Electronic Supplementary Information

Unravelling aerodynamic enhancement of water harvesting via dynamic liquid bumps

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Supplementary text:

Experimental section:

Materials and characterization:

The water contact angles of the various coatings on the aluminum surface were measured using an LSA 100 goniometer. The morphologies of the coatings were observed using a scanning electron microscope (Phenom XL-SED-EDS). The shelf and air extraction device were printed using a 3D printer (Donzy Reflect 2, Dongzhiying Technology Co. Ltd., China). Fog for the fog collection test was generated by an ultrasonic humidifier (YaDu, China), and the fog for video shooting was generated by an ultrasonic humidifier (Yuwell, China). The detailed formation and departure processes of the DLibs were recorded by a high-speed camera (5KF10, Revealer, China). The Harp-Like Fog Collectors were engraved by Huagong Laser (LSU10).

Preparation of surface with various wettability:

SHL surface: After boiling an aluminum plate in deionized water for 1 hour, a superhydrophilic reagent (LumiNano Co. Ltd., China), containing 3% (w/w) silica sol, 0.5% (w/w) hydrophilic cellulose-based polymer, and 0.5% (w/w) Triton X-100 surfactant was sprayed to the plate. After the coating had fully solidified at 100 °C for 4 hours, the treated surface was rinsed with deionized water to remove remaining template molecules.

Aluminum oxide surface: The aluminum plate was calcined in a muffle furnace at 600 °C for 1 hour to form aluminum oxide surface.

Waterborne polyurethane surface: A water-soluble polyurethane solution was uniformly coated on the aluminum sheet and then cured.

ACR surface: Acrylic resin (purchased from Taobao) was dissolved in 10% ethyl acetate (Aladdin

Biochemical Technology Co., Ltd., Shanghai) (w/v) and sprayed onto the aluminum plate. The coating was then cured to form the ACR layer.

Slippery surface: 1 mL of KH550 (γ-Aminopropyl triethoxysilane) and 1 mL of KH560 (Glycidoxypropyltrimethoxysilane) were dissolved in 5 mL of ethyl acetate to form a clear solution, which was then transferred into a 20 mL glass container. Subsequently, 3 mL of dimethicone oil and 0.8 g of silicon dioxide were added dropwise under continuous stirring. The mixture was stirred for 24 hours and sprayed onto the Al plate. Subsequently, the plate was cured in air for 24 hours.

PDMS surface: Polydimethylsiloxane (Sylgard-184, Dow Corning Co. Ltd.) was dissolved in n-hexane at a concentration of 10% (w/v), uniformly sprayed onto the aluminum plate, and cured at 60 °C for 24 hours.

SHB surface: A PDMS solution (Sylgard-184, Dow Corning Co. Ltd., 10% w/v in hexane) was applied to the aluminum plate. R972 powder was then sprinkled onto the tacky PDMS layer, and the surface was cured at 60 °C for 24 hours.

Supplementary figures:

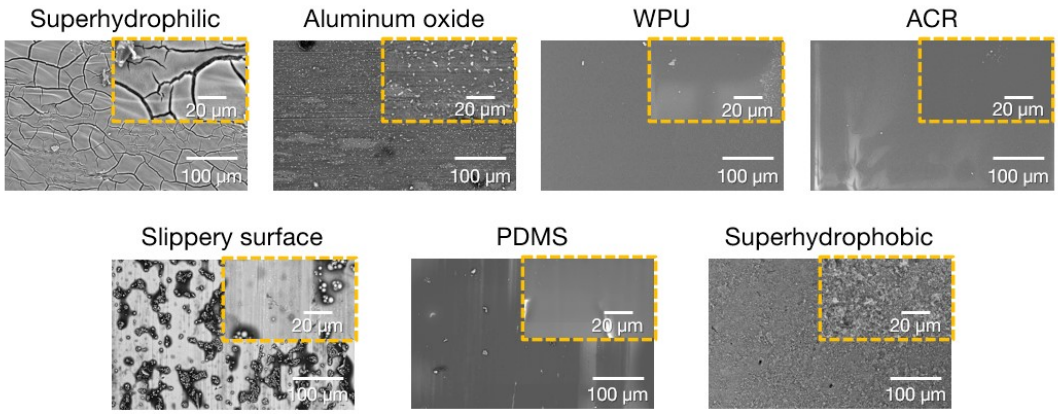

Fig. S1. The scanning electron microscope (SEM) images of the Al plate treated with different coatings reveal a microscopic level of flatness.

