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ScienceDirect

Biosurface and Biotribology 2 (2016) 70–74

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Effects of the natural microstructures on the wettability of leaf surfaces

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Received 4 May 2016; received in revised form 12 June 2016; accepted 12 June 2016

Abstract

The effects of natural microstructures on the wettability are investigated based on the systematic analysis on the contact angles and morphology of the leaf surfaces of four kinds of plants, *Photinia serrulata*, Ginkgo, Aloe vera and *Hypericum monogynum*. *P. serrulata* possesses the most wettable leaf surface due to the small corrugation and raised boundary of the microstructures, while *H. monogynum* leaf shows the largest contact angle as it exhibits corrugated microstructures with smaller pitch value and larger height compared with that of Aloe vera. The long-shaped and well aligned microstructures, which are beneficial for the diffusion of water, make the Ginkgo leaf surface to be hydrophilic. The study elaborates the effects of microstructures on the surface wettability, which shed light on the design of surfaces for different wettable needs.

Keywords: Wettability; Microstructures; Leaf surface; Contact angle; Morphology

1. Introduction

Nature shows diverse vagarious functions through millions of years of evolution, intriguing much research interest in the recent few decades [1–4]. One of the most concerned functional systems refers to the superhydrophobic surface, like the leaf and petal surfaces [5,6]. Water-repellent surfaces also exit among animals, for instance, water strider [1,7], shark skin [8], butterfly wings [9] and so on. Ascribed to the fancy property and wide variety of bionic applications (such as water-proofing [10], self-cleaning [11], drag-reduction [8], anti-biofouling [12]), scientists have shown great interest in understanding the mechanism of wettability, especially the superhydrophobicity and superhydrophilicity mechanisms and imitating such surfaces [13–15].

The chemical compositions of the wax and structures on the surface are reported to be the main influencing factors on the wettability [4]. The compositions of the wax reduce the surface energy and then increase the contact angle, but the maximum contact angle can only reach 120° even on surface with extreme low energy [16]. So researchers believe that the impact of the composition of wax on the wettability is smaller, compared to the surface structures [17]. The surfaces with superhydrophobicity in nature are mostly rough and multiscale. The most notable one is the lotus leaf surface, which is superhydrophobic and self-cleaning (known as "lotus effect") [18], and exhibits microstructures covered by nanostructures on the surface. The structural effect on the surface wettability is so complicated due to the diversity of Nature that it is not fully understood yet, though continuous attention has been paid for a long period. Thus in this paper, we investigate the effects of microstructures on wettability by employing four kinds of leaf surfaces as objects. The contact angles of the surfaces are compared and the studies on the surface structures are further conducted based on the persuasive surface data. We hope the results increase our understanding of the structural effects on the surface wettability and provide useful data for the design of surfaces with different wettability.

2. Experimental methods

In this study, leaves of four kinds of plants, *Photinia serrulata*, Ginkgo, Aloe vera and *Hypericum monogynum*, which show

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Peer review under responsibility of Southwest Jiaotong University.

http://dx.doi.org/10.1016/j.bsbt.2016.06.001

different wettability are chosen for comparison. The surface morphology of the samples is analyzed using 3D laser scanning microscope (Keyence VK-X200). The wettability of the samples is characterized by the static contact angle (CA) for deionized water, which here is measured using SL-200 contact angle meter. For the convenience of contact angle measurements, the samples are finely flatted on glass slide. The deionized water droplets are strictly controlled at 5 μl. The shape of the droplet is imaged by a CCD camera and then the contact angle is calculated by the included software.

3. Results and discussion

Fig. 1 shows the contact angle values of the leaf surfaces of the four kinds of plants, *P. serrulata*, Ginkgo, Aloe vera and

