Supporting Information

Scalable Drop-To-Film Condensation on a Nanostructured Hierarchical Surface for Enhanced Humidity Harvesting

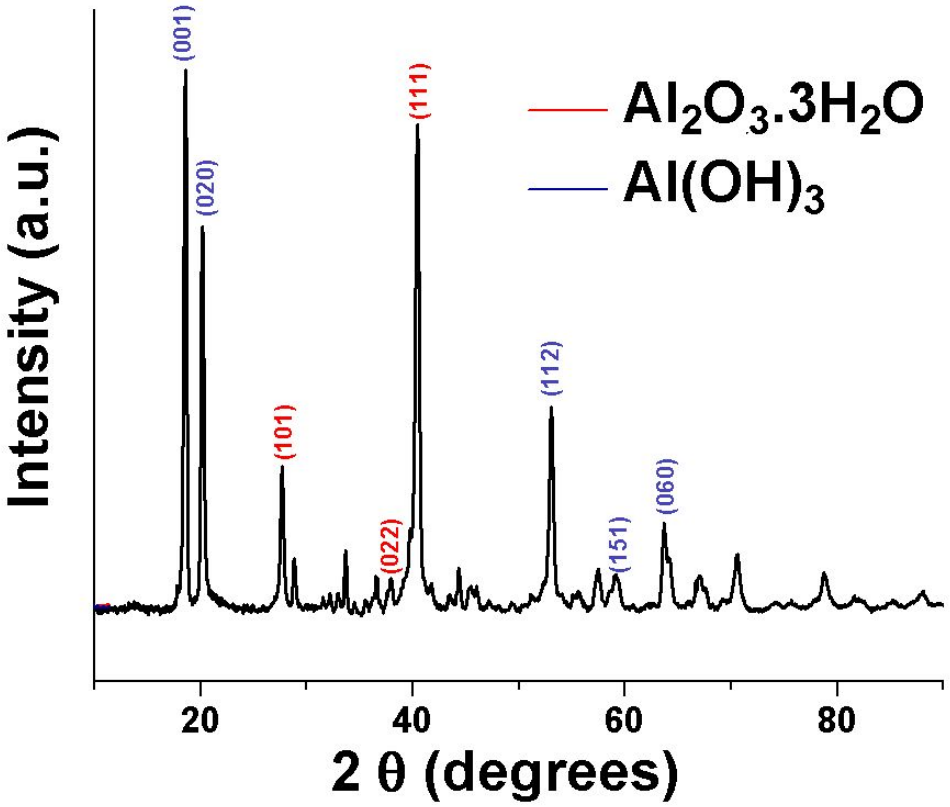
Ankit Nagar[†,‡]*, Ramesh Kumar*[‡]*, Pillalamarri Srikrishnarka*[†]*, Tiju Thomas*[*,‡] *and Thalappil Pradeep*[*,†]

[†]DST Unit of Nanoscience, Thematic Unit of Excellence, Department of Chemistry, Indian Institute of Technology Madras, Chennai 600036, India.

[‡]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600036, India.

Email: tijuthomas@iitm.ac.in, [*,‡] pradeep@iitm.ac.in [*,†]

S1. Characterization of the h surface



Name and formula

Reference code:	01-077-0250
Mineral name:	Bayerite
ICSD name:	Aluminum Hydroxide
Empirical formula:	AlH_3O_3
Chemical formula:	$Al(OH)_3$

Crystallographic parameters

Crystal system:	Monoclinic
Space group:	C2/m
Space group number:	12
a (Å):	5.0100
b (Å):	8.6800
c (Å):	4.7600
Alpha (°):	90.0000
Beta (°):	90.0000
Gamma (°):	90.0000
Calculated density (g/cm^3):	2.50
Volume of cell (10^6 pm^3):	207.00
Z:	4.00
RIR:	2.13

Name and formula

Reference code:	00-008-0096
Mineral name:	Bayerite, syn
PDF index name:	Aluminum Oxide Hydrate
Empirical formula:	$Al_2H_6O_6$
Chemical formula:	$Al_2O_3 \cdot 3H_2O$

Crystallographic parameters

Crystal system:	Hexagonal
a (Å):	5.0400
b (Å):	5.0400
c (Å):	4.7200
Alpha (°):	90.0000
Beta (°):	90.0000
Gamma (°):	120.0000
Calculated density (g/cm^3):	2.49
Measured density (g/cm^3):	2.53
Volume of cell (10^6 pm^3):	103.83
Z:	2.00
RIR:	-

Figure S1. Powder XRD of the particulates obtained after scraping the hierarchically structured surface (h).