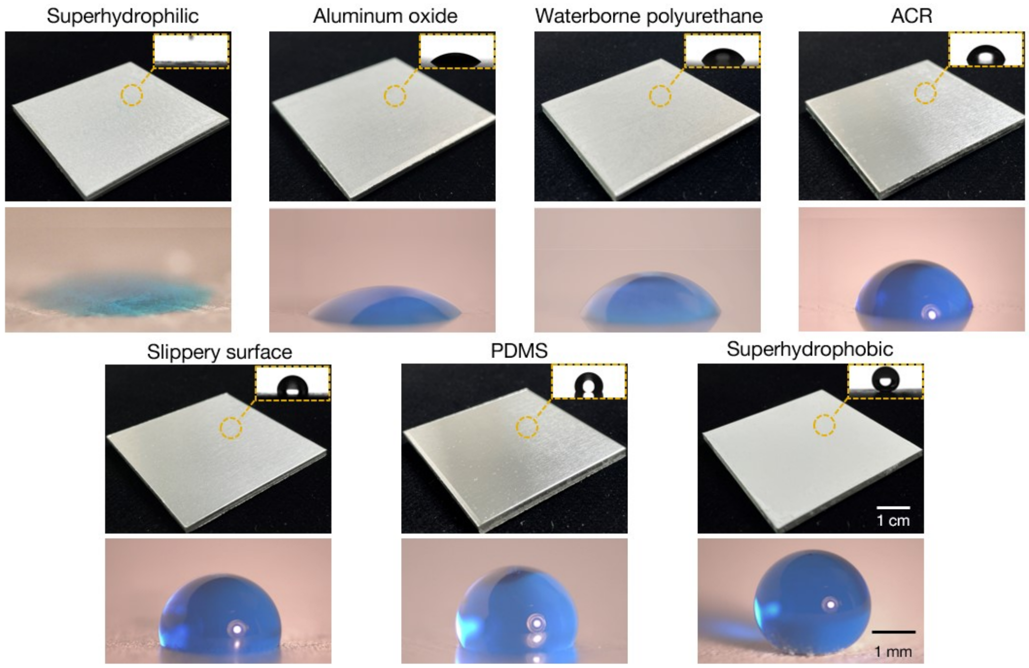

Fig. S2. The surface morphology and contact angles of different materials. All the surfaces remain smooth and flat, with no noticeable structures.

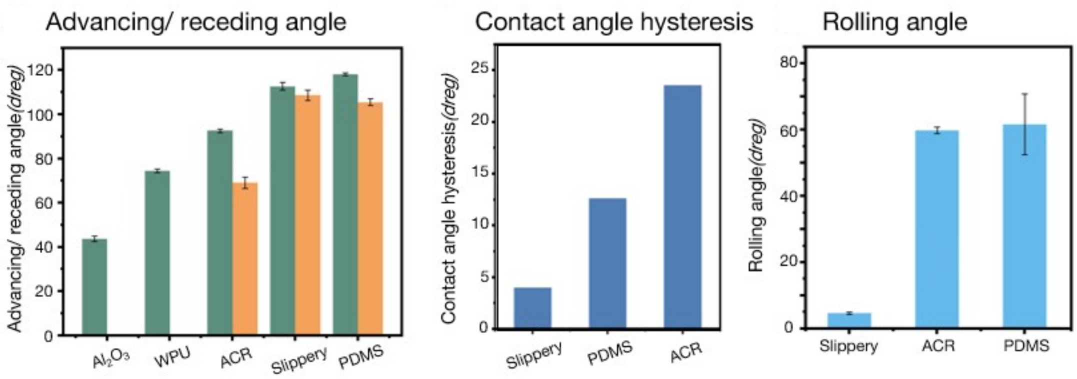

Fig. S3. Contact angle measurements and rolling behavior of different surfaces.

