Blow Spinning deposition of silicon nitride and metalized nanomaterial for multifunctional wound healing applications

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Statement of Purpose: Wound healing is a critically essential but complex process requiring intense or prolonged medical intervention to achieve positive clinical outcomes. In addition, the increasing prevalence of chronic nonhealing wounds places a significant burden on a patient's quality of life and sizeable financial strain on healthcare providers, especially as the treatment options are limited. Metal nanoparticles have gained popularity as an alternative treatment for reducing microbial infections over the past decade, making them essential in wound healing applications. Halloysite nanotubes (HNTs) and metal nanoparticles have been shown to enhance polylactic acid (PLA) and possess antibacterial properties (Humayun and Mills 2020; Luo et al. 2020). This research aimed to fabricate antimicrobial blow spun fibers to facilitate wound healing and reduce microbial infection.

Methods: A patented electrodeposition process was used to coat magnesium (Mg) on the HNT outer surfaces to add additional antimicrobial properties and favorable mechanical properties due to the addition of HNTs. Gentamicin sulfate was vacuum loaded into the lumen of the HNTs, which has already been coated with Mg for additional antimicrobial properties by the tubular entrapment method. Silicon nitride (Si_3N_4), which is not cytotoxic, was added to the Gentamicin loaded Mg/HNT to promote cell adhesion and differentiation. To form a fiber solution, the combination was dissolved with PLA in Dichloromethane/Acetone (1:1). The fiber was blow spun onto a square (4 in X 4 in) sterile gauze using the solution blow spinning technique. Distribution analysis of Si_3N_4, Mg/HNT, and PLA was performed using a digital microscope, SEM, and EDS. Material characterization (SEM and FTIR) was used to confirm the presence of Mg on the HNT outer surface. The antimicrobial activity of the blow-spun fibers was tested against *Escherichia coli* and *Staphylococcus aureus* using the microtitration method before and after the addition of Gentamicin. Evaluation of the blow spun fibers on Human fibroblast cells was carried out; Scratch assay was used to analyze in vitro cell migration, Live/dead assay was carried out to estimate the cell viability, and the proliferation assay was carried out for seven days. A porosity test was carried out using the liquid displacement method.

Results: FTIR and SEM images showed the presence of metal on Halloysite. Cytotoxicity test shows that our fibers are not toxic to mammalian cells. The results of the antimicrobial activity show that coating the HNT with Mg before loading with Gentamicin sulfate produces lower bacteria inhibition because the metals block the surface of the HNT lumen, hindering the drugs from entering the HNT, but when loaded with Gentamicin sulfate before Coating with Mg, it shows a pronounced inhibition of bacteria growth. Cell proliferation assay showed that Si_3N_4 enhanced proliferation. Our fiber also cures the wound created, which was indicted by the scratch assay. The porosity test showed that the addition of Si_3N_4 does not affect the porosity and the cell attachment. Further tests are currently being carried out on the fabricated fiber, including animal studies.

Conclusions: Fabricated fiber-containing Si_3N_4/Mg/HNT/PLA/DCM: Acetone showed great prospect when compared to fabricated Mg/HNT/PLA/DCM: Acetone fiber and Si_3N_4/PLA/DCM: Acetone fiber because each component brought significant advantages to the fiber, such as inherent antimicrobial properties that can reduce the spread of infection and able to support the growth and collagen formation in biological systems, biodegradability, favorable mechanical properties and they are eco-friendly and low-cost materials. Our favorable results suggest that our composite fiber may have multifunctional applications in biomedical use as a wound dressing material to reduce microbial infection, enhance wound healing, and be used for drug delivery.

References:

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