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Research Article

Preparation and Characterization of Chitosan Nanoparticles-Doped Cellulose Films with Antimicrobial Property

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Cellulose films with antimicrobial property were prepared by incorporation of chitosan nanoparticles as antimicrobial agents into the cellulose films. The antimicrobial property of these chitosan nanoparticles-doped cellulose films against *Escherichia coli* (*E. coli*) was evaluated via diffusion assay method, minimum inhibitory concentration (MIC) method, and minimum bactericidal concentration (MBC) method. The effects of antimicrobial agent amount, size-related property (nanoparticles and bulk chitosan), and crosslinking by citric acid on antimicrobial activity of cellulose films were studied. It was observed that the antimicrobial activity was enhanced when chitosan nanoparticles were used as compared to when bulk chitosan was used. A maximum *E. coli* inhibition of 85% was achieved with only 5% (v/v) doping of chitosan nanoparticles into the cellulose films. Crosslinking of the cellulose films with citric acid was observed to have resulted in 50% reduction of water absorbency and a slight increase of *E. coli* inhibition by 3% for chitosan nanoparticles-doped cellulose films.

1. Introduction

Most microbes are harmful and can cause numerous disease infections such as diarrhea, respiratory illness, whooping cough, and fever [1]. Noble metals (silver, copper, and zinc) and natural products (essential oil, biopolymer, and organic acid) are among the antimicrobial agents available for prevention of microbial infection [2, 3]. Antimicrobial films were required to prevent microbial growth in food for food packaging industry, wound dressing in medical devices, and clothing in textile industry and footwear industry [4, 5].

Chitosan was commonly used as an antimicrobial agent and blended with other polymer films to produce antimicrobial films. Some examples are cellulose/chitosan [6], starch/chitosan [7], starch/chitosan/lauric acid [8], guar gum/chitosan [9], polyethylene oxide (PEO)/chitosan [10], and glucomannan/chitosan/nisin [11]. Chitosan inhibited and suppressed microbial activities through their electrostatic charge interaction between positive charges on polycationic chitosan molecules (amino groups) with negative charges on microbial surface [12]. This interaction caused disruption on the microbial cells, which then changed their metabolism and led to cell death [13, 14]. However, chitosan was not used in nanoparticulate form. The small size of chitosan nanoparticles rendered them with unique physicochemical properties such as large surface area (providing more cationic sites) and high reactivity and thus could potentially enhance the charge interaction on the microbial surface and lead to more superior antimicrobial effect [15]. Some researchers have incorporated chitosan nanoparticles into starch and hydroxypropyl methyl cellulose (HPMC) films to prepare antimicrobial films. However, their works have focused on the effect of chitosan nanoparticles doping on the film barrier and their mechanical properties. They concluded that the improvement of antimicrobial films properties was attributed to the good interaction between chitosan nanoparticles and polymeric-based films [16, 17]. However, it is also useful to investigate the effectiveness of chitosan nanoparticles-doped antimicrobial films against microbial activity.