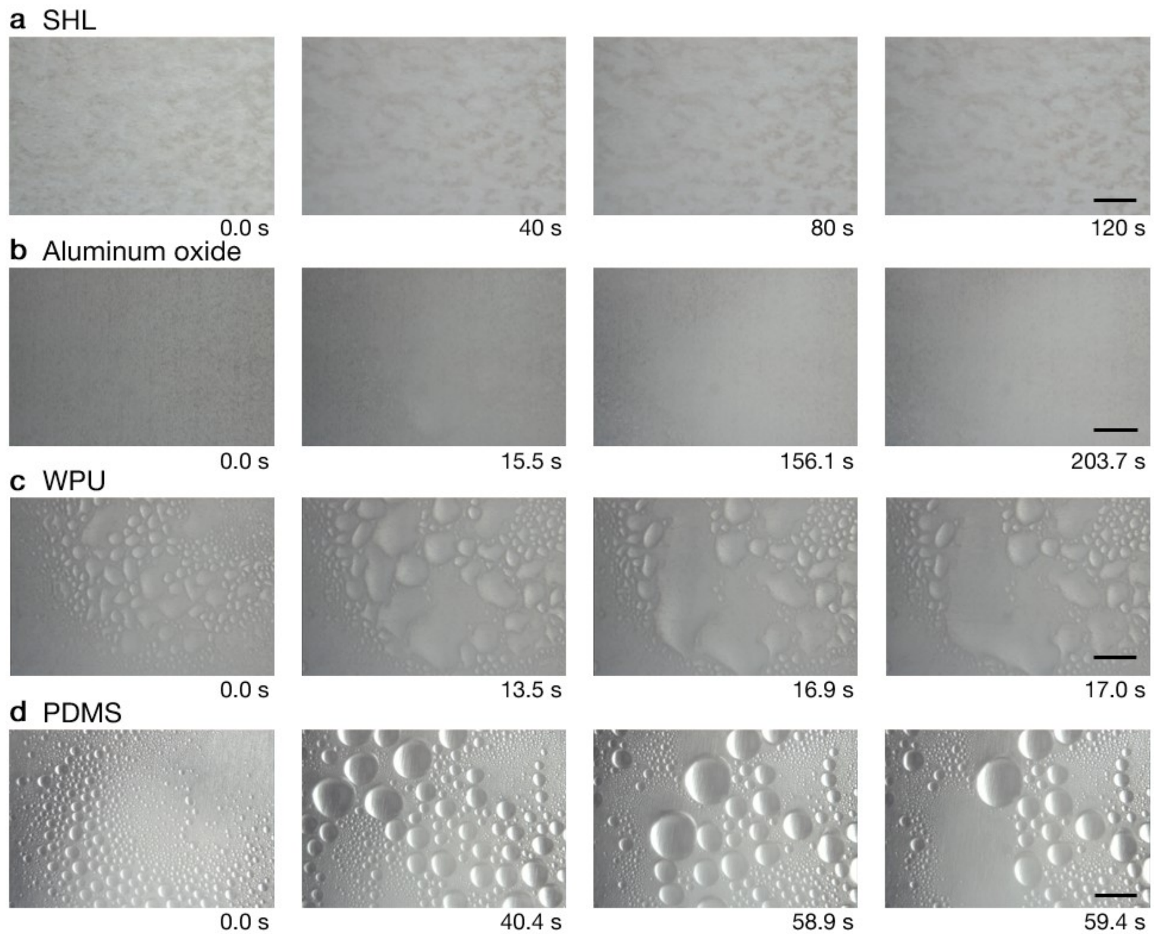

Fig. S4. Dynamic behavior of DLibs during fog collection process. Scale bar is 3 mm.

