DOCTORAL THESIS

Rapid and low-cost mass fabrication of true three-dimensional hierarchical structures with dynamic soft molding and its application in affordable and scalable production of robust and durable whole-teflon superhydrophobic coating

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Abstract

Superhydrophobic (SH) surfaces equipped on the skins of natural living beings give them trumps of self-cleaning, anti-bacterial, water harvest, and directional liquid transport, etc., to survive in harsh environments. Bioinspired Superhydrophobic (SH) surfaces have developed many emerging functions, such as self-cleaning, anti-bacterial, water harvest, anti-icing, anti-corrosion, oil-water separation, and many other fascinating functions. However, the implementations of SH coating in real world are still in its infancy, due to (i) the poor performance in the harsh real-world environment and industrial process application, where a multi-level robustness including the mechanical, chemical, and thermal robustness, as well as the strong adherent strength to substrates, is strictly required; (ii) the lack of a technology for facile and mass production. In the light of that any non-perfluorinated component in the formula of an SH coating inevitably generates vulnerable points to the external invasions and the functional applications of SH coatings require control surface topography, we here propose an SH coating entirely made of perfluorinated materials (referred to as Teflon). To achieve this goal, we developed a complete strategy involving material, fabrication, and applications. Firstly, we developed a feasible dynamic soft molding method for the fabrication of three-dimensional (3D) structures. This method paves a road not only to the fabrication of whole-Teflon SH coatings but also to the practical adoption of many other important technologies based on 3D structures. Secondly, we generated whole-Teflon and multi-resist SH coatings by using this method and tightly attached them to different substrates with superior adhering strength surpassing the conventional work. Thirdly, we performed a proof-of-concept demonstration of a roll-to-roll (R2R) hot molding process, which has the potential of translating the lab-scale and plate-to-plate fabrication to industrial mass production. Finally, some fundamental mechanisms and problems of the multifunctional applications in self-cleaning, anti-bacterial fouling, and anti-icing are studied. The outcomes are

expected to provide insight understandings on the multifunctional SH coating and move SH coatings toward real-world application.

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