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Electrospun propolis/polyurethane composite nanofibers for biomedical applications

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ABSTRACT

Tissue engineering requires functional polymeric membrane for adequate space for cell migration and attachment within the nanostructure. Therefore, biocompatible propolis loaded polyurethane (propolis/PU) nanofibers were successfully prepared using electrospinning of propolis/PU blend solution. Here, composite nanofibers were subjected to detailed analysis using electron microscopy, FT-IR spectroscopy, thermal gravimetric analysis (TGA), and mechanical properties and water contact angle measurement. FE-SEM images revealed that the composite nanofibers became point-bonded with increasing amounts of propolis in the blend due to its adhesive properties. Incorporation of small amount of propolis through PU matrix could improve the hydrophilicity and mechanical strength of the fibrous membrane. In order to assay the cytocompatibility and cell behavior on the composite scaffolds, fibroblast cells were seeded on the matrix. Results suggest that the incorporation of propolis into PU fibers could increase its cell compatibility. Moreover, composite nanofibers have effective antibacterial activity. Therefore, as-synthesized nanocomposite fibrous mat has great potentiality in wound dressing and skin tissue engineering.

1. Introduction

Propolis (bee glue) is a resinous substance produced by bees from plant exudates, beeswax, and their salivary secretions. The bees use propolis as a sealer for cracks and crevices of the hive [1,2]. Its composition varies according to the local flora, climate conditions, season and other constituents such as wax, pollen, organic compounds [3]. Propolis contains a great variety of chemical compounds mainly flavonoid aglycones, phenolic acids and their ester derivatives, phenolic aldehyde, ketons and alcohols, steroids, amino acids and some inorganic compounds [4–6]. Its color varies from green, red, to dark brown, and it represents highly adhesive properties [6].

In different part of the world, some of the beekeeper has discarded propolis as a byproduct of honey industry. However, in some communities, it is highly appreciated for its extraordinary properties. Different investigations indicate that the propolis has good medicinal and therapeutic values. Antibacterial, antifungal, antiviral, antioxidant, anti-inflammatory, antitumor and many more properties of propolis were reported [7,8]. Considering its unique adhesive and these medicinal properties, the present study was aimed to incorporate propolis through electrospun polyurethane (PU) nanofibers for different biomedical applications.

Electrospinning is a versatile technique producing non-woven polymeric membranes containing nanofibers (diameter ranging from few nanometers to hundreds of nanometer) [9,10]. These nanofibers possess the characteristic features of sufficient surface areas and porosity, enabling it to be applied for adsorption, filter, cloths, catalytic support, and tissue scaffold [11–17]. Tissue scaffold is a support that mimics the extra cellular matrix (ECM) and serves as a temporary skeleton for cell growth, migration, and finally reproduction to allow tissue regeneration. Therefore, fabrication of nanofibrous matrices with interconnected porous networks with large void volumes and high surface-to-volume ratios could provide adequate space for cell migration and attachment within the structure. The function of polymeric nanofiber membrane can be improved by incorporating different active components through it. Therefore, the PU (an FDA approved polymer) composite nanofibers that integrates the favorable properties of propolis is expected to significantly improve in material properties for biomedical application.

In this report, a facile way for propolis/PU composite nanofiber from simple blending was successfully reported. The adhesive property of propolis provides the point-bonding to the PU fibers and enhances

