Supporting Information

Three - Dimensional Multilayer Vertical Filament Meshes for Enhancing Efficiency in Fog Water Harvesting

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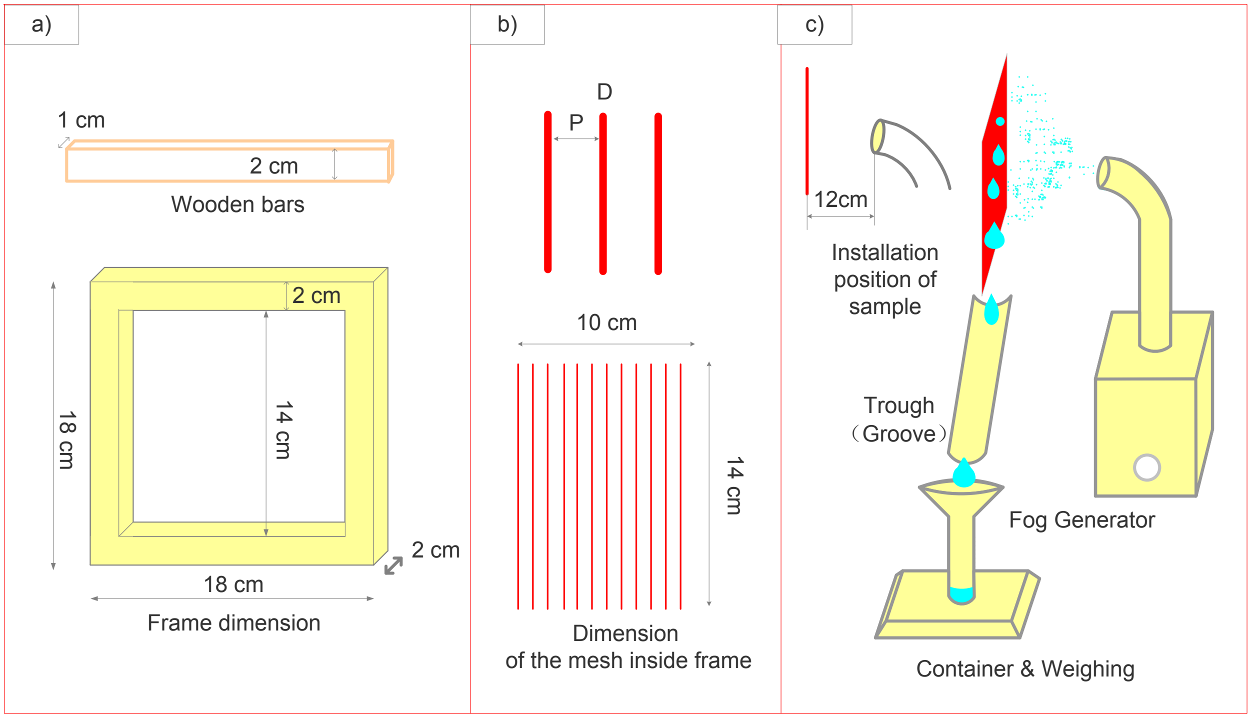

Figure S1. a) Dimension of frame and wooden bars; b) Dimension of the mesh inside frame and Distance of parallel vertical filaments (P is the center-to-center spacing between adjacent filaments, D is the diameter of the filament); c) Installation position of samples (Samples were suspended vertically facing the fog generator at a distance of 12 cm).

