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Wettability Simulation for Hydrophobic Riblet Surface

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Abstract**:** *In this study, the hydrophobicity properties for riblet surfaces that replicate shark skin are simulated. Riblet surfaces with surface roughness on riblets are generated numerically based on the measured data of real shark skin. The contact angle of a water droplet can be calculated using the Wenzel equation and Cassie-Baxter equation. The variation of contact angles with a fractional depth of penetration for the generated shark skin surfaces without and with coatings is demonstrated. The experimental and simulated results are compared. For the measurement of the contact angle for the riblet surface the shark skin replicas from a shark skin template are obtained using two different replicating forming methods. The contact angle in solid-air-water interface is evaluated for shark skin replicas. The effect of Teflon coating on the wetting properties of shark skin replicas is also observed. The measured contact angles of the shark skin template and the shark skin replica are within the simulated results. So we conclude that the contact angle of water droplet for rough surfaces can be estimated by the developed numerical method in this study.*

Keywords: *Wettability, riblet, hydrophobic surface, contact angle*

1. Introduction

Shark skin has a hierarchical structure built up by micro grooves and nano-long chain mucus drag reduction interface around the shark body. The "shark skin effect" is defined as a mechanism of wall friction reduction of a fluid resulted from a riblet structured surface similar to that of shark skin [1]. We also simulated the behavior of contact angle for the riblet surface like shark skin. Riblet surface inspired of shark skin is generated numerically and the variations of contact angle with fractional depth of penetration are demonstrated.

2. Numerical Analysis

Riblet surface with surface roughness is generated numerically based on the measured data of shark skin in the previous work[2]. We assumed that a rib on a scale is hemi-elliptical surface. Fig. 1 shows numerically generated shark skin surface. Riblet surface used in the simulation for the calculation of contact angle is composed of 9 scales like checkerboard type as, and the surface has roughness of Ra= 0.2μm as shown in Fig. 1(b).

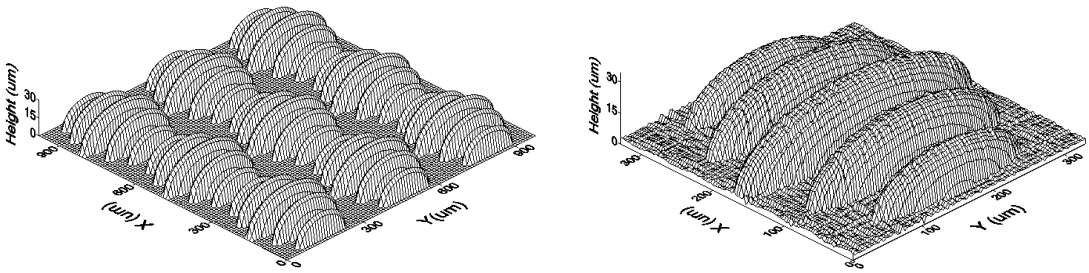
The contact angle of a water droplet θ can be calculated using the Wenzel equation and Cassie-Baxter equation.

$$\cos\theta = R_f \cos\theta_0 \tag{1}$$

$$\cos\theta = R_f f_{SL} \cos\theta_0 - 1 + f_{SL} \tag{2}$$

Where θ_0 is the contact angle of a water droplet on a smooth surface, R_f is the roughness factor defined as a ratio of the contact area of the liquid with the rough solid and that of the liquid with the flat solid, and f_{SL} is the

fractional flat geometrical area of the solid-liquid interface under the droplet. The area of solid surface patches contacting the liquid at an arbitrary depth of penetration of the water droplet can be calculated numerically.

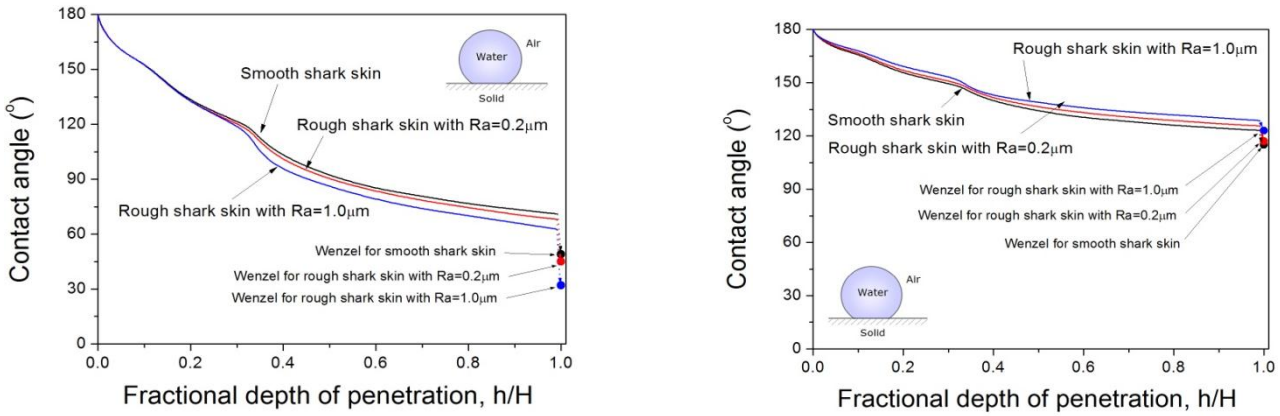


(a) Smooth shark skin (b) Rough shark skin with Ra=0.2μm

Fig. 1 Numerically generated riblet surface

3. Results

Fig. 2 shows the variation of contact angle with fractional depth of penetration for the generated riblet surfaces of without and with coatings. The measured contact angles of a water droplet on a smooth surface θ_0 are applied as 62° for without coating (Fig. 2(a)) and 108° for with coating (Fig. 2(b)). The contact angle for the surface without coating decreases with increase of the fractional depth of penetration more drastically than that for the surface with coating.



(a) Solid-air-water interface with $\theta_0 = 62°$ (b) Solid-air-water interface with $\theta_0 = 108°$

Fig. 2 Results of numerical analysis of contact angle for generated riblet surface

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