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Liquid Adhesion Control Inspired by Biology

Yupeng Chen*

Department of Environmental Engineering, University of Lodz Technology, Politechniki, Poland

Introduction

Applications in biomedicine, as components of bionic robots, and as wearable devices rely heavily on bio-inspired surfaces that enable wet adhesion management. Numerous organisms have developed wet adhesive surfaces with strong attachment capabilities over the course of biological evolution. Adhesive liquids secreted by insects enhance their adhesion to contact substrates. Concepts of bio-inspired wet adhesion are discussed here. First, the remaining difficulties in comprehending and designing biological and synthetic wet adhesive systems, as well as methods for delivering adhesive liquids to their contact surfaces, are examined. After that, specific recommendations for the development of liquid-based wet adhesive surfaces are presented. Last but not least, a model of liquid-based wet adhesion management is offered, which has the potential to assist in the development of bio-inspired wet adhesive surfaces of the following generation.

Description

A wide range of situations in which adhesive organs or systems come into contact with a counterpart surface while surrounded by liquids are referred to as "wet adhesion." Wet adhesion also includes adhesion underwater and in humid conditions. Adhesive secretions, for instance, are frequently utilized by insects to control adhesion on substrate surfaces. In the meantime, it is becoming increasingly apparent that adhesion control relies heavily on liquids. Over hundreds of millions of years, numerous organisms have developed distinctive wet adhesive surfaces. In this manner, it is remunerating to investigate the basic attachment standards, which might motivate the plan of bionic surfaces with comparable functionalities. Bio-inspired surfaces with specific wet-adhesive properties are already being used in a variety of applications. For instance, they can be used as micromotors for stomach care, portable drug delivery patches for eye treatment, flexible wearable devices for monitoring human physiological conditions, and medical tapes for wound and skin care. They can also be used as adhesive pads for bionic robots, as adhesive devices for transporting liquid droplets in intelligent manufacturing, as wet adhesives for pipe repair, and as smart tapes for micro/nanofilm transfer. Recently, patterned membranes constructed on super hydrophobic substrates were transferred to the target substrates with easy-peeling and non-destructive transfer properties, demonstrating great potential for developing free-standing patterned membranes on a large scale. Notably, surfaces with ultra-low, Predictive knowledge of the actual function of the liquids involved in wet adhesion is insufficient, despite the numerous technological applications of wet adhesion that have been reported. However, in order to develop bio-inspired wet adhesive surfaces, an understanding of specific insect adhesion mechanisms requires predictive knowledge of wet adhesion. Natural adhesive secretions are complex mixtures that are frequently difficult to analyze because they are only produced in small amounts. As a result, it is still challenging to comprehend how liquids at the contact interface influence adhesion and to utilize this knowledge for the design of artificial wet adhesive surfaces. This is one reason why there is a lack of knowledge regarding wet adhesion. Artificial adhesive surfaces with specific functionalities can be produced by making use of liquids with similar components and properties to adhesive secretions. Artificial adhesives that exhibit both strong normal adhesion and tangential adhesion on the surface, similar to the wet adhesion of mussel adhesive proteins, might be desirable for some applications. A combination of strong shear resistance and moderate normal adhesion, similar to the wet adhesion of tree frog pads, could be advantageous for other applications. This is because different organisms adapt to their complex environments. For example, adult mussels usually stick firmly to rocks to keep waves from hitting them, while tree frogs often need to be able to switch between being attached and detached to move [1-3].

***Address for Correspondence:** Yupeng Chen, Department of Environmental Engineering, University of Lodz Technology, Politechniki, Poland, E-mail: YupengChen1@lboro.ac.uk*

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Conclusion

Artificial liquids for wet adhesion have only received sporadic research attention thus far, leaving a significant amount of room for future investigation. To begin with, we talked about the advances of fluid related wet attachment. For instance, the adhesion and friction performance of cockroach adhesive organs were investigated in the presence of adhesive secretions ejected by the cockroaches, after these biological secretions had been depleted, and in the presence of artificial secretions. When compared to the untreated tarsi, the depletion of tarsal secretions resulted in a 25% decrease in tarsal adhesion. Squalane and squalane-based emulsions, on the other hand, resulted in 2- to 10-fold greater adhesion. In order to achieve the objective of simple detachment during locomotion, it is suggested that the secretions primarily function by reducing viscous dissipation. However, the secretions serve as a lubricant to prevent excessive friction on nano rough and smooth surfaces. They can increase contact surface on rougher surfaces by compensating for surface imperfections and keeping the cuticle flexible. By filling in surface irregularities, the secretions can increase the effective contact area between the adhesive pad and the substrate. Additionally, the secretions in the soft pad cuticle gaps can improve viscoelastic performance. Sum-frequency generation (SFG) spectra first demonstrated that squalane chains exhibit similar hydrocarbon organization at the interface to natural adhesive secretions of beetles. Later, multiple characterization techniques were used to investigate both surface-specific properties of artificial secretions according to the contact surfaces, these surface-active hydrocarbon components in both artificial and natural secretions can moderate traction and lubrication. The bulk emulsion had a rheological profile that was shear-thinning, which could increase traction forces while moving. Additionally, the emulsion's low surface tension ensures that it can wet a variety of hydrophilic and hydrophobic surfaces, which is necessary for the natural adhesion system. However, squalane-based emulsions cannot replicate the major property of natural adhesive secretions low adhesion with moderate friction and their stability needs to be improved. The wet adhesion performance of artificial adhesive liquids that have the same components and properties as natural adhesive secretions should be investigated after their introduction [4,5].

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