**Electronic supplementary Material (ESM) for**

**Inner surface of *Nepenthes* slippery zone: Ratchet effect of lunate cells causes anisotropic superhydrophobicity**

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**Running Head:** Ratchet effect causes the anisotropy

**S1. Derivation of the equations concerning sliding angle and structural characteristics of lunate cells**

Volume of the ultrapure-water droplet used in measuring the wettability of *Nepenthes* slippery zone is =3, and generated the static contact angle. Thus, the radius (=0.895 mm) of ultrapure-water droplet and its contact radius (=0.368 mm) on the slippery zone can be calculated.

To characterize the anisotropic wettability of slippery zone, we measured the sliding angle of an ultrapure-water droplet along downward (toward pitcher bottom) and upward (toward pitcher up) direction. At first, the slippery zone was horizontally fixed on a measuring platform and an ultrapure-water droplet was dropped to the slippery zone, and then applied a sliding angle. As shown in Fig. 4A and B, applying a sliding angle means raising the ultrapure-water droplet to a height, and thus obtains a gravitational potential energy . The resistance, such as the gravitational potential energy  and  respectively produced by the slope (Fig. 4A) and precipice (Fig. 4B) of lunate cell, as well as the work done by adhesion force  and friction force  provided by the interaction between the ultrapure-water droplet and the slippery zone (lunate cell, wax coverings), would restrict the rolling of ultrapure-water droplet. According to the law of energy conservation, the necessary condition for the rolling is

. (1)

When the ultrapure-water droplet is rolling toward the pitcher bottom (Fig. 4A, C), it should overcome the restriction of the gravitational potential energy  produced by the ‘slope’ structure, and the work done by the adhesion/friction force / of the ultrapure-water droplet on the ‘slope’ structure and the wax coverings (Fig. 4E) among lunate cells along the horizontal direction.

For the gravitational potential energy  of the ultrapure-water droplet induced by the sliding angle, we can deduce the following equation

. (2)

For the work done by adhesion force, we can obtain the following equation

, (3)

where  represents the wetting area when the ultrapure-water droplet rolls from underside to upside of the ‘slope’ structure. It includes the rectangular area (aa´b´b, Fig. 4C), and the triangular areas (abc and a´b´c´, Fig. 4C), as well as the wax coverings among the ‘slope’ structures (rectangular area aa´b´b, Fig. 4E) along the horizontal direction, namely perpendicular to the ultrapure-water rolling direction.  is the surface tension of ultrapure-water, and  stands for the static contact angle of the ultrapure-water droplet on the slippery zone. We assume that when from underside to upside, the number of lunate cells wetted by the ultrapure-water droplet is , thereby the following equation can be deduced,

 (4)

where / is the height/angle of ‘slope’ structure along pitcher bottom direction,  is the length of lunate cell. Therefore, the work done by the adhesion force can be exhibited by the following equation

 (5)

We assume that the mass of the ultrapure-water droplet which wets the ‘slope’ structure is , and the mass of the ultrapure-water droplet which wets the wax coverings among the lunate cells (along horizontal direction) is , thus the whole mass of the ultrapure-water droplet is . For the work done by friction force , , where is the friction coefficient between the ultrapure-water droplet and the slippery zone,  is the normal force provided by the ‘slope’ structure or the wax coverings to the ultrapure-water droplet,  represents the displacement of the ultrapure-water droplet rolling (wetting) from underside to upside of the ‘slope’ structure.

For the region of ‘slope’ structure (Fig. 4A), the normal force , the displacement, thus we obtain the work done by the ‘slope’ structure, as flows:

, (6)

namely,

. (7)

For the region of wax coverings among the lunate cells along the horizontal direction (Fig. 4E), the normal force , and the displacement , thus we obtain the work done by the wax coverings, as flows:

. (8)

Therefore, the work done by the friction force  can be shown by the following equation

. (9)

Finally, according to the , we can conduct the following deduction

, (10)

namely,

. (11)

In the above equation, , , µm, µm, so , and the  can be ignored. Thereby, we can obtain the following equation

. (12)

Based on the same method, when the ultrapure-water droplet is rolling toward the pitcher up (Fig. 4B, D and E), namely along upward direction, the following equation can be deduced,

, (13)

where  is the sliding angle of the ultrapure-water droplet rolling on the slippery zone along pitcher up direction, / is the height/angle of ‘precipice’ structure along pitcher up direction.

According to the Equation (12) and Equation (13), and the structural parameters of lunate cell, the theoretical sliding angle / can be calculated.