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Nanostructure-Dependent Water-Droplet Adhesiveness Change in Superhydrophobic Anodic Aluminum Oxide Surfaces: From Highly Adhesive to Self-Cleanable

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Water-droplet adhesiveness was freely controlled on a single platform of superhydrophobic anodized aluminum oxide (AAO) within the range from highly adhesive to self-cleanable. Changing the structure from nanopore to nanopillar arrays at the surface caused a dramatic increase in the receding angle and a decrease in the hysteresis of water contact angles. The presence of dead-end nanopores but not through nanoholes was recognized as one of the main causes of the adhesiveness of superhydrophobic surfaces. The adhesiveness-controllable superhydrophobic AAO can be an excellent platform on which to elucidate the physical nature of the wetting phenomenon related to the nanostructure and has promising potential in technological applications.

Since the lotus leaf was recognized as an ideal model for self-cleaning surfaces,[1] the mimetic fabrication of superhydrophobic surfaces has been an attractive goal in various fields of industry for the removal of undesirable contaminants from the surfaces of high-end products. Recently, adhesive superhydrophobic surfaces, which allow the placement of an almost completely spherical water droplet at a specific position such as a rose petal, have also garnered interest because of their promising potential in droplet-based technologies.[2−5]

The superhydrophobicity of a surface is generally defined by a static water contact angle (CA) greater than 150°.[6−8] Surface coverage with a low surface free energy material causes an increase of water CA, but the extreme CA value corresponding to superhydrophobicity cannot be achieved on a plain surface. An appropriate structure on the surface on the nanometer or micrometer scale is required to achieve superhydrophobicity.[9−15] The adhesiveness of a surface is closely correlated to the receding angle or to the hysteresis,[16] which is defined as the difference between the advancing angle and receding angle:[17] low adhesiveness is generally observed when hysteresis is minimized.

In this study, a superhydrophobic aluminum surface, the water-droplet adhesiveness of which can be freely controlled within the range from highly adhesive to self-cleanable according to the nanostructure at the surface, is demonstrated. The discovery by Masuda and co-workers[18] of self-ordering nanopores in anodized aluminum oxide (AAO) surfaces has prompted significant interest in the nanofabrication of various materials. The major experimental parameters that determine the structural features of the porous AAO structures have been previously reported with various self-ordering regimes.[18−21] We prepared well-ordered AAOs through a two-step anodization by the well-known self-ordering regime and modified the surface structure on the basis of the following principle. (See Supporting Information for the fabrication method in detail.)

There is a peculiar wet etching property of nanoporous AAO. It is etched anisotropically under acidic wet etching conditions because the walls of the pores in AAO are more prone to etching

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