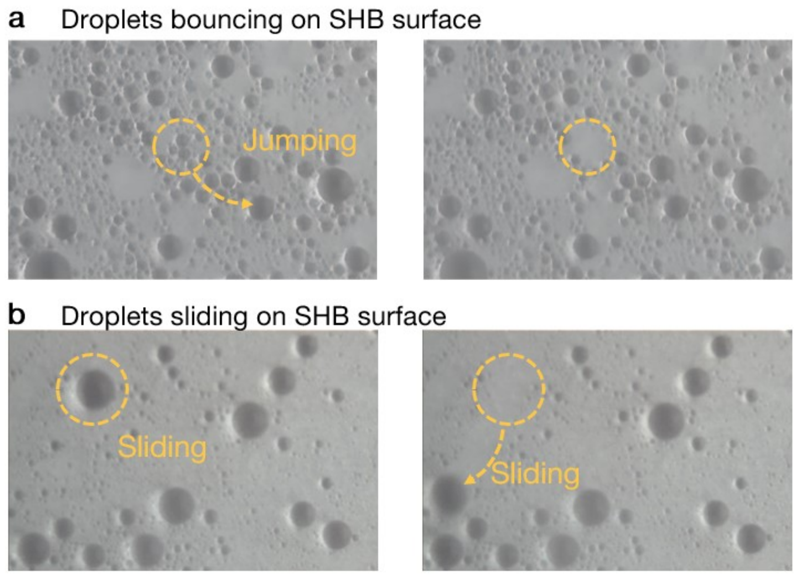

Fig. S5. The droplets jumping and sliding under different fog collecting stages. In the initial phase of the fog collection process, droplets primarily bounce off the surface (a). Over time, the surface transitions from the Cassie state to the Wenzel state, leading to an increase in droplet adhesion. Consequently, the droplet volume progressively grows, and as the droplets roll off the surface, they carry away numerous smaller droplets along their path (b).

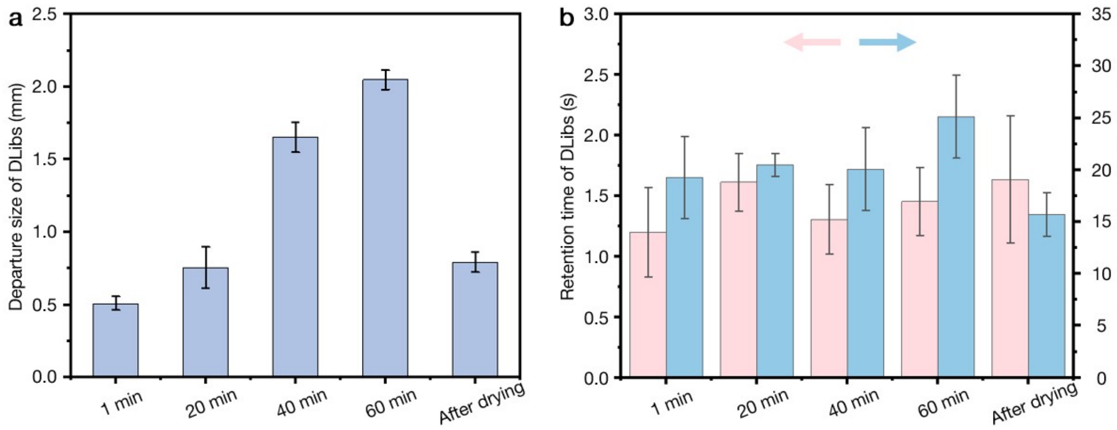

Fig. S6. The reversibility of fog collection on superhydrophobic surfaces characterized by departure size, retention time and droplet spacing of DLibs.

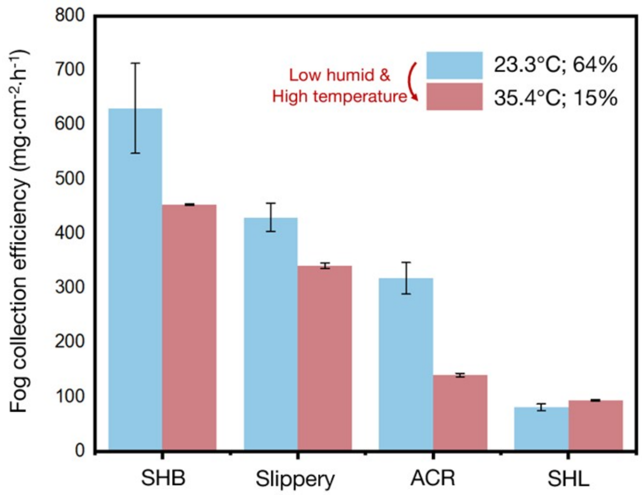

Fig. S7. Fog collection efficiency under different temperature and humidity conditions, which will decrease as the temperature increases or the humidity decreases.

