Chitosan, PLA, and PCL Composite Material for Biomedical Applications

Abdulrahman M. Al-Shami[1], Ali S. Alshami[2],
[1]Biomedical Engineering, [2]Chemical Engineering, University of North Dakota, Grand Forks, ND

Statement of Purpose: Can a biobased, biocompatible, and bioresorbable 3D-dimensional scaffolding structure be developed as a suitable platform for natural cells growth and proliferation? This research aims to answer this question. Developing three-dimensional structures of natural cells is a highly sought-after substitute for damaged human tissues and their regeneration process. However, these alternative cells require scaffolding platforms to provide a suitable proliferation environment and guide tissue growth. Biopolymers and synthetic polymers offer attractive properties to prepare functional scaffolds for tissue engineering applications. For example, chitosan (CS) (biopolymer) is biocompatible, low cost, abundant in nature, has an antimicrobial effect, and has high cell adhesion. Polylactic acid (PLA) is known for its cytocompatibility and non-toxic degradation products. Additionally, Polycaprolactone (PCL) is biocompatible, biodegradable, and relatively elastic. Nevertheless, these polymers still suffer from several significant drawbacks, especially when used alone. When neat, Chitosan can be very brittle and nonrobust; PCL suffers from a slow degradation rate, low cell adhesion poor antibacterial and mechanical properties; and PLA exhibits low elasticity, low cell adhesion, biological inertness, low degradation rate, and acid degradation by-products. Albeit, successful blending and synthesis of a composite material comprising CS-PAL-PCL has the potential to overcome the stated drawbacks, and result in reliable scaffolding material for medical applications [1,2].

Methods: the solvent casting method was used to prepare nine neat and composite constructs of PLA, PCL and Chitosan polymers from 1% (W/V %) of chitosan in 0.5 M acetic acid, 5% (W/V %) of PLA in chloroform, and 5% (w/V %) of PCL in chloroform. Polymer types and content ratio of the produced films were varied on a dynamic basis based upon response feedback from obtained properties. The chemical, optical, mechanical, properties of the produced films were investigated using SEM, ATR-FTIR, UV.VIS, Nanoindentation, and TGA characterization techniques. Also, solubility and material thicknesses were quantified, and the antimicrobial effects of each construct was assessed and numerically quantified against Gram-positive (S. aureus) and Gram-negative (E. coli) bacteria.

Results: The characterization results demonstrate the successful synthesis technique to produce neat, two and three-polymers-based composite constructs. Also, Results showed that properties of the composite material are tunable by manipulating polymer blends compositions. These constructs demonstrated outstanding antimicrobial effects, which make them promising for future biomedical, as well as for food packaging applications. A set of preliminary results are depicted in **Figure 1**.

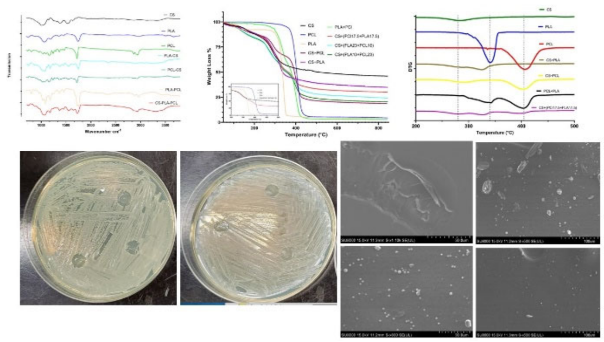

Figure 1: Selected results of the characterization analysis for the composite films.

Conclusion: Blending PLA, PCL, and CS polymers produce an adjustable approach to prepare biodegradable, biocompatible, antibacterial films with a wide range of mechanical, thermal, and physical properties. These films can be used in the future as scaffolds for different human tissues and environment-friendly food packages.

References:

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