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Preparation and biocompatibility of a chitin nanofiber/gelatin composite film

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ABSTRACT

The development of chitin-based materials with favorable mechanical properties and biocompatibility is an important research goal owing to the wide-ranging practical applications. In this study, a composite film was prepared using chitin nanofibers and gelatin. The CNF/gelatin composite film was highly viscous and had a fine nanofiber structure. The transmittances indicated high transparency, regardless of nanofiber content. The water content of the CNF/gelatin composite film increased linearly as the gelatin content increased. Although the CNF/gelatin composite film did not induce severe inflammation, it strongly induced fibroblast proliferation, indicating high biocompatibility. Based on these results, the films are suitable for biological applications, e.g., tissue engineering, medicines, and cosmetics.

1. Introduction

Chitin (β-(1-4)-poly-*N*-acetyl-D-glucosamine) is a widely distributed polymer [1]. It is the major structural component in the exoskeleton of crabs, shrimp shells, and the cell walls of fungi and yeast [1]. As chitin does not dissolve readily in common solvents, it is often converted to its more highly deacetylated derivative, chitosan [2–4]. Recently, various methods for chitin nanofiber (CNF) and chitosan nanofiber preparation have been developed [5–10]. Moreover, the biological activities of chitin and CNF have been reported [5–10]. The nanofibers have high cytocompatibility and various biological effects, such as wound healing and efficient adherence to the skin. Superficially deacetylated CNFs enhance the wound healing process [11,12]. According to Ito et al. [13], the application of CNF to the skin improves the epithelial granular layer and increases granular density. It also reduces the production of transforming growth factor β [14]. The topical application of CNF suppresses skin inflammation in an atopic dermatitis model [14]. It also suppresses neutrophil migration to the skin [14].

Chitin, chitosan, and these nanofibers can be easily processed into various products, including hydrogels, membranes, beads, micro/nanoparticles, scaffolds, and sponges [5,15]. Recently, some reports have indicated the efficiency of chitosan/gelatin composite films [16–19]. Fakhreddin Hosseini et al. [16] found that chitosan significantly increased the tensile strength and elastic modulus, leading to stronger films as compared with gelatin films, but significantly decreased the elongation at break. Chitosan drastically reduces the water vapor permeability [17]. Benbettaïeb et al. [17] demonstrated that composite films exhibit favorable water vapor barrier and oxygen barrier properties. Chitosan/gelatin composite films exhibit high antioxidant activity, as monitored by β-carotene bleaching, DPPH radical-scavenging, and reducing power activities [18]. Moreover, films containing chitosan exhibit higher antimicrobial activity against gram-positive bacteria than gram-negative bacteria [18]. However, the preparation and application of CNF and gelatin composite films have not been described. In this study, CNF/gelatin composite films were prepared and their biocompatibility was evaluated.

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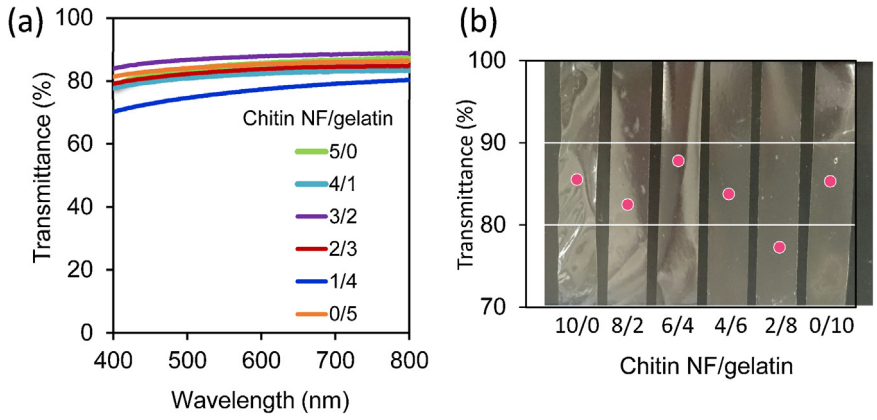

Fig. 1. The numbers in index of Fig. 1(a) means regular light transmittance (%) and wavelength (nm). They were described in the figure and figure caption as follows. Fig. 1(a) Regular light transmittance spectra of chitin NF/gelatin composite films with a different content. (b) Appearances of the composite films and their transmittances at 600 nm (red circle). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

