Lessons from Nature and Bioinspired Fabrication: Mosquito Bite and Lotus Leaf Inspired Superliquiphobic Leather

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Abstract

Bioinsipration is an emerging field of study. Commercially-available bioinspired products have already affected industries including water treatment, energy conservation and storage, transportation, and data and computing. Bioinspired products are estimated to impact the United States GDP by the order of $400 billion by 2030. The field of bioinspiration is highly interdisciplinary and it involves learning lessons from biological functions, structures, and principles of various objects found in nature. Using the lessons learned, fabricating products and/or surfaces of commercial interest can be produced.

In this research, a chapter on lessons learned on painless mosquito bite is presented first. The chapter starts with providing an overview on bioinsipiring attributes of mosquitoes, which are standing on water, sticking to any surface, flying in rain, and painless piercing. The first three attributes are a result of superhydrophobic legs, dry adhesion in the foot, and hydrophobic wings and antifogging eyes, respectively. The understanding of the fourth attribute—painless piercing—is further elucidated by investigating nanomechanical properties of its mouthpart. The mouth is a bundle of seven coherently functioning subparts. Based on experiments and available literature, it was

hypothesized that mosquitoes painlessly bite using a combination of pre-bite numbing, the frequency-dependent-gradient in its labrum's mechanical properties, its serrated-design, and vibratory actuation. At end of the chapter, based on the hypothesis, a set of mosquito-inspired microneedle design guidelines has also been proposed.

A second chapter presented is on bioinspired fabrication of water- and oil-repellent leather. Leather is a flexible, yet strong material, which has found applications including footwear, furnishing, automotive, clothing, gloves, sports, and bags. For many applications, the leather should have properties such as liquid-repellency, self-cleaning, low adhesion at high temperature, and anti-smudge. In this study for the first time, artificial leather has been reported to achieve high water- and oil-repellency by using multi-layered nanocomposite coating structure. The coated surface exhibited self-cleaning, low adhesion up to 70°C, and high mechanical durability.