



New Generation Chitosan/Nano ZnO/ Curcuminnanocomposite Wound Dressings for Infection Control

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Abstract

In this study, the development of antimicrobial nanocomposite wound dressings has been investigated. This nanocomposite comprises chitosan as hydrogel matrix, Nano ZnO (nZnO) as antimicrobial agent and curcumin as wound healing agent. However, both nZnO and curcumin have limitations such as low solubility and lack of anchoring sites hence hindering their activity. Chitosan plays dual role during nanocomposite fabrication, i.e. acts as hydrogel matrix as well as leads to solubility enhancement of both the bioactive agents by developing core-shell structure. Solvent casting method was employed for the development of antimicrobial nanocomposite membranes and these membranes exhibited excellent antimicrobial activity against *E. coli* and *S. aureus*, thus inhibiting the bacterial growth.

Introduction

Infection is serious issue of today's healthcare management systems that not only impedes the healing process at the wound site but also leads to life threatening complications [1-3]. Taking this into account, nZnO is one such agent which has antimicrobial features and has been in use to develop wound dressings with efficacy in infection resistance to various microbes [4]. While on the other hand, curcumin has shown potential as synergizing agent for both infection resistance and wound healing activity [2]. Both nZnO and curcumin have limitations such as low solubility and lack of anchoring sites, thus posing difficulties during immobilization to any material surface and reducing their antimicrobial activity. Therefore, hydrogel based nanocomposites have gained considerable attention in recent years and have become key materials in advance nanomaterials based research [5,6]. The innovation in the current study lies in the development of chitosan based hydrogel that act as capping agent for nZnO and also helps in the solubilization of curcumin. The most attractive feature of this nanocomposite is that nZnO acts as a reinforcing and antibacterial agent in the chitosan matrix whereas incorporation of curcumin renders the material highly potent for wound care applications.

Experiment

Aqueous solution of zinc acetate dehydrate was added drop wise into ethanolic solution of sodium hydroxide under vigorous stirring at room temperature resulting in the formation of a white precipitate in the solution. The precipitate was then filtered and rinsed with water and ethanol. Finally, the precursor was calcinated at 400°C for 4 h to obtain nZnO. These nanoparticles were characterized by high resolution transmission electron microscopy (HR-TEM), field-emission electron microscopy (FE-SEM) and X-ray diffraction analysis. 2% of chitosan (CS) solution was prepared using lactic acid followed by addition of 0.5 g of nZnO along with 0.5 g of curcumin in CS solution under vigorous stirring, until a homogeneous dispersion was prepared. Solvent casting technique was used for the membrane fabrication. The final CS solution containing nZnO and curcumin was poured onto petri dish and kept at 80°C in vacuum oven for drying.

Results and Discussion

Both electron microscopy results supported the polygonal structure of nZnO with 20-80 nm particle size as represented in (Figure 1). X-ray analysis provide the structural information of nZnO by observing the relevant peak observed at angles of 31.9°, 34.5°, 36.4°, 47.7°, 56.7°, 63.0°, 66.5°, 67.5° and 68.8° belong to the (100), (002), (101), (102), (110), (103), (200), (112), and (201) planes, respectively (results attached as supporting information). These peaks show very good agreement

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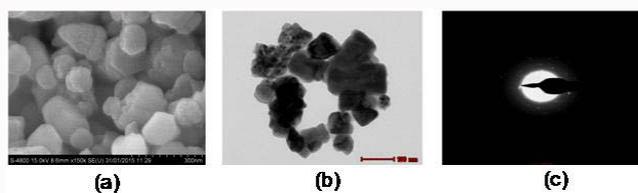


Figure 1: (a) FE-SEM, (b) HR-TEM and (c) SAX images of nZnO.

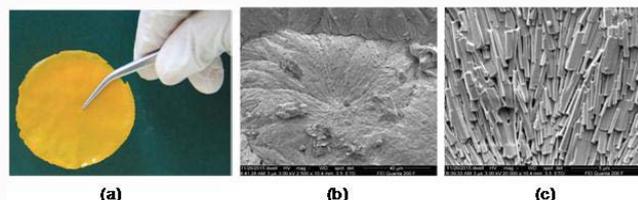


Figure 2: (a) Pictimicrograph of chitosan /nZnO/ curcumin membrane, (b) and (c) FE-SEM images of chitosan/nZnO/curcumin membranes.

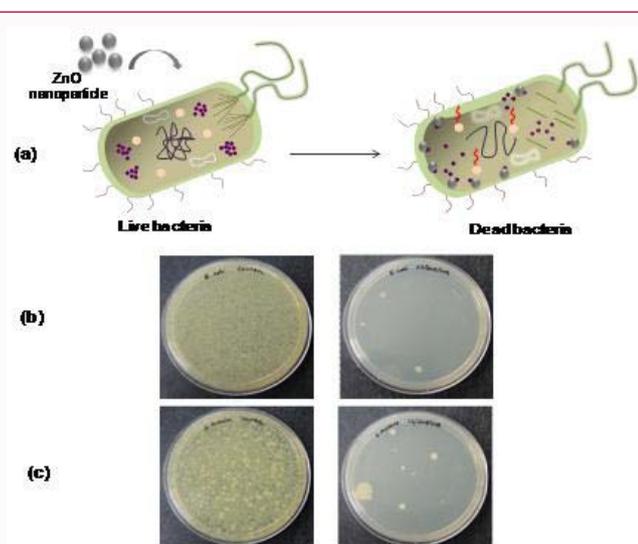


Figure 3: Revealed that the combination of nZnO and curcumin displayed excellent antibacterial activity. Pure CS and CS-nZnO membranes did not lead to sufficient reduction in the bacterial growth but after addition of curcumin in CS-nZnO matrix, almost 98% reduction was observed.

with the reported values of the Joint Committee on Powder Diffraction Standards data (JCPDS 36-1451) and confirm the formation of hexagonal wurtzite nZnO [7]. CS was used as hydrogel matrix for fabricating nanocomposite membranes. Nanocomposite membrane was characterized by FE-SEM and image sat different magnification displayed complete dissolution and homogenous distribution of nZnO and curcumin in CS hydrogel matrix (Figure 2). Moreover, nZnO was obtained in the form of nanorods as depicted in (Figure 2

a-c). Antimicrobial activity of the membranes was examined by colony forming units (CFU) method according to test method AATCC 100–1998 against *S. aureus* and *E. coli* [2,3] All the samples (~0.05 g) were placed in contact with 6 ml of freshly prepared bacterial suspension in Mueller Hinton Media having 10^8 CFU/ml and incubated at 37°C. The suspensions were vortexed again and dilutions were prepared and colonies were counted by the spread plate method. The inoculum (200 μ l) was uniformly spread on nutrient agar plate using a sterile cotton swab. Plates were incubated at 37°C and the colonies were counted after 24 h. (Figure 3). (a) Antibacterial representation of nZnO. Antibacterial study of chitosan/nZnO/curcumin membranes, (b) *E. coli* and (c) *S. aureus* using CFU technique Results demonstrate that nanocomposite membranes are capable of inhibiting the growth of microbes and play an excellent role in infection control at the wound site. Identical results were observed for both types of bacterial strains.

Conclusion

Novel synthesis of nanocomposite membranes using solvent casting technique was effectively carried out. SEM images exhibited formation of nZnO in the form of nanorods and 98% antibacterial activity against *S. aureus* and *E. coli* was manifested indicating high efficacy of the biomaterial for prevention of infection near wound area. These membranes offer excellent material for the wound care system.

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