**
Cardiovascular diseases (CVDs) lead the number one cause of death worldwide from the common diseases such as
- Atherosclerosis upon the deposition of plaque inside the wall of arteries
- Aneurysm from the ballooning of the weakened arterial walls
- Thrombosis through the coagulation of blood flow and clothing in unbroken vessels

Innovative Revascularization Techniques;
- Autograft Bypass (limited availability of healthy grafts)
- Synthetics (thrombogenic for smaller diameter < 6 mm vessel)
- Natural Substitutes (lack of compliance to physiological homeostasis)
- Tissue-Engineered Vessels (a promising approach)

**Objective**
Designing a Cardiovascular Scaffold with an Excellent Mechanical /Thermal Performance Reinforced by the Aligned Nano-sized Cellulose Whiskers within a Magnetic Field.

**Background**
Crystalline Cellulose: a Potential Avenue of Success in Cardiovascular Tissue Engineering due to its superior characteristics;
- The most abundant renewable biopolymer on earth yet possessing an environmentally benign nature
- Hydrophilic nature from the high density of the attached hydroxyl groups
- Biodegradable and Biocompatible
- Almost non-coagulative or thrombogenic
- Tear resistant and moldable with a low inner surface roughness
- Strong mechanical behavior in wet state and stable functionality for years
- Mechanically comparable to other reinforcing fibers while distinguishing a biocompatible composite for biomedical applications;

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (GPa)</th>
<th>Elastic Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber</td>
<td>4.8</td>
<td>86</td>
</tr>
<tr>
<td>Steel Wire</td>
<td>4.1</td>
<td>207</td>
</tr>
<tr>
<td>Graphite Whisker</td>
<td>21</td>
<td>410</td>
</tr>
<tr>
<td>Carbon Nanotubes</td>
<td>11 – 63</td>
<td>270 – 970</td>
</tr>
<tr>
<td>Cellulose Crystal</td>
<td>7.5</td>
<td>145</td>
</tr>
</tbody>
</table>

**Materials and Processing**
The Synthesis of Cellulose Whiskers in our Nano-Materials Lab;
- Initiating from both Cellulose and Micro Cellulose Crystalline (MCC) precursor
- Acid hydrolysis of the cellulose chains incorporating a 62% Sulfuric Acid ($\text{H}_2\text{SO}_4$) concentration upon heating
- Purification and refinement of the solid residues by the repeated cycles of centrifugation
- Repeated cycles of dialysis against distilled water to achieve pH of 5-6

**Results**
A Preliminary design of the Nanocomposite through:
- grafting the synthesized Cellulose Nanowhiskers into a Cellulose Acetate Propionate Matrix
- casting the composite films within and outside a controlled magnetic field of 0.3T
- performing the nonlinear tensile testing and Thermogravimetric Analysis (TGA) to observe the Mechanical/Thermal performance of the systems

**Conclusion**
The addition of Cellulose Nano-Crystals at only 0.2 Wt% presents an Improved Mechanical Performance yet intensifies to about Four-Fold upon the alignment of Nano-Fibers within a small field of 0.3T.
- The Biomedical applications of Cellulose and its derivatives in Drug delivery and Wound dressing could confirm the Biocompatibility and Biodegradability of our designed scaffold.

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