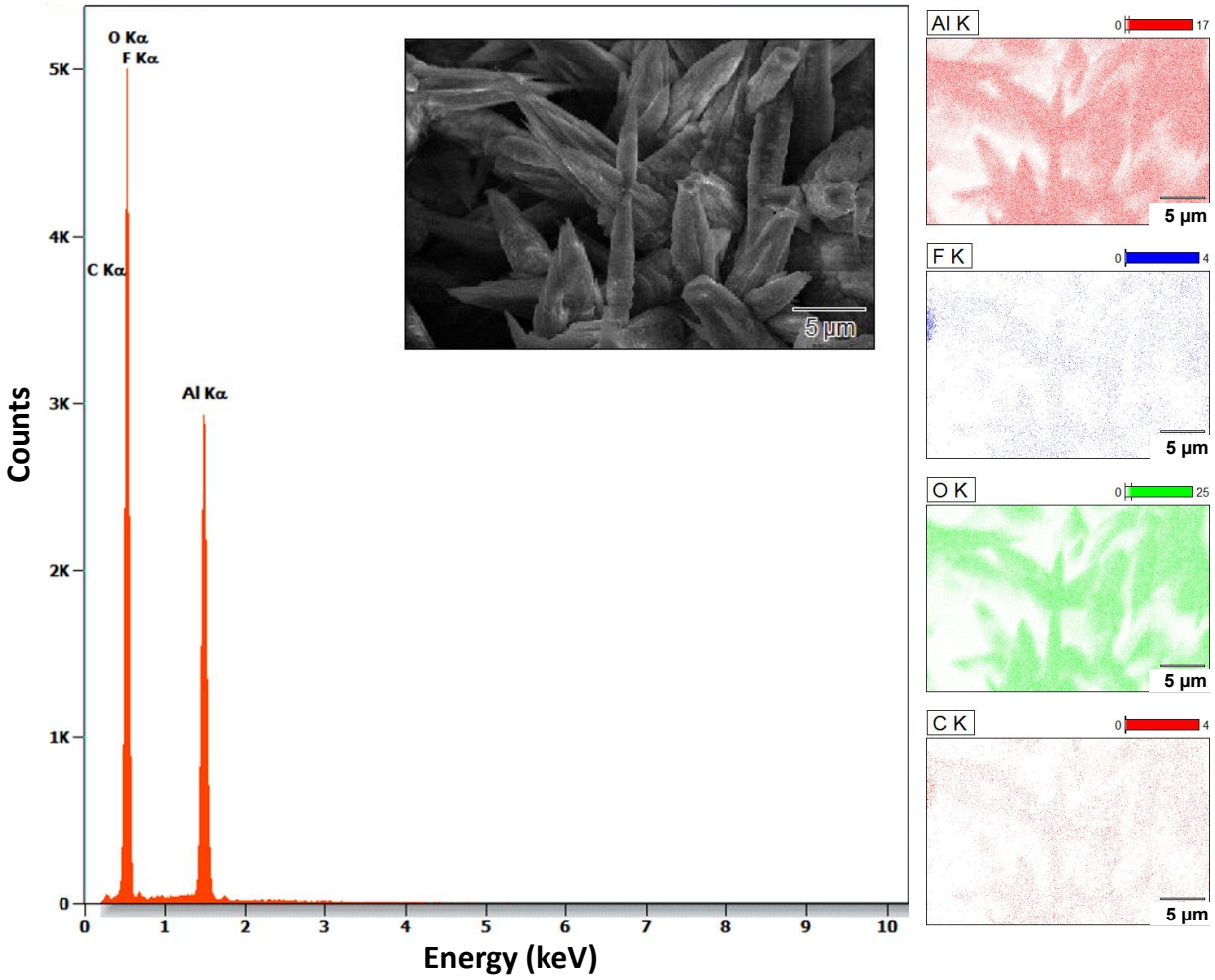


Figure S2. EDS spectrum and mapping of the h-hp surface to verify silane functionalization through fluorine distribution over the surface.

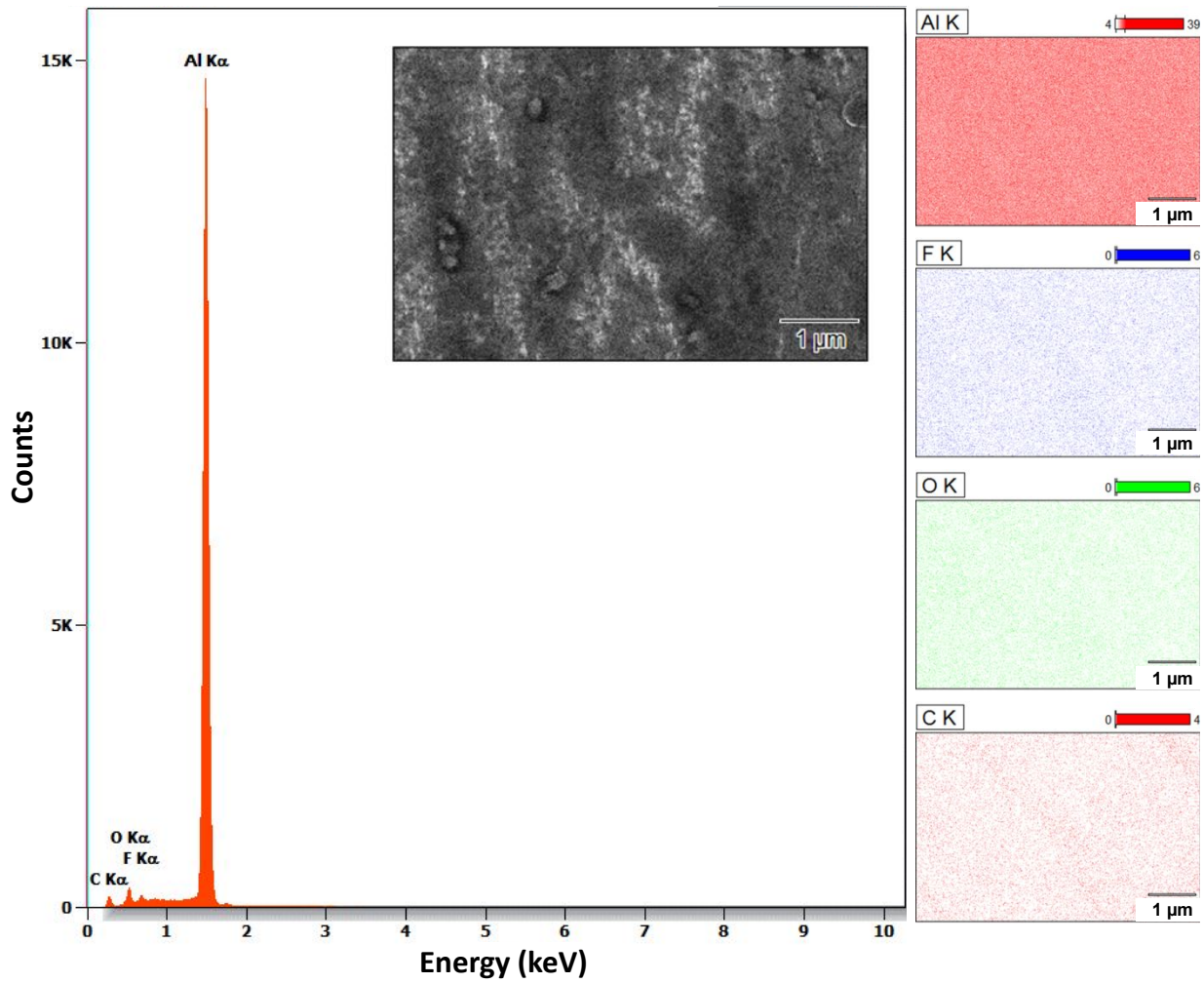


Figure S3. EDS spectrum and mapping of silane-coated plain aluminium surface (p-hp) to verify silane functionalization through fluorine distribution over the surface.