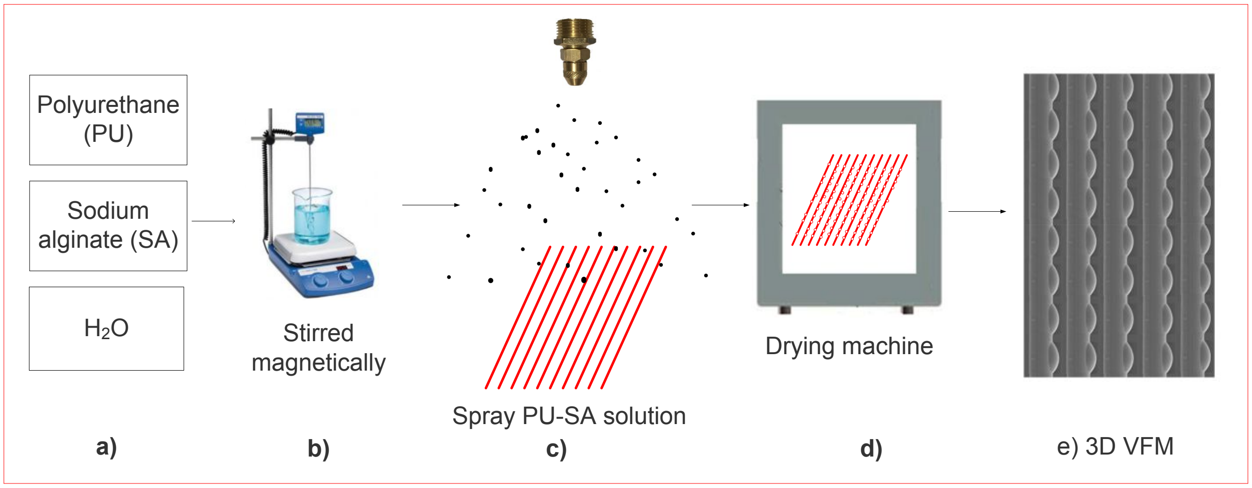

Figure S2. Preparation of 3D PU-SA microbumps structure on the surface of single filament: a) Material preparation (Polyurethane solution, Sodium alginate powder, and H_2O); b) The preparation of PU-SA mixed solution; c) Spraying the PU-SA mixed solution onto the surface of filament; d) drying the VFM; e) 3D VFM (PU-SA/VFM).

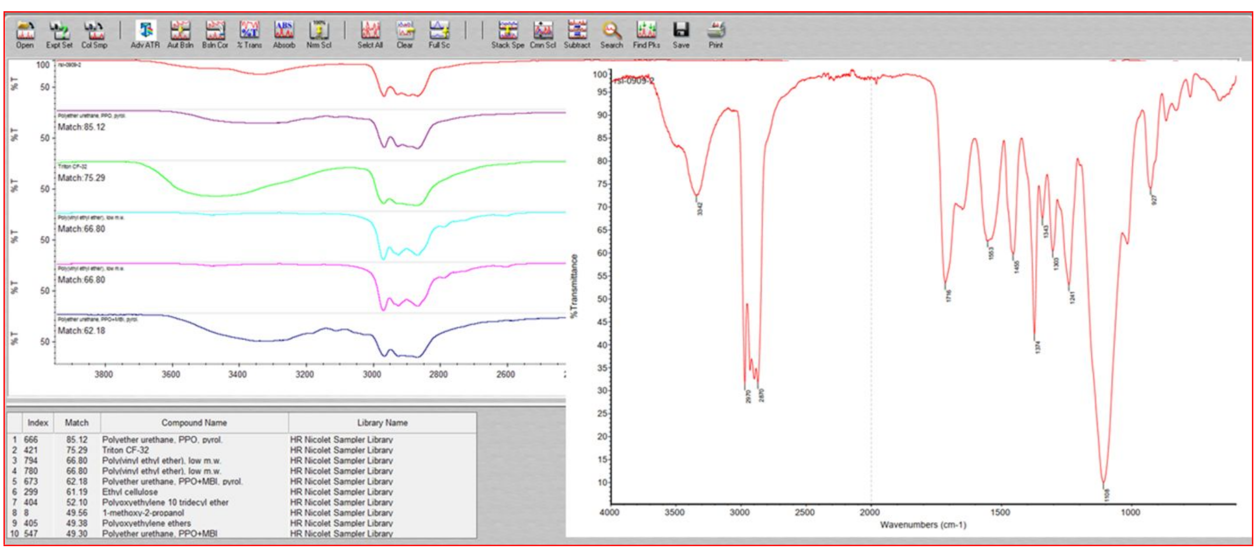

Figure S3. FTIR spectra of Polyurethane - Sodium alginate (PU – SA).

Supplementary Discussion S1.

Method 1 – Fabrication of a rough surface with dense PU-SA droplets on the entire filament surface (Rough/PU-SA). The spray nozzle (i) of the injector and sample face (ii) were together directing upwards. The spray nozzle (i) is perpendicular to the floor (iii). The concentration of the solution was 55%. Adjustment of the nozzle spray was spraying PU-SA droplets that have a higher density and size of about 30-50 µm. After the mesh sample was placing as shown in (ii), then continuously rotate the mesh in different directions so that the PU droplets can cover the entire fiber surface area. Furthermore minimized the phenomenon of forming a solution array on the filament surface. After spraying, the diameter of the smallest PU droplets on the filament surface is about 30µm (Figure S4A).

