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Influence of Counter-Face Roughness on the Friction of Bionic Microstructures

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Abstract : The problem of quick and easy reversible attachment has become of great importance in different fields of technology. For the reason, during the last decade, a new emerging field of adhesion science has been developed. Essentially inspired by some animals and insects, which during their natural evolution have developed fantastic biological attachment systems allowing them to adhere and run on walls and ceilings of uneven surfaces. Potential applications of engineering bio-inspired solutions include climbing robots, handling systems for wafers in nanofabrication facilities, and mobile sensor platforms, to name a few. However, despite the efforts provided to apply bio-inspired patterned adhesive-surfaces to the biomedical field, they are still in the early stages compared with their conventional uses in other industries mentioned above. In fact, there are some critical issues that still need to be addressed for the wide usage of the bio-inspired patterned surfaces as advanced biomedical platforms. For example, surface durability and long-term stability of surfaces with high adhesive capacity should be improved, but also the friction and adhesion capacities of these bio-inspired microstructures when contacting rough surfaces. One of the well-known prototypes for bio-inspired attachment systems is biomimetic wall-shaped hierarchical microstructure for gecko-like attachments. Although physical background of these attachment systems is widely understood, the influence of counter-face roughness and its relationship with the friction force generated when sliding against wall-shaped hierarchical microstructure have yet to be fully analyzed and understood. To elucidate the effect of the counter-face roughness on the friction of biomimetic wall-shaped hierarchical microstructure we have replicated the isotropic topography of 12 different surfaces using replicas made of the same epoxy material. The different counter-faces were fully characterized under 3D optical profilometer to measure roughness parameters. The friction forces generated by spatula-shaped microstructure in contact with the tested counter-faces were measured on a home-made tribometer and compared with the friction forces generated by the spatulae in contact with a smooth reference. It was found that classical roughness parameters, such as average roughness Ra and others, could not be utilized to explain topography-related variation in friction force. This has led us to the development of an integrated roughness parameter obtained by combining different parameters which are the mean asperity radius of curvature (R), the asperity density (η), the deviation of asperities high (σ) and the mean asperities angle (SDQ). This new integrated parameter is capable of explaining the variation of results of friction measurements. Based on the experimental results, we developed and validated an analytical model to predict the variation of the friction force as a function of roughness parameters of the counter-face and the applied normal load, as well.

Keywords : friction, bio-mimetic micro-structure, counter-face roughness, analytical model
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