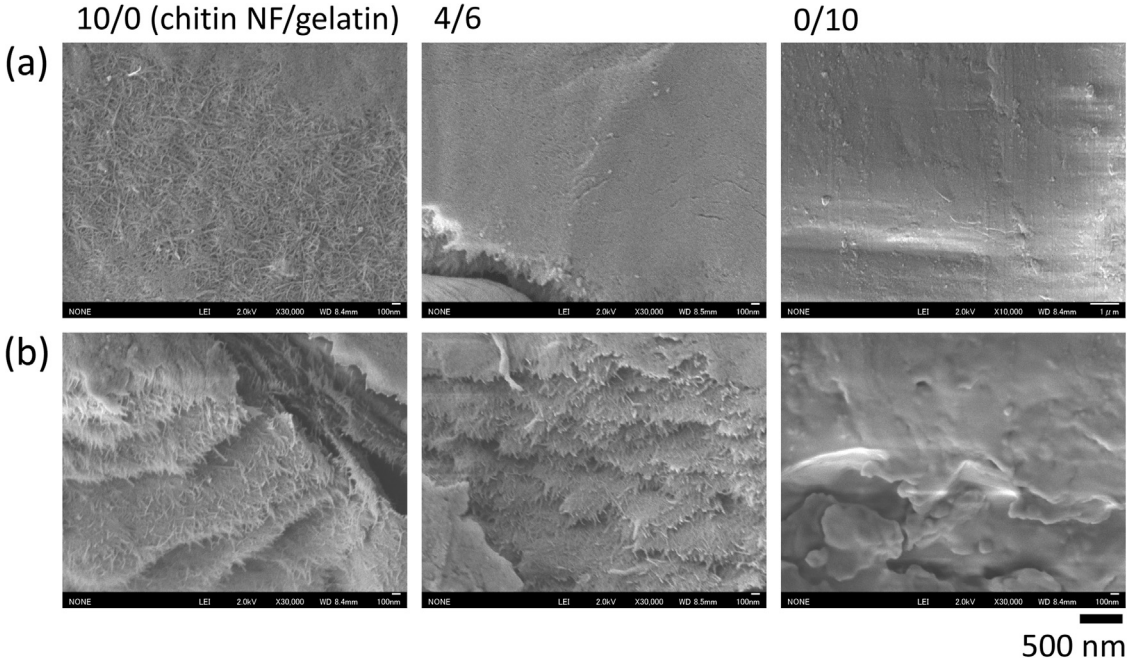

Fig. 2. (a) Surface and (b) cross-sectional images of chitin NF/gelatin composite films with ratios of 10/0, 4/6, and 0/10 (chitin NF/gelatin).

2. Materials and methods

2.1. Materials

Chitin powder from crab shells was purchased from Koyo Chemical (chitin TC-L; Tokyo, Japan). Acetic acid (99.9%) was purchased from Wako Pure Chemical Industries (Osaka, Japan) and used without further purification. Gelatin from pig skins was purchased from Nippi (Medi-Gelatin (HMG-BP), M_n = 54,700; Yokohama, Japan).

2.2. Preparation of chitin nanofiber/gelatin composite films

Dry chitin powder (22 g) was dispersed in distilled water (1800 ml) and acetic acid (10 ml) was added. The mixture was passed through a high-pressure water jet system (Star Burst Mini, HJP-25001S; Sugino Machine Co., Ltd., Uozo, Japan) equipped with a ball-collision chamber [19]. The slurry was ejected from a small nozzle with a diameter of 100 μm under high pressure (200 MPa) and collided with a ceramic ball with a diameter of 12.7 mm. The

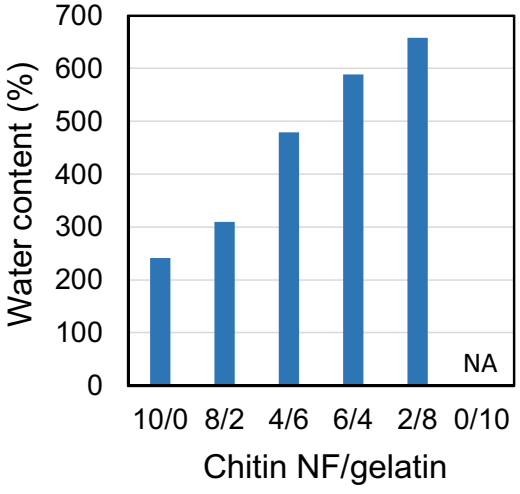

Fig. 3. Percentage of water absorption for chitin NF/gelatin composite films.

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