Mimicking Sharkskin to Create Antimicrobial Materials

Antonio González1,2, Edgar Ferrer1,2, Taras K. Oleksyk1

1Department of Biology, University of Puerto Rico, Mayagüez campus, Zeta-Alpha Chapter

Abstract

Nature often solves problems that scientists spend much time and money researching. Biomimetics is the emulation of natural phenomena to solve human problems. We look at the study where biomaterials and implants used in hospitals are developed to prevent microbial growth while promoting tissue regeneration. The problem is that, in recent years, bacterial resistance to antibiotics has become very severe. Prevention of bacterial growth on these materials has often consisted of utilizing antibiotics systemically, and they have been released from the material directly. Unfortunately, this had a limited effect on any colonies already established on a biomaterial in question. This practice is also known to give rise to antibiotic resistant bacteria. The alternative strategy is to modify surface topography to discourage microbial growth. Scientists at the University of Florida’s Department of Materials Science and Engineering created a surface design based on shark denticles. After seven days of the material, named Sharklet, had only 4% growth, versus 22% on a smooth surface; and after 14 days the material had only 7%, and showed no traces of biofilms in contrast to smooth surface that displayed a prominent biofilm and over 40% microbial growth. Thus, the Sharklet material showed a much greater resistance to the bacterial growth than the smooth surface. We present a review of literature addressing this example of biomimetics use.

Introduction

Deaths from health care and hospital associated infections are approximately 99,000 a year, according to the Center for Disease Control. 12,000 of these are the result of three antibiotic resistant pathogens (Vancomycin-resistant Enterococcus, Clostridium difficile, and Methicillin-Resistant Staphylococcus aureus). Antibiotic resistance is clearly becoming a serious problem. One method of dealing with antibiotic resistance is to decrease the use of antibiotics, and utilize them appropriately. This method takes time, however, and does not guarantee that the resistant organism will disappear. The best solution would be to keep the microorganism from growing at all. This is the solution focused on by Chung K., et al. (2007). They theorized that by utilizing an engineered topography, the growth of microorganisms (particularly bacteria) could be prevented. Their topography was based on sharkskin. Sharkskin is coated in placoid scales called dermal denticles. They are roughly and fit very closely together. Each one has a series of ridges that stretch longitudinally. These denticles provide many advantages for the shark: stealth, speed, and (of interest to us) they resist the growth of bacteria. The scientists at the University of Florida’s Materials Science and Engineering department are hoping to imitate sharkskin’s anti-microbial properties to help ameliorate the problem of antibiotic resistance.

Impact on Healthcare

Healthcare will be the most impacted by this advance in technology. The topography created by UF’s Materials Science and Engineering Department has been integrated into an adhesive-backed film named Sharklet. These adhesive films can be applied to “high traffic” locations such as door handles to prevent transmission of bacteria between people through shared contact. This would stop bacteria from jumping between people because both touched the same surface. As of now, the company that developed Sharklet has been working on creating a Urinary Catheter that incorporates this technology for the last year. Urinary tract infections are a very serious problem in many hospitals, therefore having a barrier to prevent the spread of bacteria will be very useful. Additionally, Sharklet should help, up to a certain point, in dealing with antibiotic resistance, as the topography of the material is what prevents bacterial growth (rather than chemicals towards which resistance could be developed).

Model Utilized

The topography designed by the University of Florida researchers mimics the denticles of a shark. The denticles of most sharks have a diamond-like shape. The denticles provide many benefits to the shark. The most startling of these is that their pattern stops algal, fungal, and bacterial spores from attaching to the shark. This is because the pattern makes it difficult for the spores to attach and form colonies on the surface of the shark. The reason behind this is that the uneven topography raises the amount of energy needed to colonize the skin too much. Should spores manage to attach to the skin, the ridges create a physical barrier that keeps the colonies from forming biofilms. Thanks to this sharks are kept clean while swimming.

Application of the Model

This model is applied with the Sharklet material. The adhesive films are currently being developed for push doors, bathrooms, as well as other medical applications.

Results of Sharklet Testing

Comparison of smooth surface (left) versus Sharklet pattern over a period of 21 days.

Comparison of Sharklet versus a smooth surface in a bacterial suspension. At day 21 there are no living bacteria on Sharklet.

References