25TH NATIONAL & 11TH INTERNATIONAL ANNUAL CONGRESS ON RESEARCH AND TECHNOLOGY OF IRANIAN MEDICAL SCIENCES STUDENTS
URMIA UNIVERSITY OF MEDICAL SCIENCES, URMIA, IRAN

Antibacterial and Electroconductive Silver Chloride-Loaded PVA-Based Electrospun Nanofibers for Wound Healing Applications

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ABSTRACT

Introduction: Infected wounds showcase an immature healing process, putting the patient at a high risk of systemic or local infections, inflammatory responses, and incomplete healing of the wound site. Due to the rapid emergence of drug-resistant microorganisms, extensive antibiotic administrations resulted in major drawbacks that have driven the design of progressive therapeutic dressings with antimicrobial activity to apply as a system for the delivery of antimicrobial agents. Recently, designing and fabricating nano-sized fibers with high surface area that are loaded with a wide variety of active pharmaceutical ingredients (APIs) have been extensively considered in previous literature and used as dressing materials due to the high porosity with pore-interconnectivity, which can mimic the extracellular matrix. The present work aims to fabricate and fully characterize the silver chloride (AgCl)-loaded polyvinyl alcohol (PVA) nanofibers as an antibacterial and electroconductive wound dressing scaffold by electrospinning technique.
Methods and Materials: The PVA nanofibers were produced by the electrospinning method, and AgCl was incorporated within nanofibers via an in-situ reaction between silver nitrate ($AgNO_3$) and sodium chloride (NaCl) during the fiber-forming process. The resultant nanofibers were thoroughly characterized by different physicochemical techniques, including scanning electron microscopy (SEM), Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) method, thermal gravimetric analysis (DSC and TGA), four-probe resistance meter, etc. The functional characteristics of nanofibers were evaluated by various in vitro experiments like in vitro degradation, swelling, and water retention assays, drug loading and release studies, antibacterial tests, hemocompatibility assays, and MTT tests.
Results: The resultant AgCl-loaded PVA nanofibers in this study exhibited highly uniform and randomly oriented morphologies with smoothed-surface structures. The physicochemical characterization of the constructed nanofibers confirmed the desired chemical, structural, thermal, and mechanical properties of the resultant nanofibers. The electrical conductivity of the PVA/AgCl nanofibers exhibited a more than two-fold increase compared to silver-free nanofibers. The silver release profiles of nanofibers exhibited a two-phase release profile over the experiment time. Proper hemocompatibility (less than 5% of blood cell rupture), antibacterial activity, and desired cytocompatibility (more than 80% cell viability) were observed through hemolysis assay, antibacterial experiments, and MTT assay.
Conclusion and Discussion: The results of this study confirmed that the prepared AgCl-containing PVA nanofibers possess desired physicochemical and wound healing characteristics and could be considered as potential wound dressing for the management of infectious wounds. On the other hand, the resultant nanofibers showed higher hemocompatibility and cell viability as well as good antibacterial activity against two representative strains of Gram-negative (Escherichia coli) and Gram-positive (Staphylococcus aureus) bacteria, which are desired characteristics for application in the treatment of infectious wounds.

Citation:
Abazari M, Momeni Badeleh S. Antibacterial and Electroconductive Silver Chloride-Loaded PVA-Based Electrospun Nanofibers for Wound Healing Applications. *Iranian biomedical journal*. Supplementary (12-2024): 5.

Keywords: Polyvinyl alcohol, Silver, Wound healing

[DOI: 10.61186/ibj.25th-11th-IACRTIMSS]