S2. Lab-scale setup to perform water collection experiments

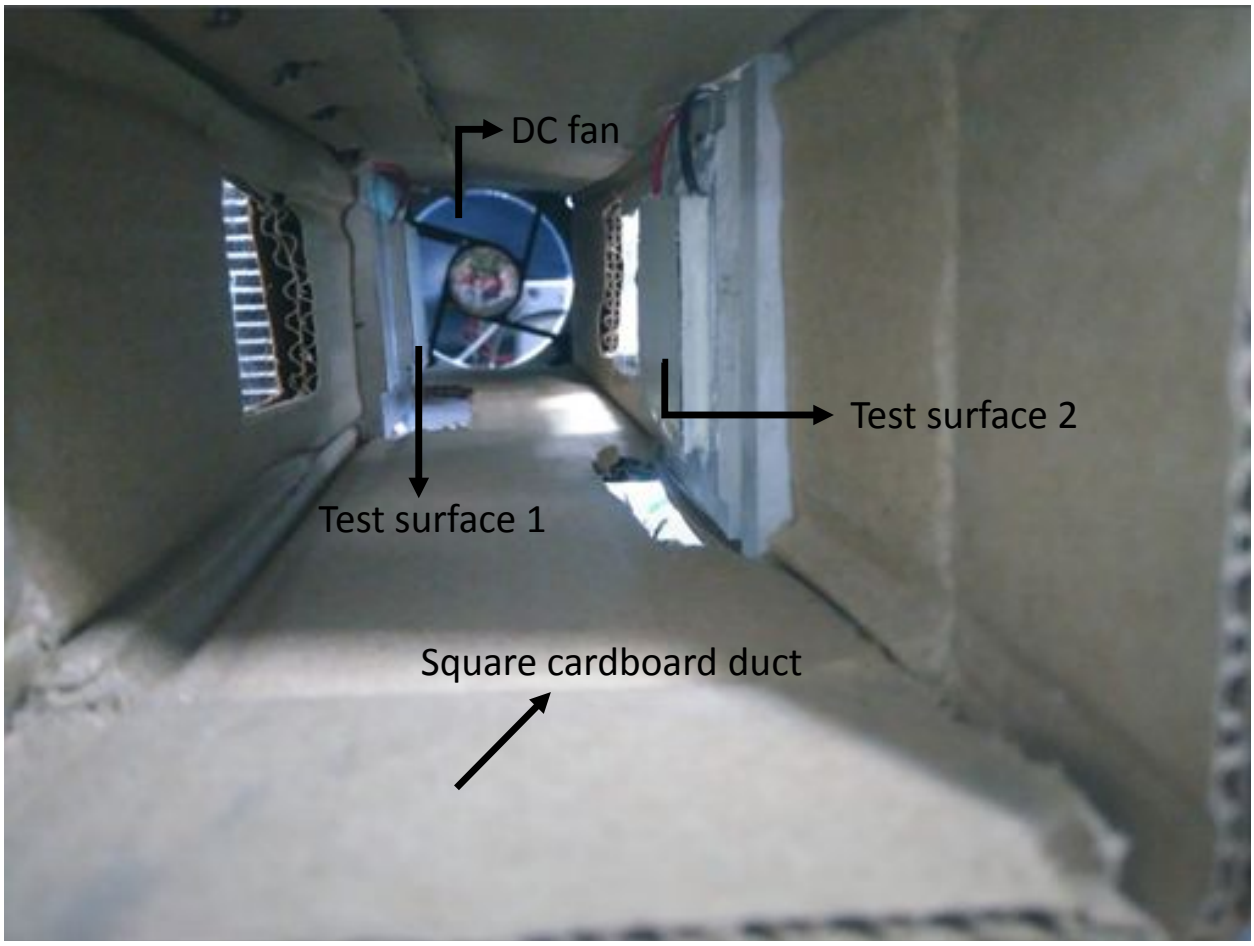


Figure S4. Inside view of a square duct made out of cardboard for restricted flow of ambient air. The test surfaces put on the peltier-heat sink assembly were exposed to the ambient air flowing inside the duct by means of a dc fan. Two surfaces were tested at the same time, placed on opposite walls of the box, with few cms distance apart.

S3. Gravity-assisted rolling on p surface

Droplets of the order of 1 mm roll down the p surface and, in the process, collect smaller droplets along with them, as shown in the figure below. The size and shape of rolling droplet being similar across the entire subcooling, it has only been shown as an illustration at $\Delta T \sim 2\ ^0C$.

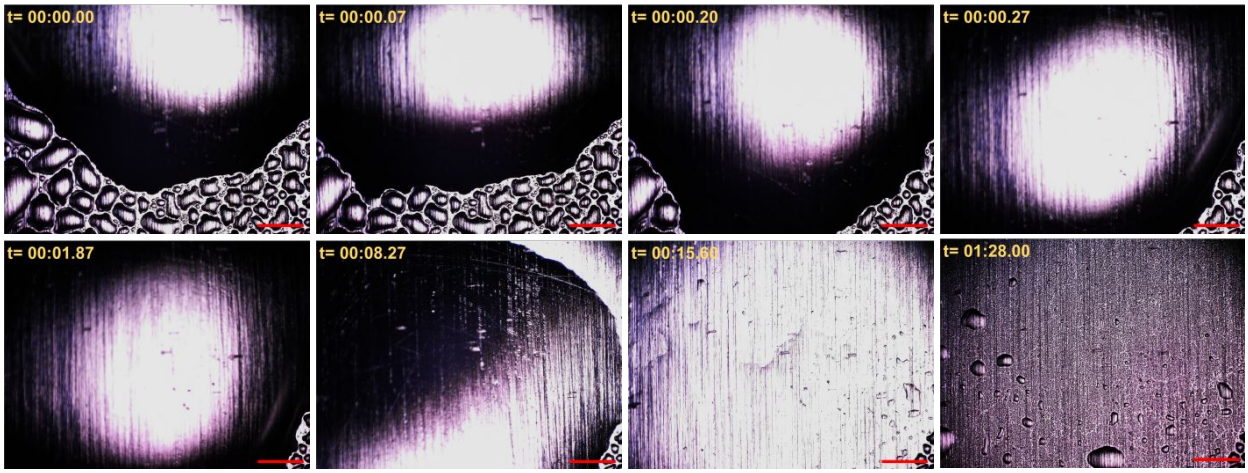


Figure S5. Rolling droplet of the order of 1 mm on the p surface, shown by time-resolved optical images (time in minutes). The event was recorded at 15 frames per second, and at a subcooling of ~2 ^0C. Scale bar: 500 μm.

S4. Gravity-assisted rolling on p-hp surface

Droplets of the order of 1 mm roll down the p-hp surface and, in the process, collect smaller droplets along with them, as shown in the figure below. The size and shape of rolling droplet being similar across the entire subcooling, it has only been shown as an illustration at $\Delta T \sim 8\ ^0C$.