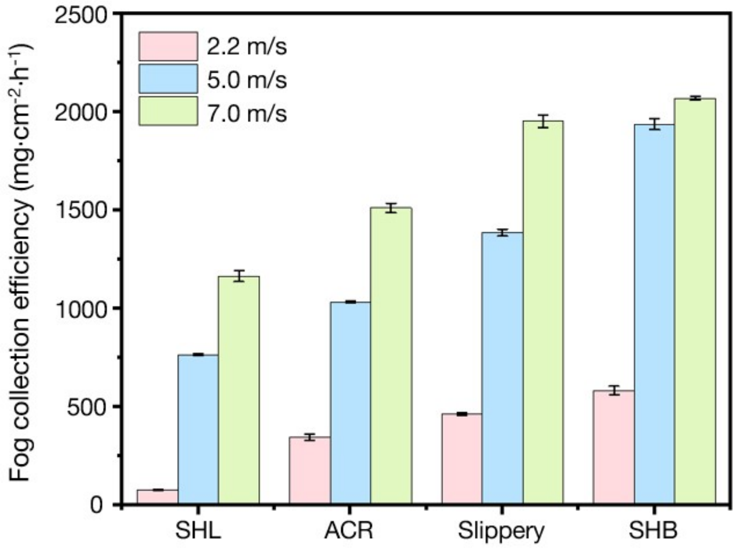

Fig. S8. Fog collection efficiency under varies wind speeds, which is positively correlated with the wind velocity.

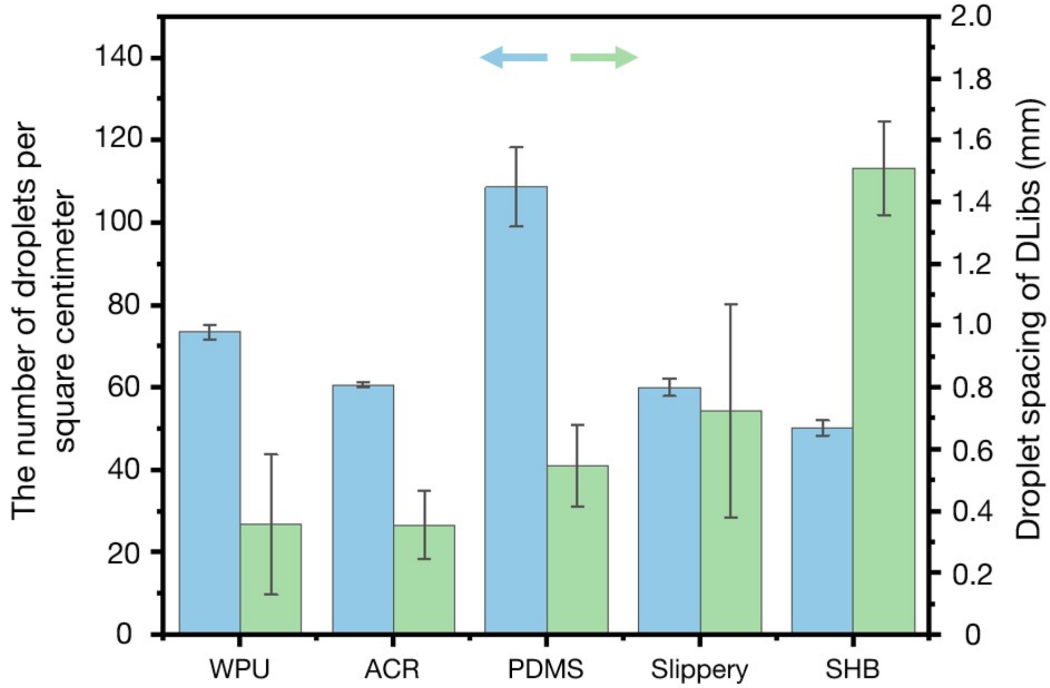

Fig. S9. The characterization of droplet density and spacing in surfaces with various wettability, with SHB highest in spacing.

