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Antibacterial wound dressing study based on poly(vinyl alcohol)/$AgNO_3$

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Abstract
Wound dressings play a crucial role in the healing process, and antibacterial materials are gaining attention due to their ability to restrain bacterial growth. This study focuses on the development of antibacterial films based on poly(vinyl alcohol) (PVOH), a biocompatible polymer with non-toxic and hydrophilic properties. The PVOH-based composite films, loaded with $AgNO_3$ (0.25, 0.5, 0.75, 1 and 3 w%) exhibit excellent antibacterial performance against Escherichiacoli (E. coli) and Staphylococcus (S. aur), the composite could be suitable for wound healing applications.

Keywords: antibacterial, wound dressing, poly(vinyl alcohol), $AgNO_3$, Escherichiacoli, Staphylococcus.

Introduction
Impaired wound healing is a significant complication that can lead to prolonged wound closure, a high infection rate, and even organ disabilities. The healing process is complex and dynamic, requiring a favorable environment to accelerate and improve it [1]. Wound dressing is a crucial external agent in this process, and antibacterial materials have been gaining attention due to their ability to restrain and decrease bacterial proliferation [2]. The World Health Organization (WHO) reports that approximately 1.4 million people worldwide suffer from hospital-acquired bacterial infections annually, primarily caused by the use of medical devices. This highlights the need for innovative solutions to combat bacterial infections [3].
PVOH is a synthetic, semi-crystalline biocompatible polymer commonly used in biological and medical applications. Its advantages include non-toxicity, hydrophilicity, and the ability to be crosslinked through a freeze-thaw method without the use of toxic crosslinking agents, which is essential for enhancing strength and maintaining structural stability in wound dressings [4].
In this study, antibacterial films based on PVOH were prepared by loading $AgNO_3$, which was used to induce antibacterial activity against 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
Materials
PVOH (grade24) was obtained from the Wanwei Co., China. $AgNo_3$ was obtained from the Betagen Co., Iran. E. coli (ATTC25922) and S. aur (ATTC25923).
Method
To obtained a homogeneous solution, PVOH (12 w%) are added to deionized water at room temperature under continuous stirring. Then $AgNo_3$ (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 concentrations of $AgNo_3$ on antibacterial behavior of the PVOH films against E. coli and S. aur were studied. The diameter of inhibition zone Against $AgNO_3$ w% is presented (Table 1, Figure 1).
The radios were increased quickly at the starting study and then decreases slightly before reaching a constant range (Figure 1a). However, the curve rises and then levels out at a constant range (Figure 1b). Therefore, these findings confirm that a concentration of around 0.75 w% is the best for this additive in the range study.
Addition of antibacterial agents to the sample showed promising bacterial activity against both of the E. coli and S. aur. Notably, S. aur was found to be more responsive to the antibacterial agent. The prepared piece can observe better antibacterial properties for S. aur (Figure 2).

Conclusions

Wound dressings based on PVOH was successfully prepared, loaded with 0.25, 0.5, 0.75, 1 and 3 %w of $AgNO_3$. Although these dressings exhibited good antibacterial properties against both of the E. coli and S. aur in all used concentrations, the experiments confirmed that about 0.75 w% addition is the best antibacterial behaviour. These findings suggest that the PVOH-based wound dressings loaded with silver nitrate could be a promising approach for wound healing applications, particularly in the management of bacterial infections.

Table 1: Effect of AgNo3 w% on diameter of inhibition zone

$AgNO_3$ w%	The diameter of inhibition zone against **S. aur** (mm)	The diameter of inhibition zone against **E. coli** (mm)
0	0	0
0.25	4.5	2.5
0.5	5	2.5
0.75	5.25	4.5
1	5	8
3	6	3

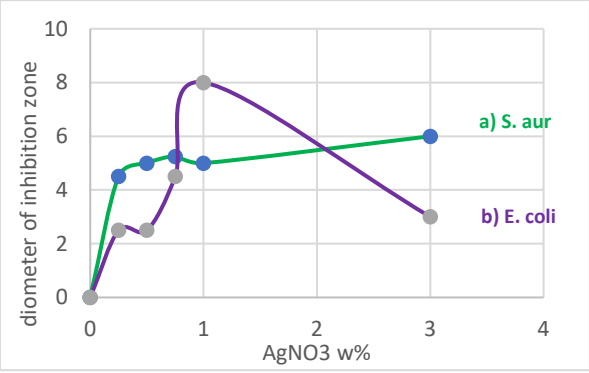

Figure 1: Effect of different concentration of $AgNO_3$ on antibacterial behavior of the PVOH films against E. coli and S. aur.

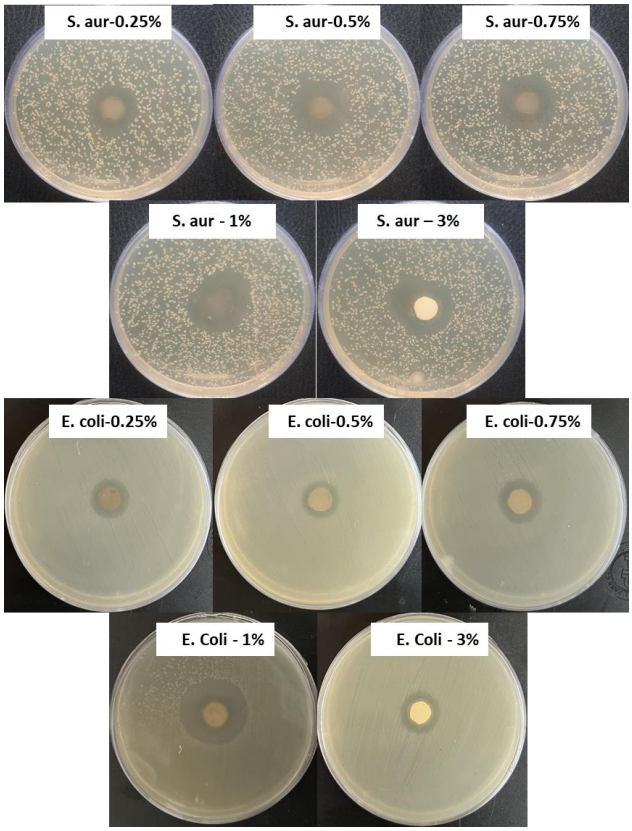

Figure 2: Antibacterial properties of the prepared samples for E. coli and S. aur.

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