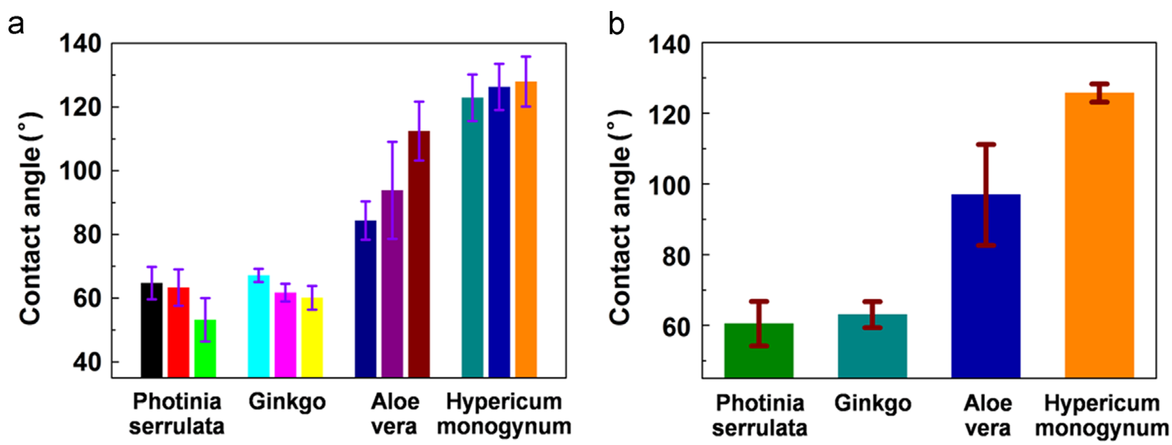

Fig. 1. (a) The contact angles of the leaf surfaces of *Photinia serrulata*, Ginkgo, Aloe vera and *Hypericum monogynum*. From the left to the right side, the three columns of each kind of plant corresponds to the contact angles measured at the regions near the root, middle and apex parts of the leaves (the left, right and root parts for Ginkgo), respectively. (b) The average contact angles obtained based on the three contact angle values in (a).

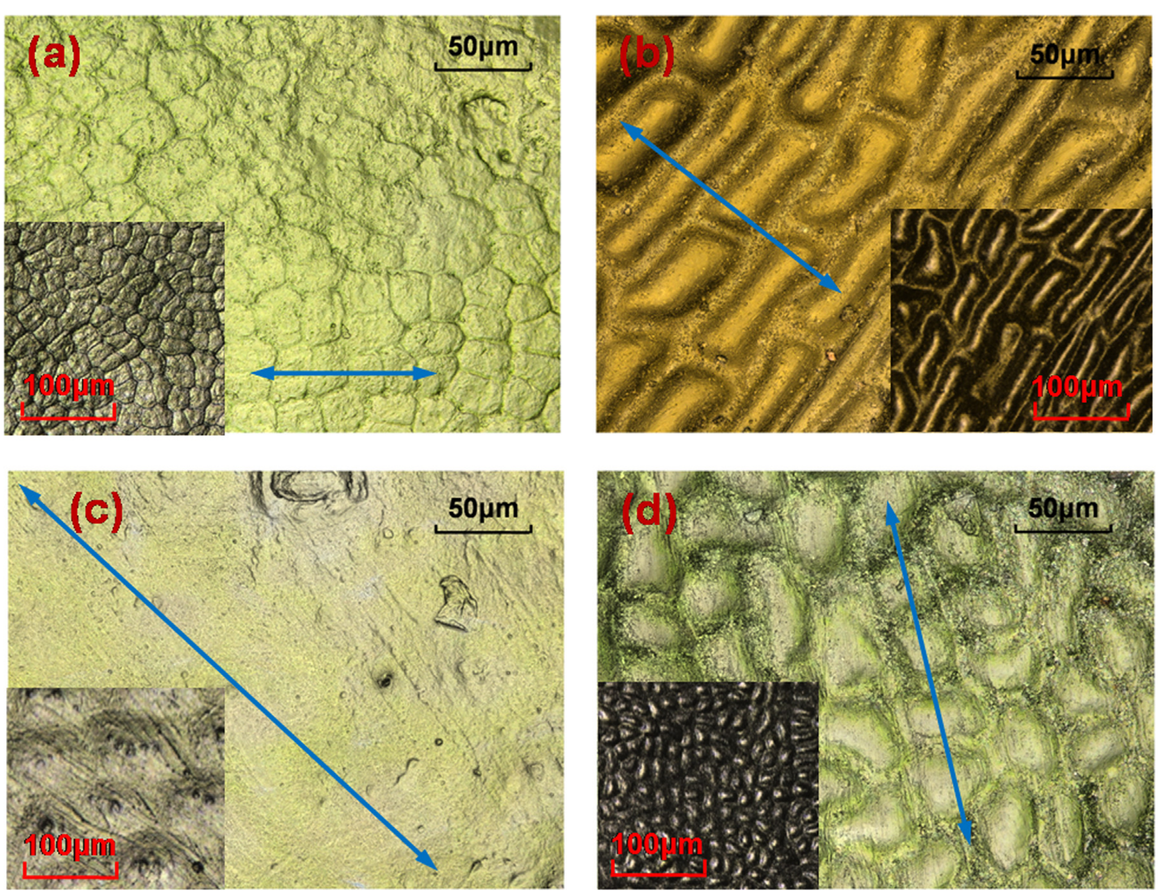

Fig. 2. The surface morphology with the magnification of one thousand times of the four kinds of plant leaves: (a) *Photinia serrulata*, (b) Ginkgo, (c) Aloe vera and (d) *Hypericum monogynum*. The insets show the morphology magnified four hundred times. The blue lines indicate the locations of the cross sections shown in Fig. 3.