Synthesis of a novel organosoluble, biocompatible, and antibacterial chitosan derivative for biomedical applications

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ABSTRACT: Electrospun materials have a number of applications in the tissue engineering field. However, the limited solubility of chitosan (CS), especially in organic solvents, makes its electrospinning with other synthetic organosoluble polymers impossible. In this article, we report the synthesis of a novel organosoluble derivative of CS through the application of a simple synthetic methodology. CS was reacted with 1,3-diethyl-2-thiobarbituric acid (DETBA) with triethylorthoformate in the presence of methanol and acetic acid (4:1). The functional groups in the synthesized materials were confirmed by Fourier transform infrared and solid-state NMR spectroscopy, whereas X-ray diffraction revealed the level of crystallinity. The CS derivative (CS–DETBA) was tested for its cytotoxic effects on human gastric adenocarcinoma AGS cells and was found to be nontoxic. The prepared derivative showed a much enhanced inhibitory effect on the growth of three bacterial strains, Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus, over that of CS itself. Overall, CS–DETBA showed good solubility in a range of organic solvents, such as dimethyl sulfoxide and N,N-dimethylformamide, and was blended with polycaprolactone (PCL) to form films and electrospun nanofibers. The morphologies of the synthesized materials were analyzed by field emission scanning electron microscopy, and the fiber diameter was 360 nm under optimum conditions. This study demonstrated that the CS–DETBA–PCL blend could be a potential material for tissue engineering and biomedical applications. © 2017 Wiley Periodicals, Inc. J. Appl. Polym. Sci. 2018, 135, 45905.

INTRODUCTION

Electrospinning is a versatile tool that allows for the production of nanofibrous sheets with larger surface areas, high porosities, adjustable pore sizes, and morphological similarities to extracellular matrixes, especially carbohydrate-polymer-based nanofibers.1 Nanofibrous materials have various biomedical applications, including drug delivery, wound dressings, enzyme immobilization, regenerative medicine, and scaffolds. Chitosan (CS) and its derivatives blended with other synthetic polymers have been used extensively to fabricate electrospun nanofibers for biomedical applications.2 Natural-polymer-based electrospun nanofibers provide many instructive cues that are prerequisites for cell attachment and proliferation.3 A combination of natural polymers with synthetic polymers offers modified properties that lead to the ease of fabrication into nanofibers. Ohkawa et al.4 showed that the addition of a very small amount of poly(l-lactic acid-co-ε-caprolactone) to CS facilitated its easy electrospinning into nanofibers.

Among various polysaccharides, CS has recently attracted a lot of attention for biomedical applications because of its biodegradability, biocompatibility, and nontoxic nature.5–8 Chitin is the second most abundant natural polymer after cellulose,9 and upon deacetylation, it produces CS. The repeating unit of CS is β-(1,4)-2-amino-2-deoxy-d-glucopyranose along with various