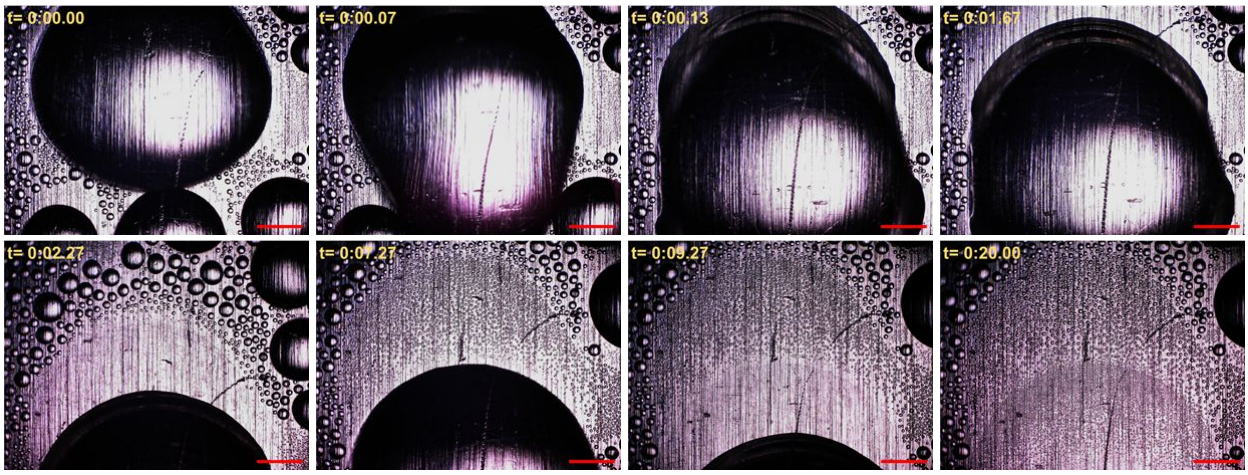


Figure S6. Rolling droplet of the order of 1 mm on the p-hp surface, shown by time-resolved optical images (time in minutes). The event was recorded at 15 frames per second, and at a subcooling of ~8 ^{0}C. Scale bar: 500 μm.

S5. Drop-to-film coalescence on h surface

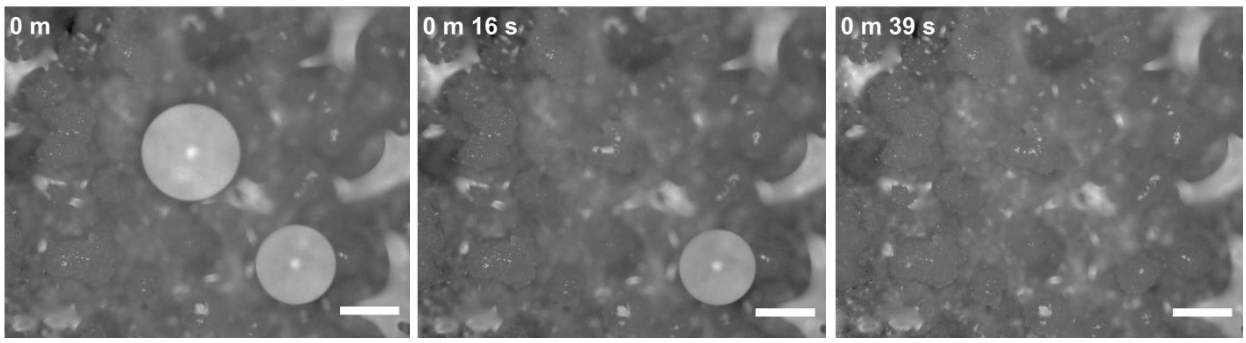


Figure S7. Droplets of the order of 100 μm leave behind a wet bundle after undergoing coalescence with the film. The coalescence mechanism has been discussed through Figures 3 and 4 in the article.

S5. Gravity-assisted rolling on h-hp surface

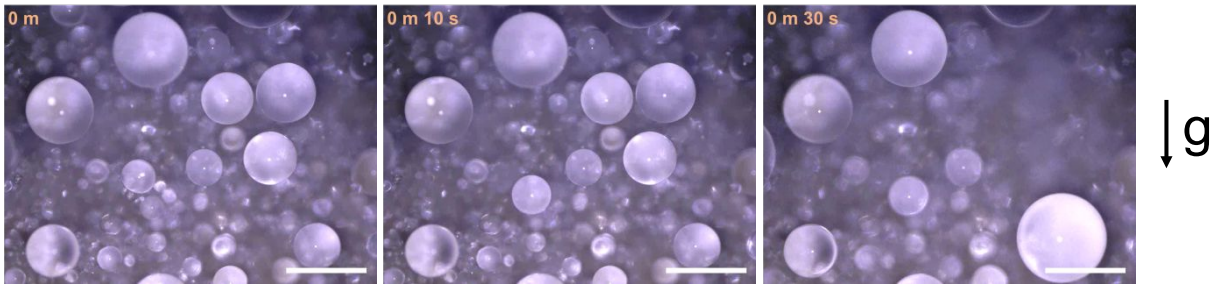


Figure S8. Coalescence of multiple droplets forms a larger droplet of the order of 100 μm which rolls down under the effect of gravity.

S6. Jumping-droplet condensation on h-hp surface

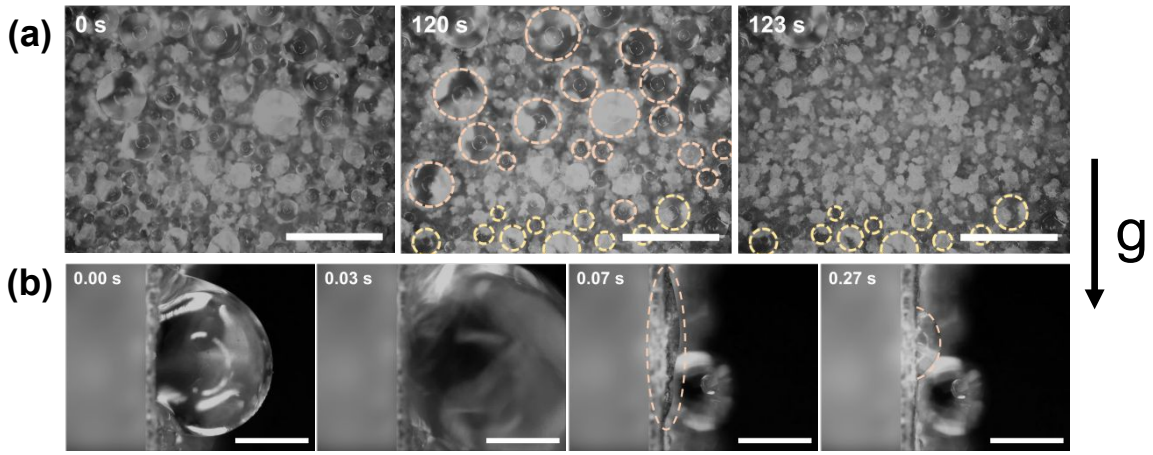


Figure S9. Representative examples of jumping mode of condensation on h-hp surface at ΔT~ 8 ^{0}C.(a)Time-resolved optical imaging of the h-hp surface from the front side (gravity acting downwards). The droplets grow and reach the top of the surface as time passes. Upon reaching a certain size, a set of droplets suddenly jump off the surface (indicated by pink dashed circles).