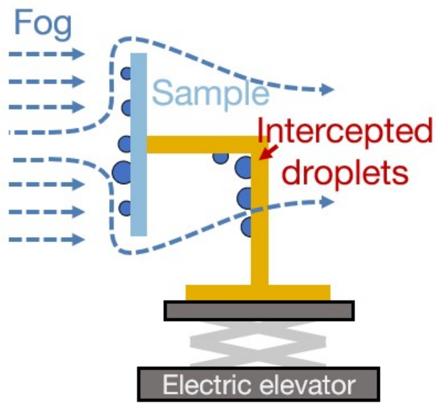

Fig. S10. Schematic diagram of the mass measurement device without air extraction. The fog will be intercepted and collected on the shelf, which influences the precision of the test.

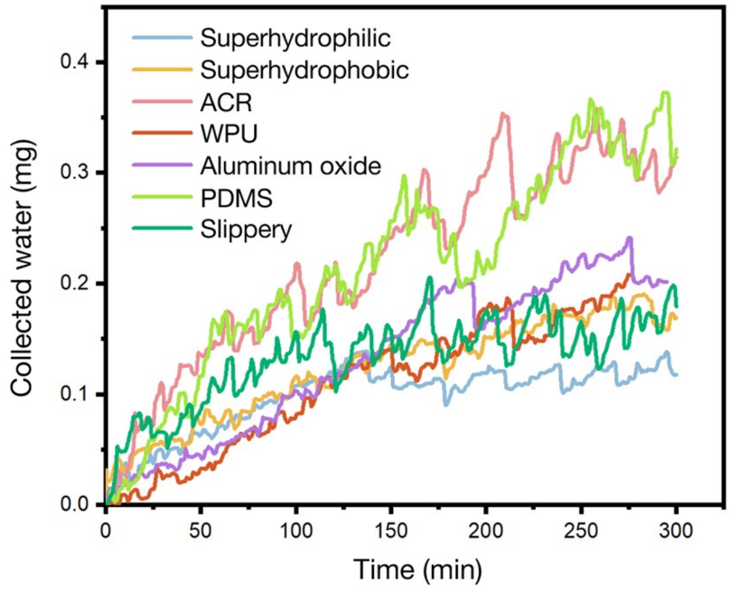

Fig. S11. Real-time analysis of water accumulation of various surface during fog collection.

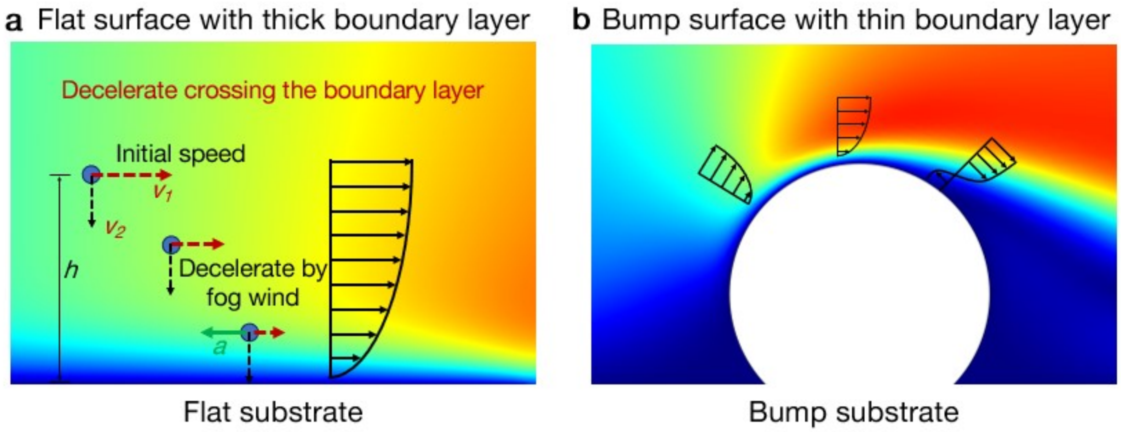

Fig. S12. Comparation of boundary layer between flat and bump surface by COMSOL simulation.