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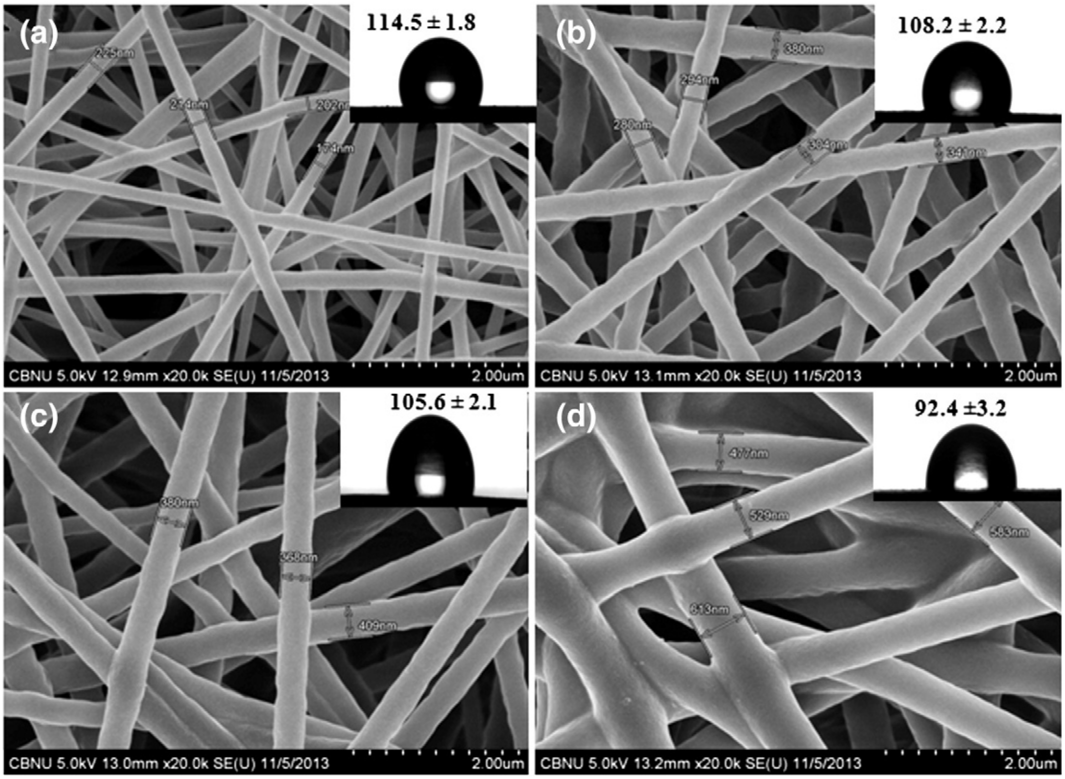

Fig. 1. FE-SEM images of PU fibers obtained from (a) 0, (b) 5, (c) 10, and (d) 30 wt.% propolis containing PU solution and insets are their corresponding water contact angle.

their mechanical properties. Moreover, active constituents of propolis on the surface of fibers introduce additional functionalities to the PU fibers. Since many researchers have reported that PU has frequently used for wounds dressing because of its oxygen permeability and excellent barrier properties, the incorporation of propolis through PU fibers further makes it potential in this field [18,19]. So far, no composite bio-membrane of electrospun PU or other polymeric fibers containing propolis has been reported. The antibacterial activity of propolis/PU composite fibers was evaluated using gram negative bacteria (*Escherichia coli*). The cytocompatibility of as-fabricated composite PU nanofibers with different amounts of propolis was studied using MTT test. The results showed that the incorporation of small amounts of propolis through PU fibers could enhance some physicochemical properties of PU fibers. These improved properties of PU mat caused by propolis could make it a potential candidate in wound dressing and skin tissue engineering.

2. Experimental

2.1. Materials

Propolis (Homart, Australia) and polyurethane pellets (Skythane X595A-11) were used to make propolis/PU electrospun mats.

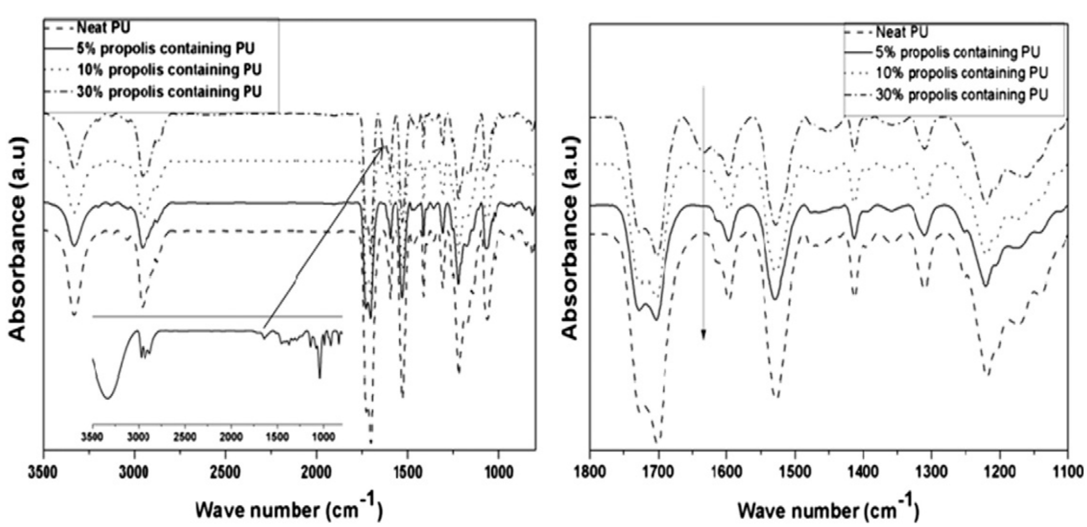

Fig. 2. FT-IR spectra of different electrospun mats (inset is FT-IR spectra of propolis) where right hand side figure shows the increasing peak intensity at 1638 cm^{-1} with increasing amount of propolis.