The jumping is evident from the yellow circled droplets beneath them, which stay as is, after the jumping event has occurred. All scale bars: 1 mm. (b) Side-view time-resolved imaging revealed jumping of an O (1 mm) droplet from the surface (t= 0 s), leaving behind a reminiscent water film (t= 0.07 s). Another droplet begins to grow at the same location (t=0.27 s) and the cycle continues to repeat itself. All scale bars: 1 mm.

S7. Toppling droplet on h surface

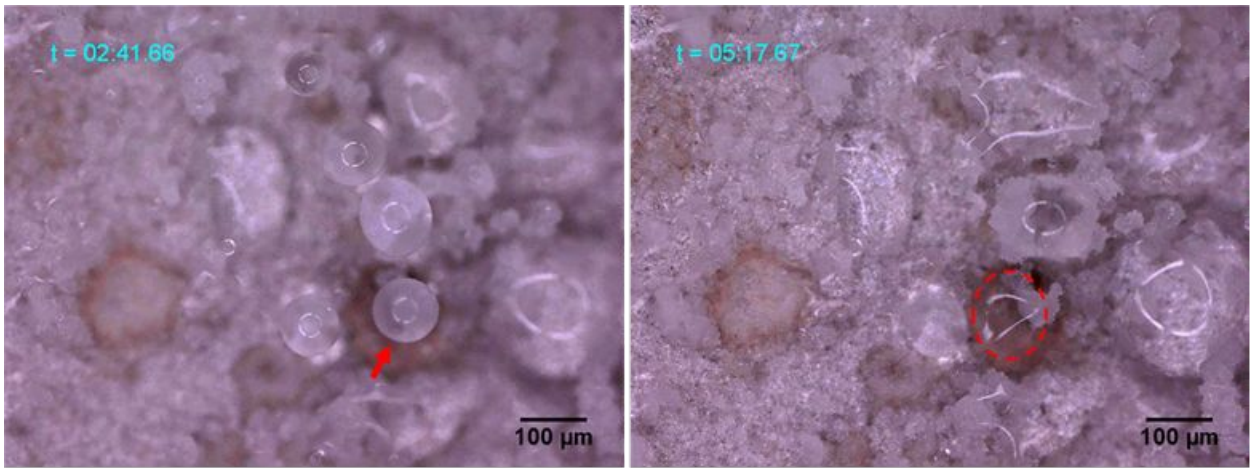


Figure S10. At t=2:41.73 mins, the droplet (indicated by red arrow) topples down the bundle, as evident from the distorted reflection of the toppled droplet later at t= 05:17.67 mins (within the dashed circle in red). The reflection extends from the bundle to the surrounding basal water film indicative of the toppling.

S8. Test runs of the p and h prototypes

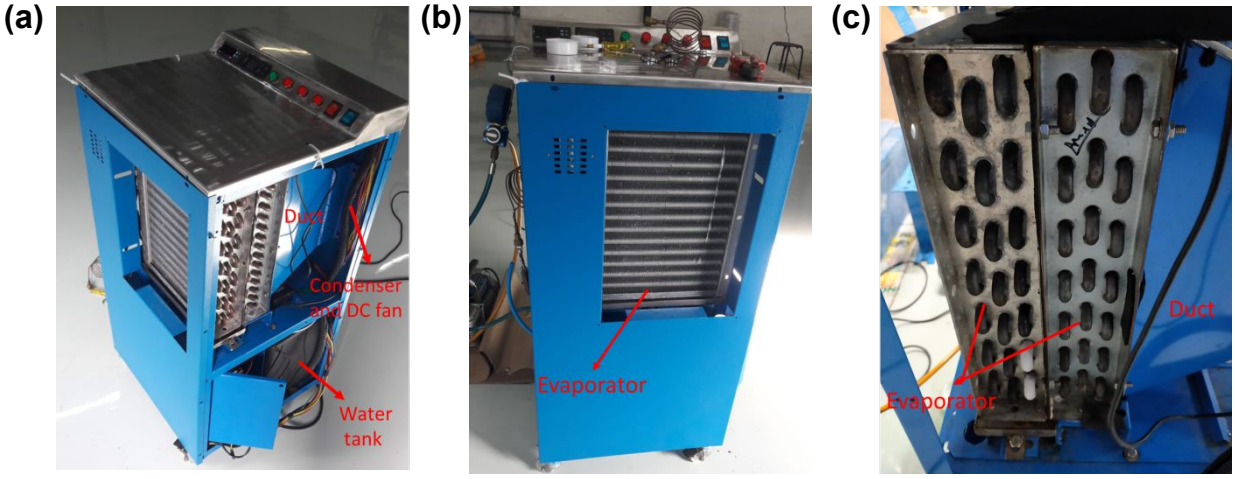


Figure S11. Images of one of the home-built prototype assembly showing various parts: (a) Perspective view, (b) front view (without air filter), and (c) side view.

