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Mini Review

Wound Dressings from Electrospun Gelatin Fibres Coated with Zinc Oxide nano Particles

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Abstract:

Traditional wound dressings require frequent replacement, are prone to bacterial growth and cause a lot of environmental pollution. Therefore, biodegradable and antibacterial dressings are eagerly desired. In this paper, gelatin/ZnO fibers were first prepared by side-by-side electrospinning for potential wound dressing materials. The morphology, composition, cytotoxicity and antibacterial activity were characterized by using Fourier transform infrared spectroscopy (FTIR), X-ray diffractometry (XRD), particle size analyzer (DLS), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), thermogravimetry (TGA) and Incucyte™ Zoom system. The results show that ZnO particles are uniformly dispersed on the surface of gelatin fibers and have no cytotoxicity. In addition, the gelatin/ZnO fibers exhibit excellent antibacterial activity against Staphylococcus aureus (S. aureus) and Escherichia coli (E. coli) with a significant reduction of bacteria to more than 90%. Therefore, such a biodegradable, nontoxic and antibacterial fiber has excellent application prospects in wound dressing.

Key words: gelatin fibers; zno particles; antibacterial activity

1.Introduction

Skin, as the human body's largest organ, exerts a vital role in protecting the human body from external harm. Skin damage can lead to microbial invasion of the human body, resulting in a threat to human health [1–3]. Medical dressing is a kind of medical equipment which can cover damaged skin and form a microenvironment conducive to wound healing, thus playing an effective role in wound care and treatment. At present, most medical dressings still use traditional cotton gauze. Nevertheless, traditional cotton gauze needs to be replaced frequently, and easily adheres to the wound, which can easily lead to secondary tissue trauma and bacterial breeding [4–6]. Moreover, huge dressing wastes cause great harm to the environment. Therefore, it is urgent to design new biodegradable and biocompatible dressing materials with good antimicrobial activity. Gelatin, as a kind of natural material, is hydrolyzed from collagen in animals, which has many advantages, such as good accessibility, a wide source of raw materials and low cost. Its amino acid composition is similar to collagen and has good biocompatibility, biodegradability and low immunogenicity [7–9]. Especially in the past decades, with the development of electrospinning technology, gelatin fibers can be prepared simply and quickly. Furthermore, there are many small secondary structures on the surface of gelatin fibers, which is similar to the structure of extracellular matrix (ECM) and closer to the structural size of organisms. Therefore, it plays an important part in cell attachment, growth, migration and differentiation, as well as the formation of new tissues [10–12]. Meanwhile, gelatin fibers have strong adsorption, good filtration, barriers, adhesion and hygroscopicity [13–16]. Therefore, the gelatin 3D nanostructures prepared by electrospinning can be widely used in the biomedical materials, which receives more and more attention. In addition, in recent years nano-inorganic ions and nano-metal oxides have been found to have extensive antibacterial properties, which caused widespread concern [17–19]. Among them, ZnO particles were generally recognized as a safe (GRAS) material by the Food and Drug Administration (FDA) [20]. It has excellent antibacterial properties and minimal effect on human cells, which is extensively used in biomedicine and health products [21–23]. Recently, the blending of ZnO particles with gelatin has been used in the research of antimicrobial materials. Liu et al. prepared gelatin/ethyl cellulose/ZnO nanofibers by electrospinning. The results showed that the nanofibers had a good inhibitory effect on Escherichia coli (E. coli) and Staphylococcus aureus (S. aureus) [24]. Chhabra et al. synthesized ZnO doped gelatin and poly-methyl vinyl ether-alt-maleic anhydride (PMVE/MA) composite electrospun scaffolds, which can inhibit bacterial activity and have no cytotoxicity to mammalian cells [25]. Münchow et al. prepared ZnO loaded gelatin/polycaprolactone (PCL) composite nanofibers by electrospinning technique [26]. At present, the current preparation of ZnO/gelatin fibers

is usually carried out in the form of blending spinning. Nevertheless, ZnO particles are hard to fully exert efficient antibacterial activity when encapsulated in gelatin fibers. Consequently, it is necessary to increase the content of ZnO particles to achieve better antibacterial effects [27]. However, with that, excess ZnO particles cause waste of materials, and even more seriously excess ZnO particles may lead to cytotoxic effects and affect the growth of the tissue [28–30]. In this paper, unlike the traditional blending method, ZnO particles were dispersed in ethanol, so that ZnO particles can follow the solvent to be sprayed on gelatin fibers by using the side-by-side spray nozzles in the electrospinning process. With the volatilization of ethanol solvent, ZnO particles can be uniform spread only on the surface of gelatin fibers (as shown in Figure 1), so as to achieve the best antibacterial effect with the minimum content of ZnO particles.

2 Technical details

The following methodology has been adopted

a) Gelatin (type B, basic-processed, prepared by bones, with a molecular weight of 100,000, viscosity value of 4.9 MPa·s −1) has been used as the material.

b) Preparation of ZnO Particles [31-33]

c) Preparation of Gelatin/ZnO Fibers [34-38]

d) Characterization

e) Stability of GZ2 in Aqueous Solutions

f) Cell Culture and Proliferation

g) Antibacterial Evaluation

h) Statistical Analysis

The following studies have been carried out

a) . Morphologies of Gelatin/ZnO Fibers

Characterization of ZnO Particles

Characterization of Gelatin/ZnO Fibers

b) Bioactivity Studies of Gelatin/ZnO Fibers

Cell Activity

Antibacterial Activity [39-41]

3 Conclusions

In summary gelatin/ZnO fibers has been first fabricated via side-by-side electrospinning technique as a potential wound dressing. The data indicate that ZnO particles can be uniformly dispersed on the surface of gelatin fibers. Although gelatin/ZnO fibers have some inhibitory effect on MRC-5 cells, the corresponding cytotoxicity level is 0 or 1 per the standard, which indicates that fibers have no cytotoxicity. Moreover, the gelatin/ZnO fibers show excellent antibacterial activity against E. coli and S. aureus, which is caused by the superoxide radicals (·O2 −) produced by ZnO particles. In addition, the reductions of bacteria are all more than 90%. The experiments imply that gelatin/ZnO fibers have excellent application prospects for wound dressing.

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