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Antibacterial wound dressing study based on poly(vinyl alcohol)/ZnO

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Abstract

Wounds can result from various reasons such as burns, skin ulcers, and diabetes. poly(vinyl alcohol) (PVOH) is a biopolymer with excellent properties, including biocompatibility and oxygen permeability, making it suitable for wound healing. In this study, PVOH was loaded with zinc oxide (0.25, 0.5, 0.75, 1 and 3 w%) to create antibacterial films that can effectively combat with both Escherichiacoli (E. coli) and Staphylococcus (S. aur), offering a promising solution for wound healing applications. Antibacterial efficiency was so good using ZnO even at 0.25 w% concentration.

Keywords: antibacterial, wound dressing, poly(vinyl alcohol), ZnO, Escherichiacoli, Staphylococcus.

Introduction

Skin is the largest organ of body which need to protect against external threats. It also serves many other vital functions, such as regulating temperature and moisture levels, as well as providing insulation. Therefore, it is crucial to maintain the skin's health[1]. Any deviation from the skin's normal state is considered as a wound. The more skin loss, the higher the risk of infection, disability, or even death. Wounds can be caused by burns, skin ulcers, diabetes, and other factors. Wound healing can be challenging due to the recovery time required, during which additional complications may arise [2].

PVOH is a biopolymer that is hydrophilic, biodegradable, and non-toxic, possessing outstanding chemical, thermal, and mechanical properties, as well as the ability to form fibers, absorb moisture, and swell. These characteristics make it an ideal material for wound healing. Due to their biocompatibility and excellent oxygen permeability, PVA nanofibers can absorb wound exudate and aid in tissue repair [3].

In this study, antibacterial films based on PVOH were prepared by loading ZnO, which was used to induce antibacterial activity against both E. coli and S. aur. The resulting PVOH-based composite film is expected to serve as an ideal medical dressing due to its excellent antibacterial performance, providing a promising solution for wound healing applications.

Experimental

Material

PVOH (grade24) was obtained from the Wanwei Co., China. ZnO nanoparticles (30-50 nm) was obtained from the Betagen Co., Iran. Dionized water used as solvent. E. coli (ATTC25922) and S. aur (ATTC25923) were used.

Method

To obtained a homogeneous solution, PVOH (12 w%) are added to deionized water at room temperature under continuous stirring. Then ZnO (0.25, 0.5, 0.75, 1 and 3 w%) was gently added to the PVOH solution and stirred (for 30 min). The obtained solution was casted into a glass plate.

Antibacterial test

S. aur as a Gram-positive test strain and E. coli as a Gram-negative test strain were obtained from laboratory-preserved strains. The antibacterial property of the PVOH composite films was tested according to the National Standard GB/ T20944.1–2007 using the agar plate diffusion method. Nutrient broth and agar medium were prepared and set aside for use. The E. coli and S. aur cultures were diluted to 19×10^8 CFU/ml as the test solution. Under aseptic conditions, was injected into a dish of solid medium via a micropipette (20 μl). After evenly spreading the bacterial solution using a spreading rob, sample to be tested was placed on the solid medium in complete contact with the control sample using sterile forceps. The medium containing the pieces was placed in a constant temperature incubator for incubation (temperature 37 ℃ ± 1 ℃, for 18 to 24 h).

Results and discussion

Effect of different concentration of ZnO on antibacterial behavior of the PVOH films against E. coli and S. aur were studied. The diameter of inhibition zone against ZnO w% was studied. The radius was raised quickly at the starting study following to a decrease slightly to a limiting range for S. aur and However, the curve rises and then levels out at a constant range before reaching a constant range for E. coli (Table 1, Figure 1). Addition of antibacterial agents to the sample demonstrated inhibitory effects against both E. coli and S. aur (Figure 2). Notably, S. aur exhibited greater susceptibility to the antibacterial agent even at concentration of 0.25 w%. The prepared films can exhibit enhanced antibacterial efficacy against S. aur. (Figure 1).

Conclusions

Wound dressings based on PVOH were effectively created, incorporating varying percentages of ZnO (0.25, 0.5, 0.75, 1, and 3 w%). While these dressings displayed antibacterial characteristics against both of E. coli and S. aur at any used concentrations, the research indicated that even low concentration (0.25 w%) is sufficient for wound dressings containing ZnO which is a valuable strategy for managing bacterial infections in wound healing applications.

Table 1:Effect of ZnO w% on diameter of inhibition zone

ZnO w%	The diameter of inhibition zone against **S. aur** (mm)	The diameter of inhibition zone against **E. coli** (mm)
0	0	0
0.25	1.5	0.5
0.5	1.25	0.5
0.75	1.62	0.25
1	1.75	0
3	1.5	0.75

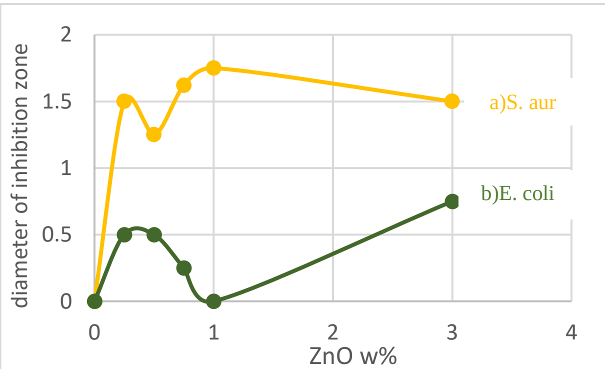

Figure 1: Effect of different concentrations of ZnO on antibacterial behavior of the PVOH films against E. coli and S. aur.

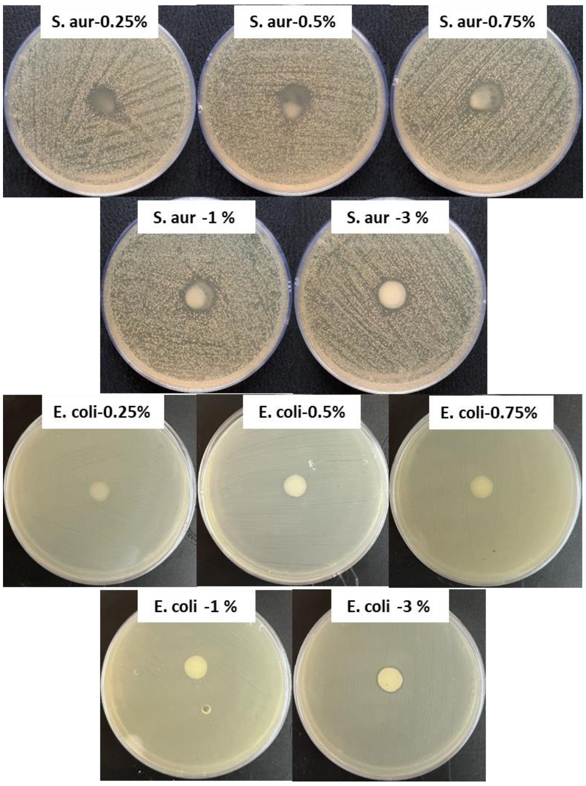

Figure 2: Antibacterial properties of the prepared samples for E. coli and S. aur.

Acknowledgements

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