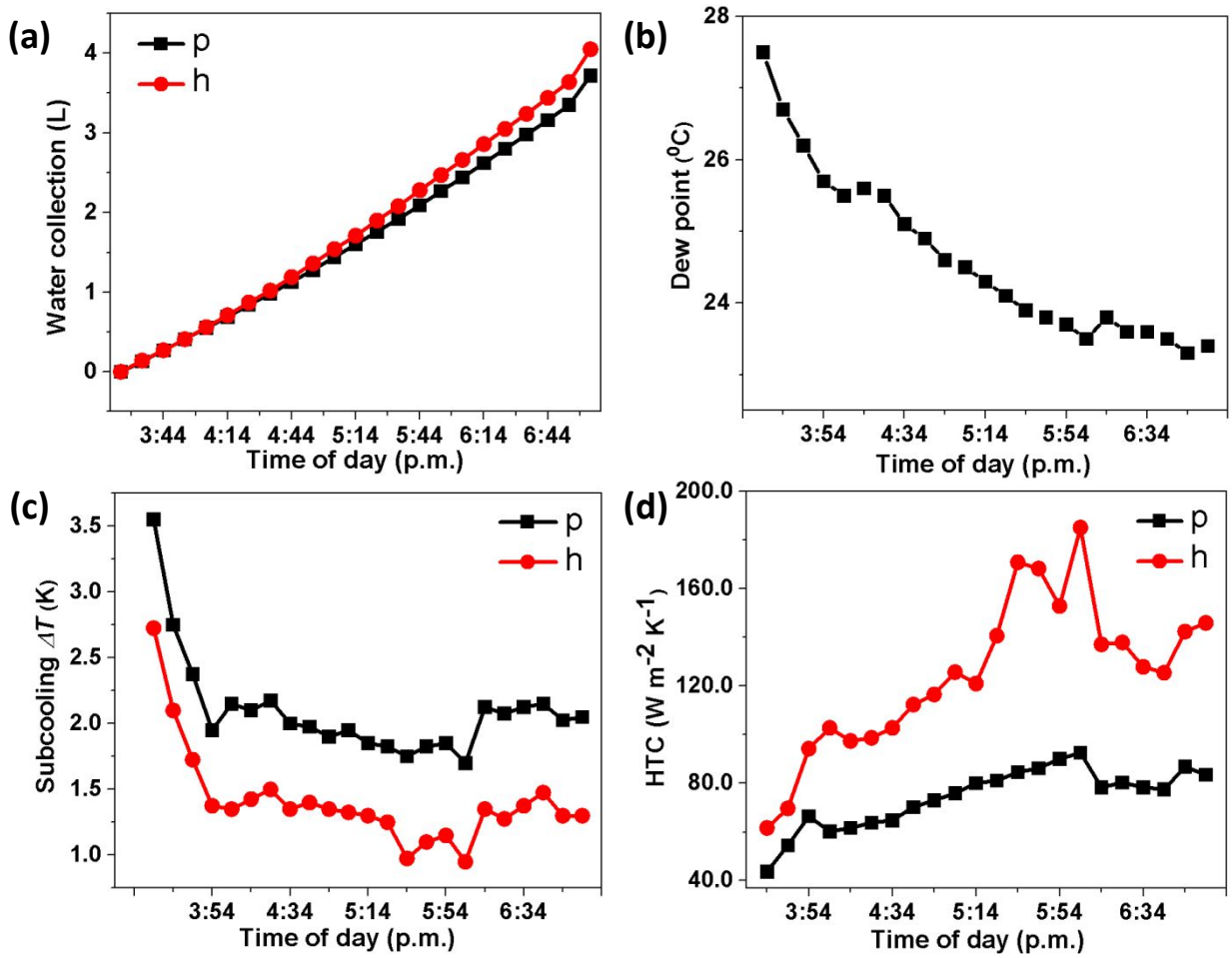


Figure S12. (a) Cumulative water collection, (b) Dew point, (c) Subcooling, and (d) HTC for the first test run (corresponding to Figure 7 in the main text).

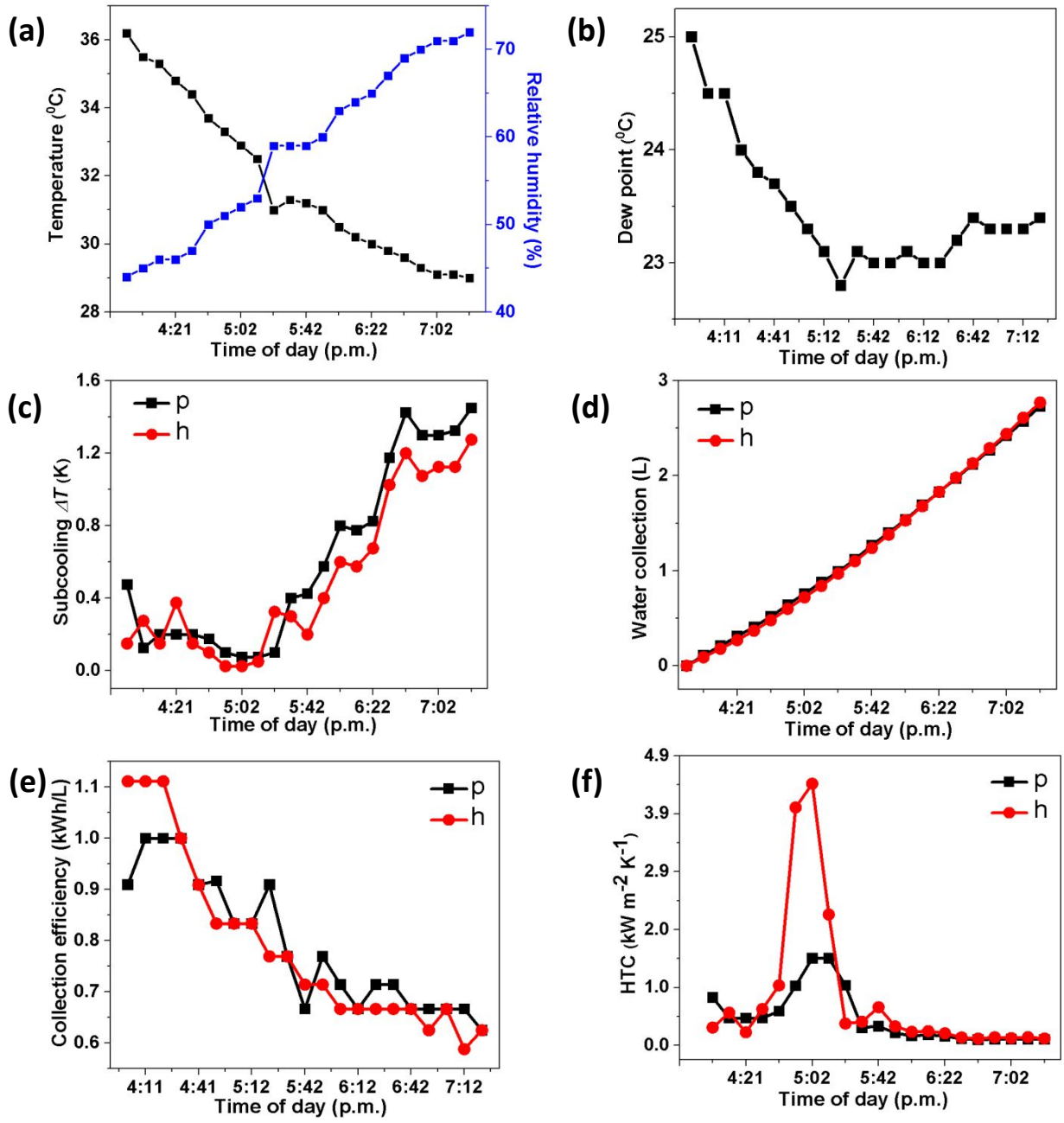


Figure S13. Second test run of the prototypes, showing variation in (a) ambient conditions, (b) dew point temperature, (c) degree of subcooling, (d) cumulative water collected, (e) collection efficiency, and (f) HTC, for the duration of the test run.

