Supporting Information for

Bioinspired Cone Structures with Helical Micro-grooves for Fast Liquid Transport and Efficient Fog Collection

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Supplementary Figures

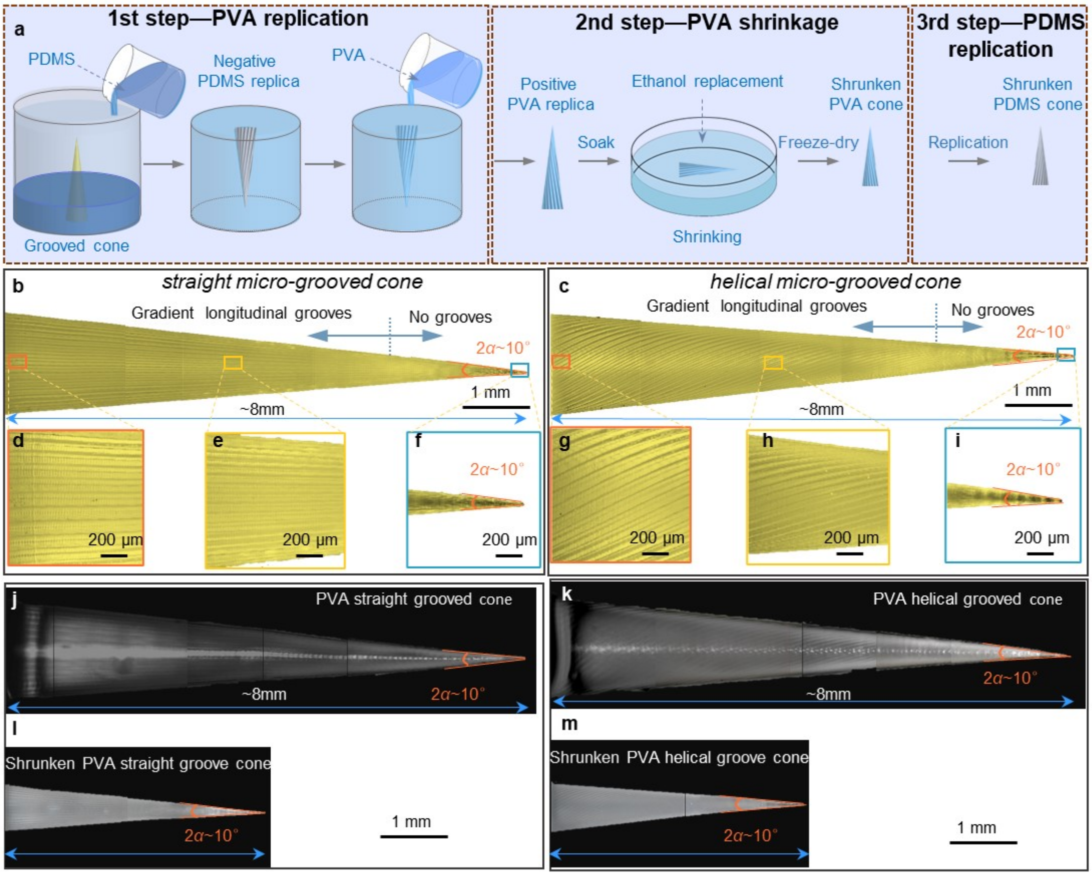

Figure S1. The fabrication process and optical images of the micro-grooved cones. (a) The PDMS cones were prepared through three replication steps, scaling down in size from the 3D printed cones. Optical images of the 3D printed straight (b, d-f) and helical (c, g-i) micro-grooved cone, PVA straight (j) and helical (k) micro-grooved cone in original size, shrunken PVA straight (l) and helical (m) micro-grooved cone.

Figure S2. The water vapor generated by an ultrasonic humidifier blew vertically to the cone tip.

