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Designing electrospun shellac nanofibers with mupirocin using the Box-Behnken approach for topical wound care

Nawinda Chinatangkul [a,c], Sirikarn Pengon [a,c], Wantanwa Krongrawa [b,c], Siraprapa Chansatidkosol [b,c], Chutima Limmatvapirat [d], Sontaya Limmatvapirat [b,c,*]

[a] Faculty of Pharmacy, Siam University, Bangkok, 10160, Thailand
[b] Department of Pharmaceutical Technology, Faculty of Pharmacy, Silpakorn University, Nakhon Pathom, 73000, Thailand
[c] Pharmaceutical Biopolymer Group (PBiG), Faculty of Pharmacy, Silpakorn University, Nakhon Pathom, 73000, Thailand
[d] Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Silpakorn University, Nakhon Pathom, 73000, Thailand

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ABSTRACT

This study attempted to develop shellac (SHL) nanofibers containing a topical antibiotic, mupirocin (MP), as an alternative wound healing material. The impacts of formulation and process parameters such as SHL concentration, MP content, and applied voltage on the morphology of fibers were examined based on a 33 Box-Behnken experimental design with triplicate center points. The results indicated that the amounts of polymeric SHL and encapsulated MP were considered factors affecting the morphology of fabricated fibers, including size and bead ratio. As the concentrations of SHL and MP increased, the large-sized fibers would be obtained. Meanwhile, the appearance of beads would be lessened with the enhanced amount of SHL. The excellent encapsulation of MP in SHL carrier was indicated by the high entrapment efficiency (88.12 ± 0.09% - 109.93 ± 3.23%) which might be possibly due to the ultrafine network and microporous structures of nanofibers and the good affinity of MP for entrapping between the polymeric SHL as referred to the results of the characterization study. According to the assay of antimicrobial activity, S. aureus, the leading cause of wound infection, was entirely killed since 5 min after exposure to the SHL nanofibers loaded with MP, and the regrowth of living S. aureus was not found throughout the next 6 h. Therefore, the SHL nanofibers containing MP seemed to be an effective wound dressing with high encapsulation efficiency and potential antimicrobial activity against S. aureus over a period of time.

1. Introduction

The healing process of a wound is impaired by infection, which could prolong the inflammatory phase, a distinct stage of the normal healing process, leading to the prevention of subsequent proliferative phase by an enhanced macrophage function [1]. The development of advanced wound dressing materials with an excellent antimicrobial activity, which could protect wounds from both local and surrounding infections, seemed to be challenged. The electrospun nanofibers have been recently used in wound healing management due to their small diameter structure, thus providing high specific surface area and pore interconnectivity. In addition, the nanofiber wound dressing would maintain a moist wound environment, contributing to the rapid healing process by shortening the inflammatory phase of wound healing, preventing scab formation, decreasing the pH of the wound surface, and also providing growth factors, white blood cells and enzymes to facilitate wound healing [2]. According to previous studies, shellac (SHL) nanofibers have been successfully fabricated [3,4]. Based on its natural origin, SHL has been considered a non-toxic and harmless material [5]. Recently, SHL has been mainly used in tablet and fruit coating applications ascribable to its excellent protective property [6,7]. Thus, SHL might be an effective carrier of therapeutic agents for the treatment of wounds.

Recently, the incidence of nosocomial pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) associated with wound chronicity, especially in burn wounds, has become a serious clinical problem, leading to considerable mortality and morbidity worldwide [8]. Mupirocin (MP), an effective antimicrobial agent produced from *Pseudomonas fluorescens*, is mainly active against cutaneous infection with Gram-positive bacteria, including *Staphylococcus aureus* and *Staphylococcus epidermidis* [9,10]. It has been shown to be effective in the elimination of MRSA [9,10]. However, the generality of the Gram-negative

* Corresponding author. Department of Pharmaceutical Technology, Silpakorn University, 6 Rachamankra Road, Ampur Mueng, Nakhon Pathom, 73000, Thailand.
E-mail address: limmatvapirat_s@su.ac.th (S. Limmatvapirat).

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