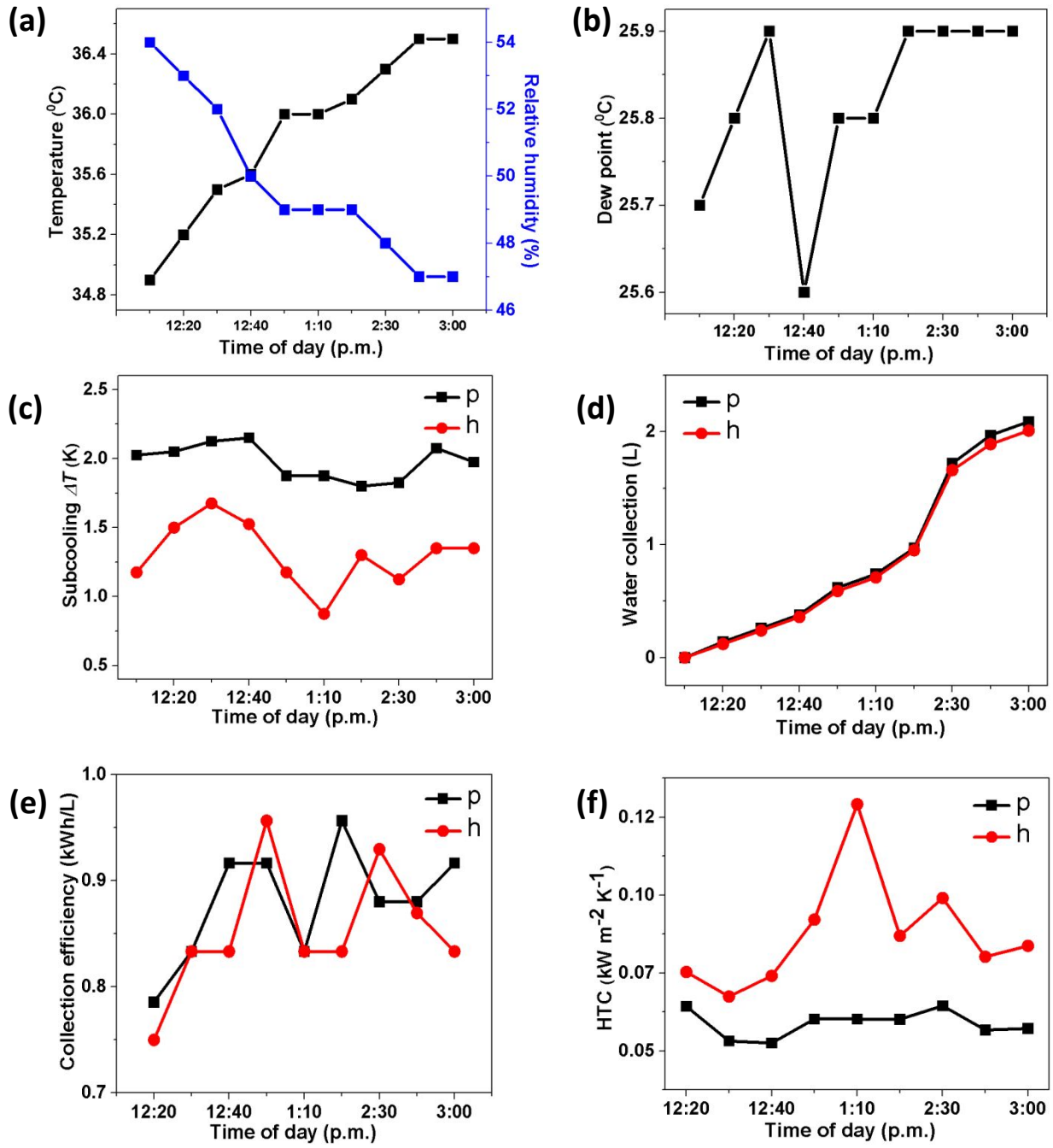


Figure S14. Third test run of the prototypes, showing variation in (a) ambient conditions, (b) dew point temperature, (c) degree of subcooling, (d) cumulative water collected, (e) collection efficiency, and (f) HTC, for the duration of the test run.

