

## Evaluation of Antibacterial Effects of Polyurethane-*Cinnamomum zeylanicum* Nanofiber Scaffolds against Clinical Isolates of *Staphylococcus aureus*

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**ABSTRACT**

**Background and Objectives:** In recent years, infections caused by antibiotic-resistant strains of *Staphylococcus aureus* have become a major health issue. It has been suggested that the extract or essential oil of cinnamon tree has antibacterial properties. In this study, we investigated the antibacterial effects of polyurethane-cinnamon nanofibers against clinical isolates of *S. aureus*.

**Methods:** Polyurethane-*Cinnamomum zeylanicum* nanofiber scaffolds were synthesized. Polyurethane nanofiber and cinnamon polymers were also used to prepare the scaffold under the electrospinning process. Infrared spectroscopy, electron microscopy and mechanical tensile test were utilized to assess the scaffolds. Minimum inhibitory concentration of the nanofiber against the bacteria was determined using the broth dilution method according to the Clinical & Laboratory Standards Institute guidelines.

**Results:** The results of antibiogram test showed that all tested disks were susceptible to *S. aureus*. Diameter of growth inhibition zone for polyurethane-cinnamon 10% was 41 mm. Minimum inhibitory concentration of the nanofiber against *S. aureus* isolates was 0.02 µg/ml.

**Conclusion:** We demonstrated that the polyurethane-cinnamon nanofiber has favorable antibacterial effects against clinical isolates of *S. aureus*. It is recommended to conduct further studies on the antibacterial effects of this nanofiber on other bacteria.

**Keywords:** *Staphylococcus aureus*, Cinnamon, Nano fiber.

## INTRODUCTION

*Staphylococcus aureus* is a normal flora of the nose, skin and digestive tract of some people. The bacterium causes various infections ranging from simple skin infections to life-threatening diseases, such as pneumonia, meningitis, endocarditis, toxic shock syndrome and septicemia. It is also one of the main causes of nosocomial infections, especially post-surgical ulcers. It is estimated that 500,000 people in American hospitals become infected with *S. aureus* every year (1). Various factors including hemolysins, surface antigens, exotoxins, exogenous enzymes, siderophore and staphylogensin are involved in virulence of this bacterium (2). Pantone–Valentine leukocidin is an important virulence factor in almost all methicillin-resistant *S. aureus* strains, which plays a role in the spread of cutaneous infections by eliminating leukocytes (3).

Currently, over 90% of *S. aureus* strains are resistant to penicillin, and resistance of these strains to semi-synthetic penicillins (methicillin, Nafcillin and oxacillin) is also increasing. Other antibiotics used for treatment of *S. aureus* infections include penicillin-like drugs such as carbapenems, sulbactam, cephalosporins and amoxicillin-clavulanic acid.

Medicinal herbs have various advantages over the chemical drugs namely less side effects, fewer risk of environmental pollution and widespread availability (4). Many studies have investigated the antibacterial activity of medicinal plants against various bacteria. In this study, we evaluated the inhibitory properties of polyurethane-*Cinnamomum zeylanicum* nanofiber scaffolds against *S. aureus* using the Kirby–Bauer test.

## MATERIALS AND METHODS

Design and construction of nanoscaffolds consisted of two steps: solution preparation and setting up of an electrical apparatus. Fourier-transform infrared spectroscopy was used to evaluate the scaffold's structure. Tensile testing was done to examine the tensile strength and scanning

electron microscope (SEM) was used to assess the morphology and topography of the scaffold. Twenty clinical isolates of *S. aureus* were obtained from the Baqiyatallah hospital in Tehran, Iran. Susceptibility of the isolates to the polyurethane-*Cinnamomum zeylanicum* nanofiber was assessed using the Kirby–Bauer test. *S. aureus* isolates were identified using catalase, coagulase, mannitol salt agar, production of deoxyribonuclease enzyme and bacitracin tests and sensitivity to novobiocin. After isolating the bacteria, a number of colonies was taken using a sterile loop and dissolved in sterile physiological serum. Turbidity was adjusted at 0.5 McFarland standard. Then, a homogenous solution was prepared and transferred on cation adjusted Muller Hinton agar. Polyurethane-*Cinnamomum zeylanicum* nanofiber disks were placed on the Muller Hinton agar and the plate was incubated at 37 °C for 24 hours. Minimal inhibitory concentration (MIC) of polyurethane-*Cinnamomum zeylanicum* nanofiber against *S. aureus* was determined using the broth dilution method according to the Clinical & Laboratory Standards Institute guidelines at concentrations of 0.01, 0.02, 0.03, 0.04 and 0.05 µg/mL (5).

## RESULTS

In the Kirby-Bauer test, all strains were sensitive to the polyurethane-*Cinnamomum zeylanicum* nanofiber. Young's results show that by adding a polyurethane-darchine to a scaffold during electronics, it causes a slight decrease in tension and also a reduction in the Young's modulus (Table 1).

The diameter of growth inhibition around the disks was 41 mm (Table 2) and MIC of the nanofiber was 0.02 µg/mL against *S. aureus* isolates. Mechanical tensile test was carried out to examine the mechanical properties (tensile strength) of the scaffold. The elasticity of the scaffold of polyurethane nanofiber alone and in combination with the cinnamon essential oil was 3.94% and 0.096%, respectively, indicating a linear deformation of the scaffold (Figure 1).

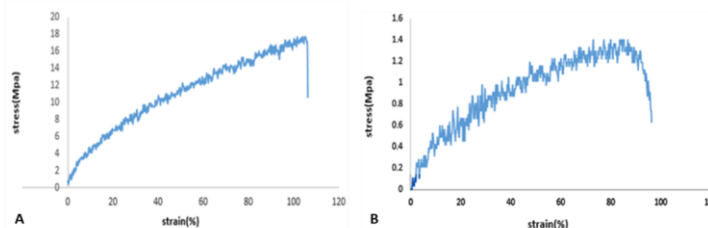
Table1- Results obtained from the Young's modulus

Sample	Width (mm)	Thickness (mm)	Gage length (mm)	Young's modulus
Polyurethane	10	0.066	20	0.752 ± 0.02
Polyurethane + Cinnamon	10	0.035	20	0.096 ± 0.01

Table 2- The diameter of the fibers using Image J software

Group	Average (mm)	Standard deviation
Polyurethane	0.5892	0.470
Polyurethane + Cinnamon	0.910 ± 0.267	0.699 ± 0.241

Figure 1- Results of the tensile test. A: Control scaffold, B: electrospun polyurethane-cinnamon scaffold.



## DISCUSSION

Currently, excessive use of antibiotics is among the main causes of increased rate of drug resistance (5). Infections caused by *S. aureus* may have serious health consequences, which requires effective and efficient treatment methods (6). The extract or essential oil of cinnamon tree contains bioactive ingredients including cinnamaldehyde, which has antibacterial properties. This study was the first to investigate the inhibitory effects of polyurethane-cinnamon nanofibers on *S. aureus*. *S. aureus* can cause various infections in humans ranging from superficial skin lesions (boils and furuncle) to life-threatening infections such as pneumonia, meningitis and endocarditis. It is also one of the most important causes of nosocomial infections, especially via surgical wounds or medical equipment. Community acquired-methicillin-resistant *S. aureus* can colonized in the host and evade the immune response with the help of its virulence factors (7-9).

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## CONCLUSION

Given the favorable results obtained in our study, the electrolytic polyurethane-cinnamon nanofiber can be suggested as a potential antibacterial agent for the treatment of infections caused by *S. aureus*.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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