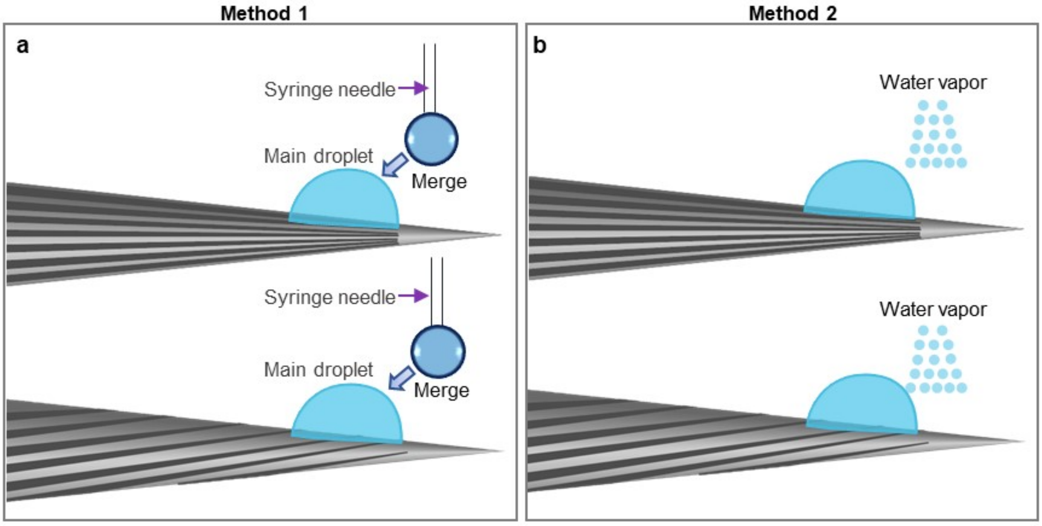

Figure S3. Two methods to explore droplet's motion behavior on the cone surfaces. (a) In method 1, a tiny droplet of 0.15 μL was initially placed on the tip of cone, followed by liquid feeding through a needle at a speed of 10 μL/min. The main droplet grows and moves directionally as long as its volume gets to a critical value. (b) In method 2, the same tiny water droplet of 0.15 μL was initially placed on the tip of cone, and continuous water vapor with a velocity of 40-50 cm s^{-1} was applied to the cone tip. The condensed water merges with the main droplet, promoting droplet to move directionally.

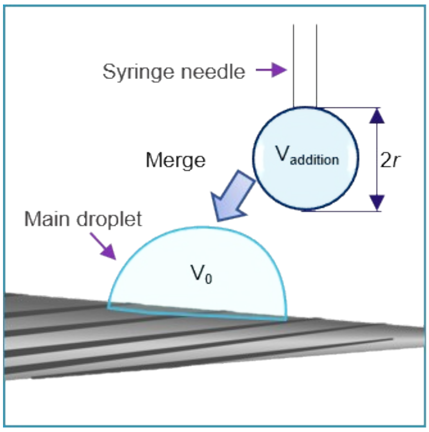

Figure S4. The droplet volume on the cone was determined according to the equation: $V_{\text{total}} = V_0 + V_{\text{addition}} = V_0 + \frac{4}{3}\pi(r_1^3 + r_2^3 + \ldots + r_{end}^3)$, where V_0 is the main droplet volume of 0.15 μL, and V_{addition} is the sum of the droplet volume from the syringe needle before merging with the main droplet.

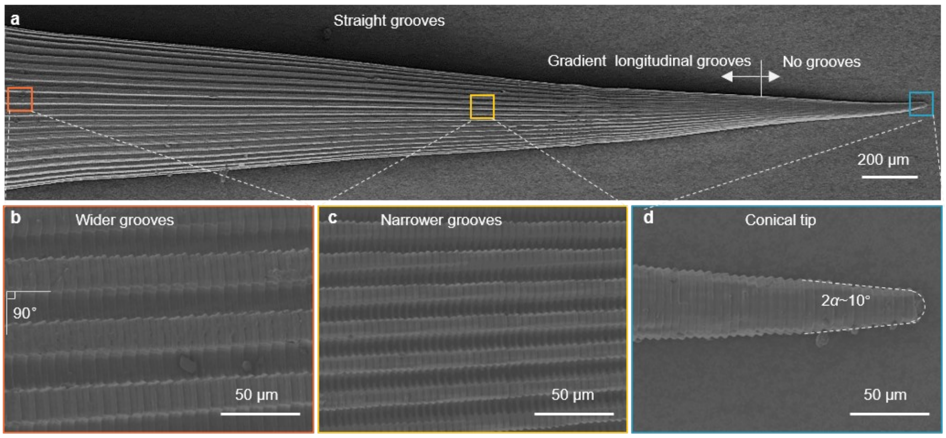

Figure S5. SEM images of the straight micro-grooved cone. (a) The gradient longitudinal micro-grooves are clearly visible on the cone except the tip region with a length of ~600 μm. (b-d) Magnified images of regions near the base (e), middle (f), and tip (g) of the cone, respectively. The width of the micro-grooves increases gradually from the tip to the base of the cone. The helical angle is 0° (b) and the apex angle (2α) of the tip is ~10° (d).