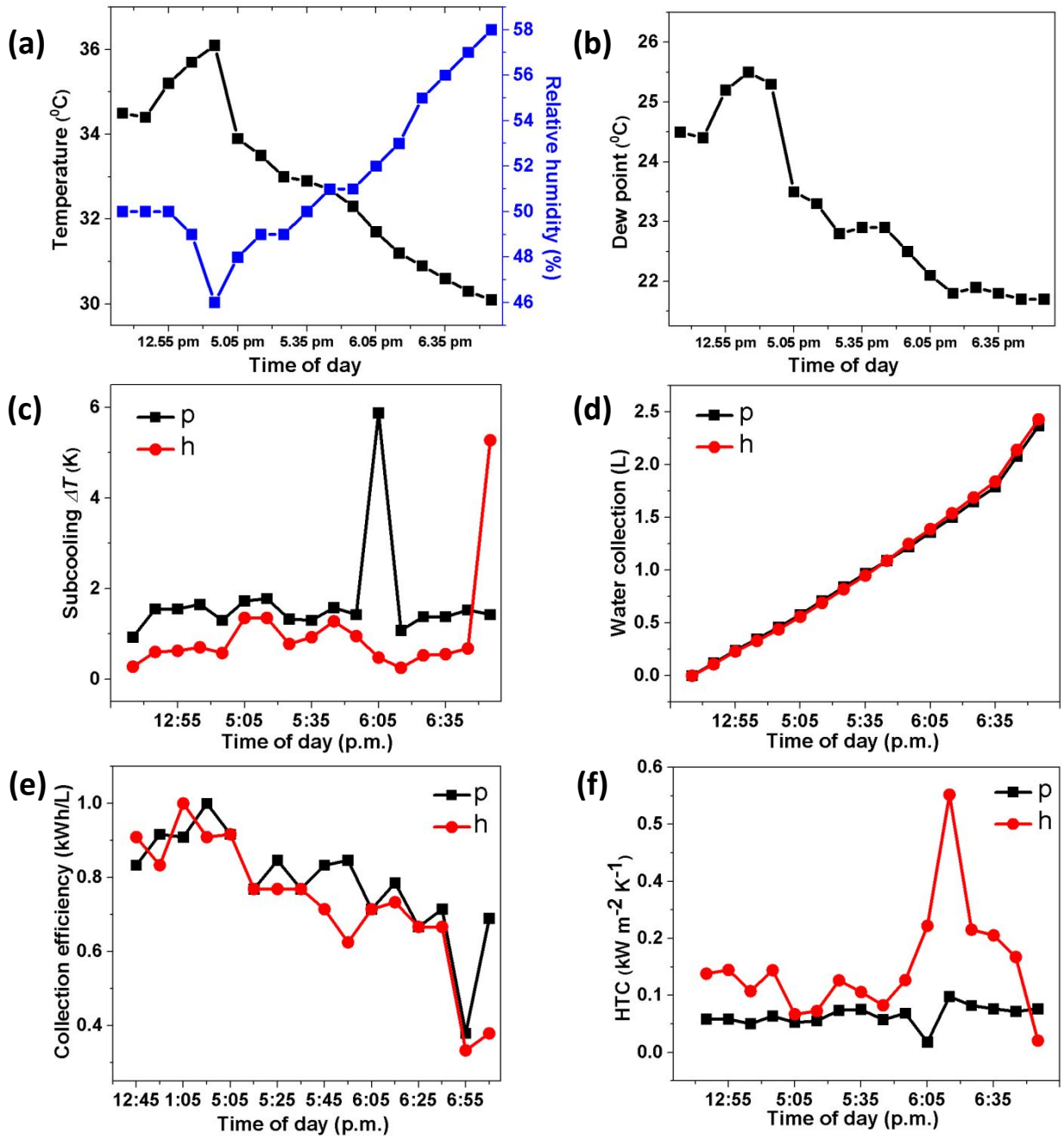


Figure S15. Fourth test run of the prototypes, showing variation in (a) ambient conditions, (b) dew point temperature, (c) degree of subcooling, (d) cumulative water collected, (e) collection efficiency, and (f) HTC, for the duration of the test run.

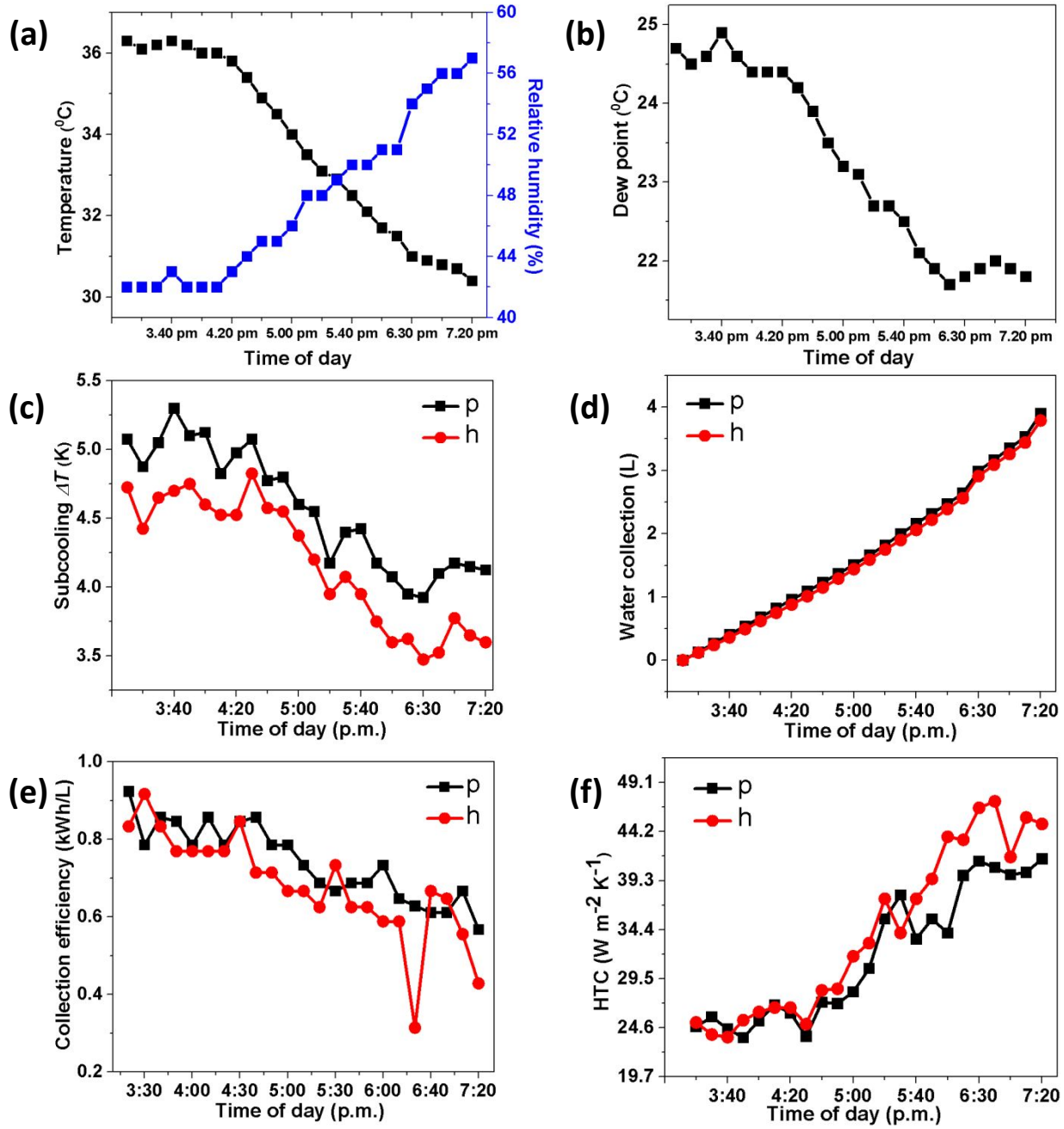


Figure S16. Fifth test run of the prototypes, showing variation in (a) ambient conditions, (b) dew point temperature, (c) degree of subcooling, (d) cumulative water collected, (e) collection efficiency, and (f) HTC, for the duration of the test run.