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Research Article

Quality-by-Design Optimization of Electrospinning Parameters to Formulate Scaffolds for Topical Inflammatory Disease Management *via* Drug Repurposing

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ABSTRACT

This study investigates the fabrication of chitosan (CS)/polyvinyl alcohol (PVA) blend nanofibers *via* electrospinning, aiming to create nanofibers with enhanced properties for broad applications. The research focuses on optimizing electrospinning parameters to reduce bead formation and achieve uniform nanofiber morphology. A detailed experimental design, employing a nineteen-point plan developed with Design-Expert software, examined variables such as polymer concentration, distance from the needle to the collector, the required voltage, and the rate at which solution was ejected from the needle. Morphological characteristics of the nanofibers were analyzed using advanced microscopy, complemented by drug release and wound healing assessments. The optimal electrospinning conditions were determined to be a 1:3 CS/PVA solution concentration ratio, an 8 cm needle-to-collector distance, a 20 kV applied voltage, and a 1-mL/hour flow rate. Scanning electron microscopy revealed uniform nanofibers with 100 to 250 nm diameters devoid of bead defects. *In-vitro* analysis demonstrated a sustained release profile of azilsartan (AZL), while *in-vivo* studies on rats indicated enhanced wound healing, corroborated by histological examination. The findings suggest that CS/PVA nanofibers, fabricated under these conditions, possess promising characteristics for use as a drug-delivery scaffold in wound treatment applications.

Introduction

Skin is susceptible to injury from various sources, including heat and mechanical forces.[1,2] The therapeutic approach to accelerate healing and reduction of scars entails applying wound dressings to cover injured skin areas. The ideal wound dressing material surpasses its role as a mere physical barrier and creates a microenvironment conducive to exhibiting excellent biocompatibility, creating a moist and adsorbent environment, and excellent scaffold formation. The utilization of materials derived from biological macromolecules has garnered increased attention in this context due to their notable biocompatibility, biodegradability, and renewability.[2, 3] Electrospinning is gaining attention for producing nanofibers (NF) with potential therapeutic benefits and lower toxicity than traditional forms. Using electrostatic force, this technology forms high-viscosity polymer solutions into fibers. Biodegradable/bioresorbable NF scaffolds, particularly for wound dressings, show promise in swift healing, outperforming conventional dressings. Their ECM-like morphology allows customization, drug loading, and prevention of biofilm formation. Nanofibers enhance wound healing through attributes like substantial surface area, moisture control, sustained drug delivery, air exchange, and support for cell processes crucial in tissue regeneration.[4-7] Drug-loaded nanofibers play a pivotal role in various biomedical applications. Dwivedi and colleagues[8] developed modified mats with recombinant human epidermal growth factor and gentamicin to address diabetic wound healing. Similarly, Rathinavel *et al.*[9] synthesized amine-functionalized

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