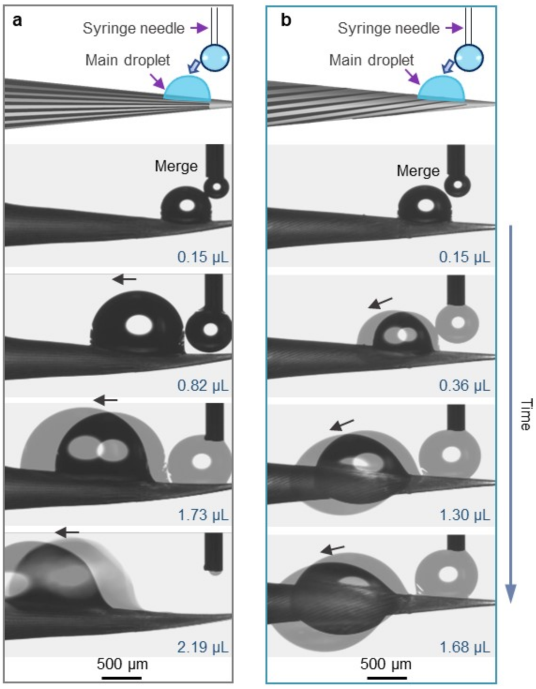

Figure S6. Wide field optical microscopic observation of the main droplet's motion on the different cones upon continuous feeding of water. (a) On the cone with straight micro-grooves, water droplet starts to move at a volume of 0.82 μL. (b) On the cone with helical micro-grooves, water droplet start to move at a volume of 0.36 μL. The critical volume of droplet's motion on the helical micro-grooved cone is much smaller than that on the straight micro-grooved cone.

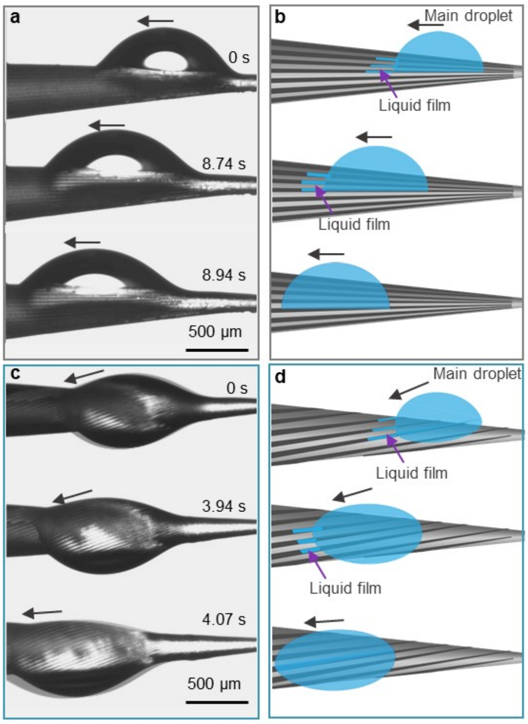

Figure S7. Optical microscopic observation (a, c) and schematic diagram (b, d) of droplet motion on the micro-grooved cones in detail. Precursor water films appear in the micro-grooves at the front of the main droplet. The main droplet on the cone moves from the tip to the base along the direction of the micro-grooves. The motion track of the droplet on the straight micro-groove cone is a straight line on the top of the cone (a, b), while the motion track of the droplet on the helical micro-grooved cone is a helical line around the cone (c, d).