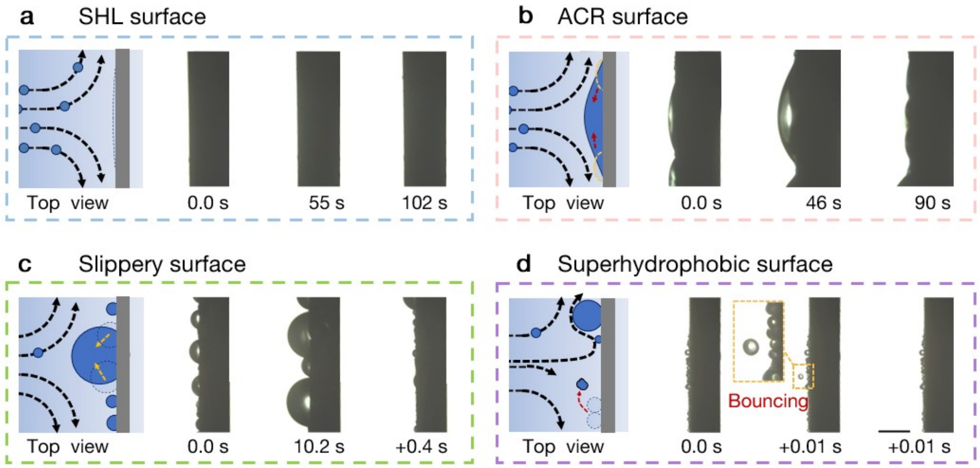

Fig. S13. Top view of Dynamic behavior of DLibs during the fog collection process. Superhydrophilic surfaces do not form DLibs. As surface hydrophobicity increases, DLibs become increasingly bulged and detached from the surface at a progressively faster rate.

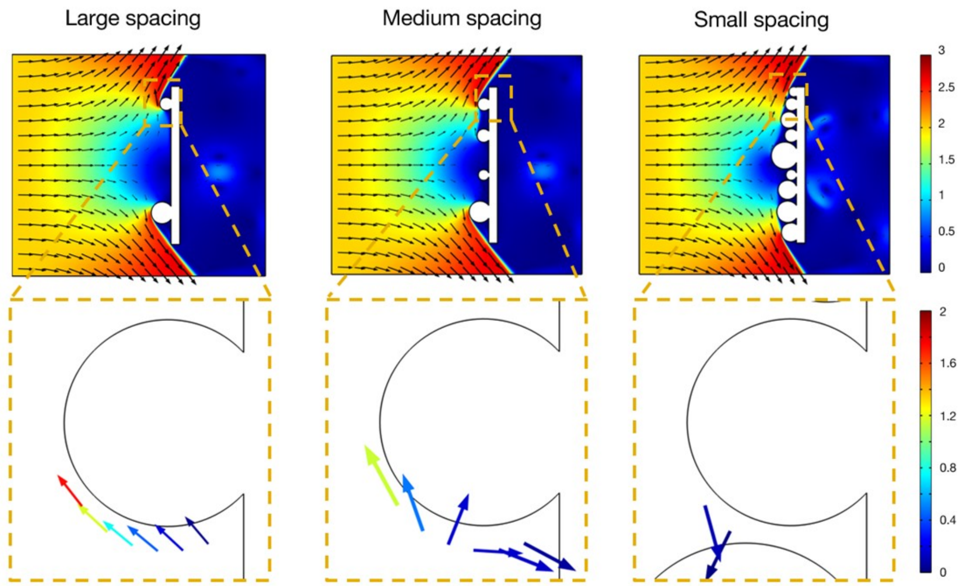

Fig. S14. COMSOL simulation of fog collection with varying spacing. To ensure simulation accuracy, liquid droplets were modeled with distinct diameter distributions.

Movie S1. Dynamic interactions of DLibs on various surfaces during the fog collection process.

Movie S2. Top-view observation of DLibs behavior on surfaces with varying wettability during fog collection.

Movie S3. COMSOL simulation of fog collection at varying spacing to validate actual process.

Movie S4. Influence of surface wettability on the fog collection performance of harp-like collectors.