Cicadas Beat Infection! Insect Inspired Nanomaterials to Prevent Bacterial Infections

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Abstract

Statement of the Problem: More than 1.2 million deaths were associated with antibiotic-resistant infections in 2019. According to the U.S. Centers for Disease Control and Prevention (CDC), 1 out of 25 patients who go to the hospital will develop a hospital-acquired infection. 80% of these infections are due to biofilm formation on implants and frequently touched surfaces. Recently, it was discovered that dragonflies and cicadas have nanopillars on the surface of their wings that are antibacterial and antifouling. However, the mechanisms by which the nanostructures kill bacteria have yet to be determined. Soft antibacterial nanostructures have also not been fabricated. In this study, antibacterial nanopillars were fabricated out of stiff (PMMA) and soft(chitosan) materials to slow down biofilm formation on a variety of different surfaces. The antibacterial mechanisms of the nanopillars were also examined. The nanopillars were fabricated via drop cast lithography in which the solution was first poured into nanohole molds with a periodicity of 500 nm, then crosslinked. After curing, the films were peeled off of the mold revealing nanopillars, and subsequently characterized with a scanning electron microscope. Both stiff and soft films resulted in a 60-70% decrease in bacterial growth. The films were analyzed with a scanning electron microscope, and the results showed that the nanopillar films slowed down biofilm formation. Tensile testing was used to determine the modulus of the materials. The chitosan nanopillars were shown to be much softer than that of a bacteria cell wall, proving that mechanical force isn't the bacteria-killing mechanism. This is the future of the next-generation biomaterials to effectively inhibit biofilm growth without antibiotics.

Image

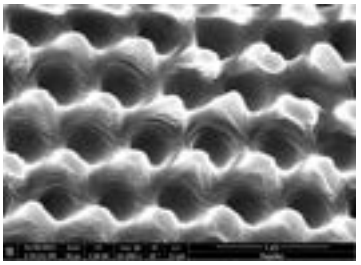


Image 1: Chitosan Hydrogel Nanopillars

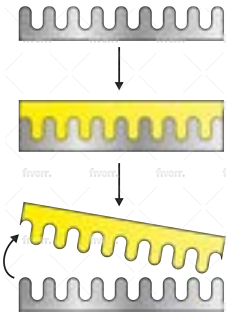


Figure 2: Drop Cast Lithography Fabrication



Biography

Kara Fan is a research intern at the University of California at Irvine. She has a passion for using nanotechnology to mitigate antibiotic resistance in healthcare. She created a nanosilver liquid bandage and won the 3M Young Scientist Challenge in 2019. Her subsequent research focused on the nanopillars on the wings of dragonflies and cicadas. She fabricated these nanostructures on stiff and soft materials to prevent biofilm formation on a variety of surfaces without antimicrobials. She also investigated the complicated mechanisms by which the nanopillars kill bacteria.

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