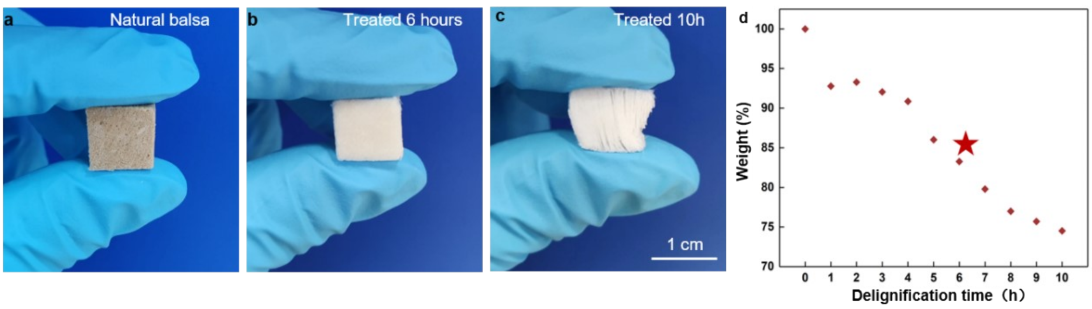

Figure S8. The appearance and mechanical property of (a) natural balsa wood, (b) delignified balsa wood for 6 hours (b) and 10 hours (c). The balsa wood sample turns from light brown to white with prolonged treating time. The wood sample becomes fragile after treating for 10 hours. (d) The weight change of balsa wood with delignification time. Red star labels the selection in the work.

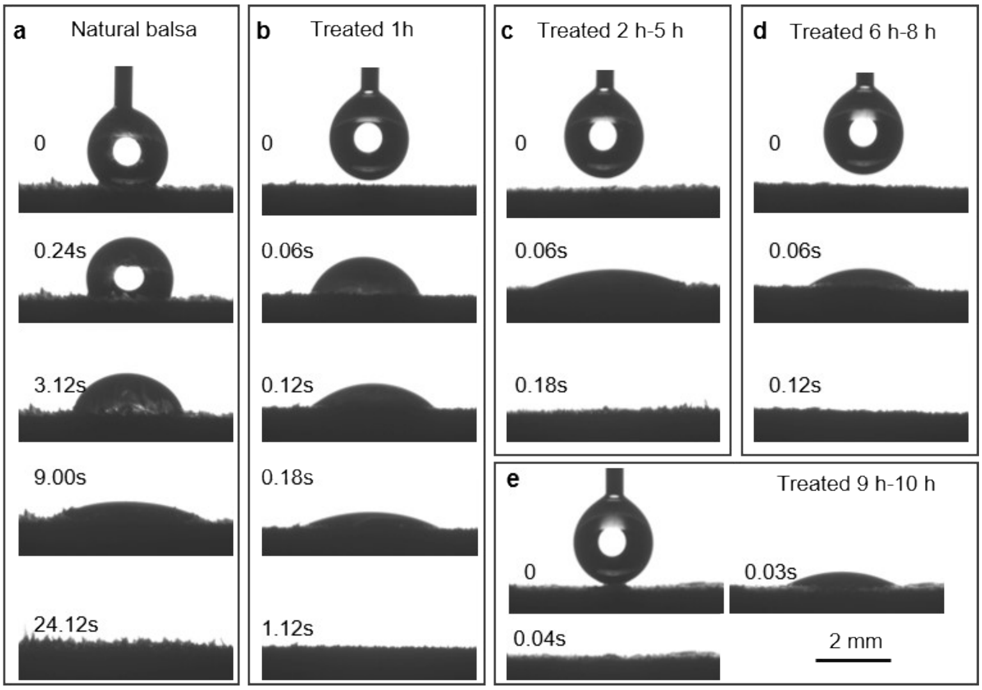

Figure S9. (a-e) Optical images of water absorption process of balsa wood with different delignification time (water droplet volume: 5 μL). The longer the treating time is, the faster the droplet is absorbed by the wood block.

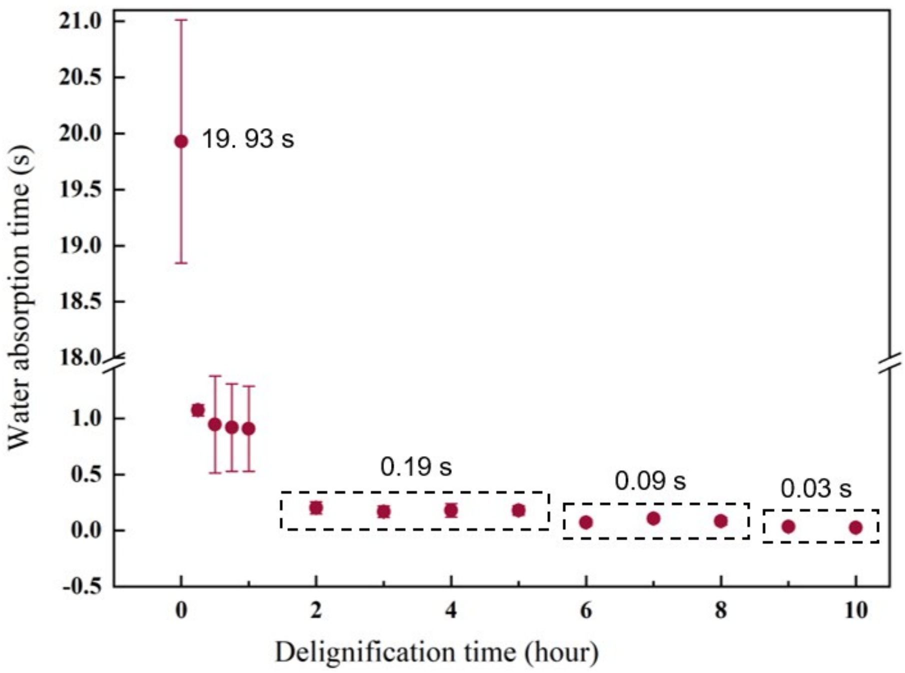

Figure S10. Statistics of water absorption time of balsa samples with delignification time. Basically, the absorption time decreases with the increase of treating time. The absorption time for 5 μL water droplet on the natural balsa wood is ~ 19.93 s, and decreases to ~ 0.03 s after treating for 9-10 hours.

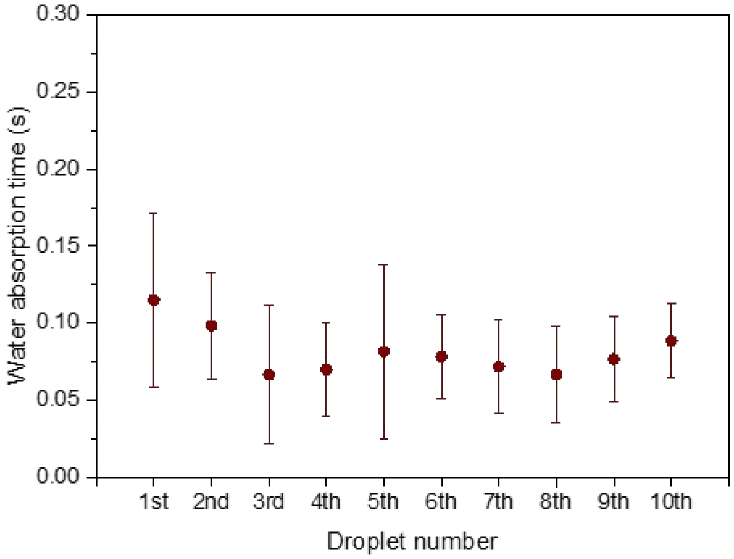

Figure S11. Statistics of water absorption time of balsa samples underwent 6-hour delignification treatment, with successive water droplet addition. Over the course of 10 cycles of water droplet addition, the absorption time for 5 μL water droplets on the delignified balsa wood was consistently below 0.13 seconds.

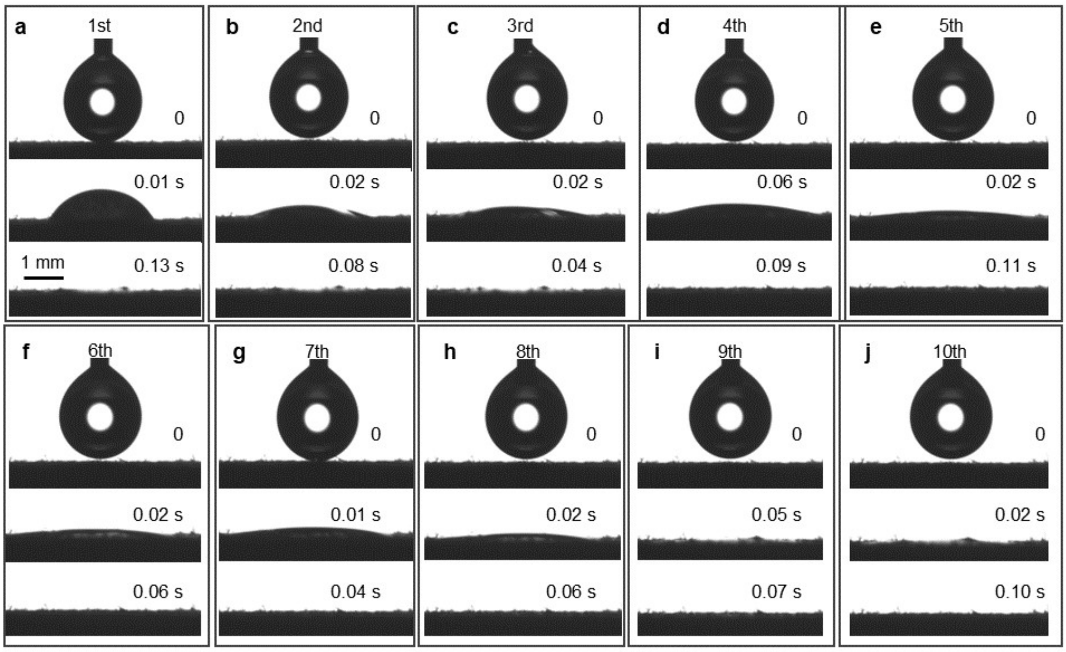

Figure S12. (a-j) Optical images of water absorption process of balsa wood (6-hour delignification treatment) with successive addition of water droplet (volume of each droplet: 5 μL). Over the course of 10 cycles of water droplet addition, the water absorption time on the delignified balsa wood was consistently less than 0.13 s.

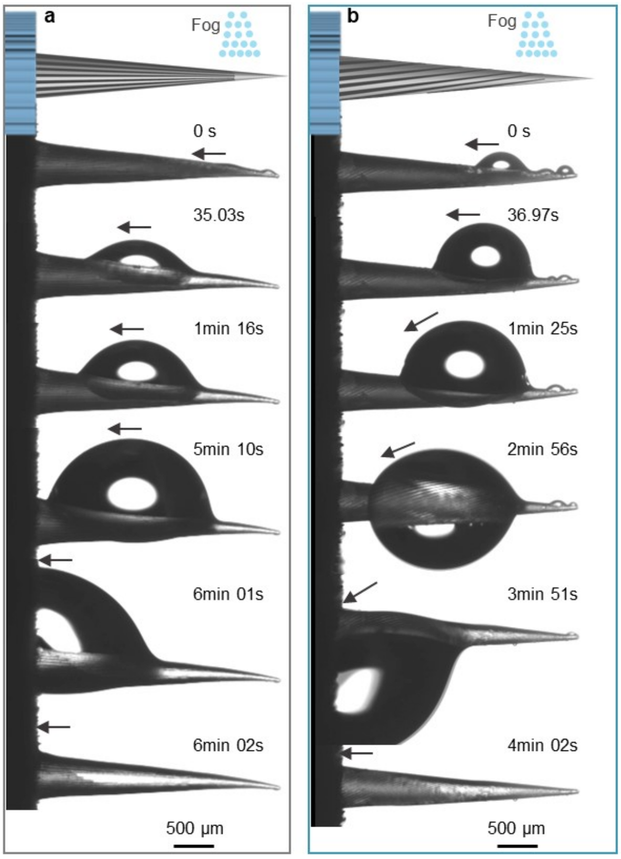

Figure S13. The optical microscopic observation of droplet motion on the wood-cone fog collection system. (a), on the system with straight micro-grooved cone, the water droplet sticks to the clam-shell conformation, moving directionally from the tip to the base of the cone. After 6 min 02 s, the droplet was absorbed by the wood. (b), on the system with helical micro-grooved cone, the water droplet transforms from clam-shell to the barrel conformation, moving quickly directionally. After 4 min 02 s, the water droplet was absorbed completely by the wood.