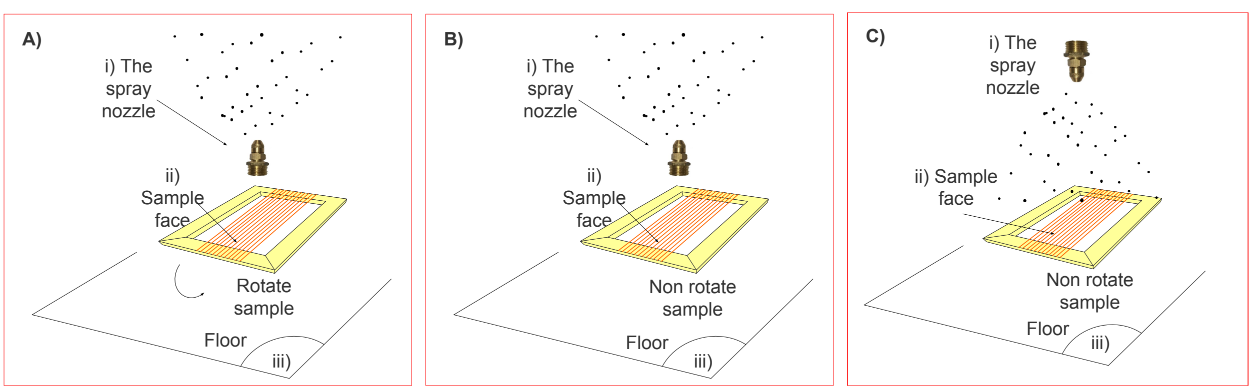

Figure S4: A) Fabrication method of the Rough/PU-SA; B) Fabrication method of the Bump/PU-SA; and C) Fabrication method of the Spindle knot/PU-SA.

Method 2 - Fabrication of the Small Bump/PU-SA (3D PU-SA micro bump). The spray nozzle (i) of the injector and sample face (ii) were together directing upwards. The spray nozzle (i) is perpendicular to the floor (iii). The concentration of the solution is 55%. Adjustment of the nozzle spray was spraying PU-SA droplets are about 100-200 μm in size. Then the mesh sample was placed as shown in (ii), and the direction of the mesh surface fixed (not rotate the mesh sample). Meanwhile, ensure PU-SA drops are regularly distributed and spaced on the fiber surface. There are two reasons to form the PU-SA solution droplet on the filament surface. The first reason is the enhancement of surface energy and surface tension of the filament coated with PU-SA solution (Young's theory). The second reason is the chemical nature of PU-SA, which based on Furmidge's theory of the retention of spray liquids on solid surfaces and the volume of spray liquid that will retain on a solid surface. This method is must ensure that the bumps (hemispheres) only on a part of the filament surface (top side). And the PU-SA solution is to ensure non-cover on the entire circumference of the filament. After spraying, the PU-SA droplets have periodic distance on the top side of the filament surface. The length and height of formed PU-SA droplets are about 200μm and 50μm, respectively. The width of PU-SA droplets is smaller than the diameter of the single filament 0.2 mm, and the distance between PU-SA drops is about 50-150μm (Figure S4B).

Method 3 - Fabrication of the Small Spindle knot/PU-SA: the spray nozzle (i) of the injector was directing downwards. The spray nozzle (i) was perpendicular to the floor (iii). The mesh surface was parallel to the floor (fixed unchanged). And the sample face (ii) towards upwards. The concentration of the solution was 40%. Adjustment of the nozzle spray sprayed PU-SA droplets are about 100-200 μm in size. The spraying time of method 3 used here is much longer than that of method 2 to obtain a bigger droplet on the filament surface. It based on Furmidge's theory, the size and distance of the droplets will increase after subsequent consecutive spays. The PU-SA solution droplets of the next spay make droplet transport and condense coalesced towards the previous adhesive droplets on the fiber surface, shaping larger PU-SA droplets with periodic distance on the surface front of the filament. By continuing to spray more PU-SA solution, the entire fiber surface coated by a large PU-SA membrane. The formed PU-SA solution film immediately broke up into moving and condensing shape periodic PU-SA droplets at regular intervals under the effect of Laplace force and Reight force (Reight's instability). In the Spindle knot/PU-SA position, the PU-SA solution was covering on the entire circumference of the filament. The maximum diameter, length, width, and distance of the PU-SA drops have approximately value as 0.4 mm, 0.8 mm, 0.4 mm, and 0.4 mm, respectively (Figure S4C).

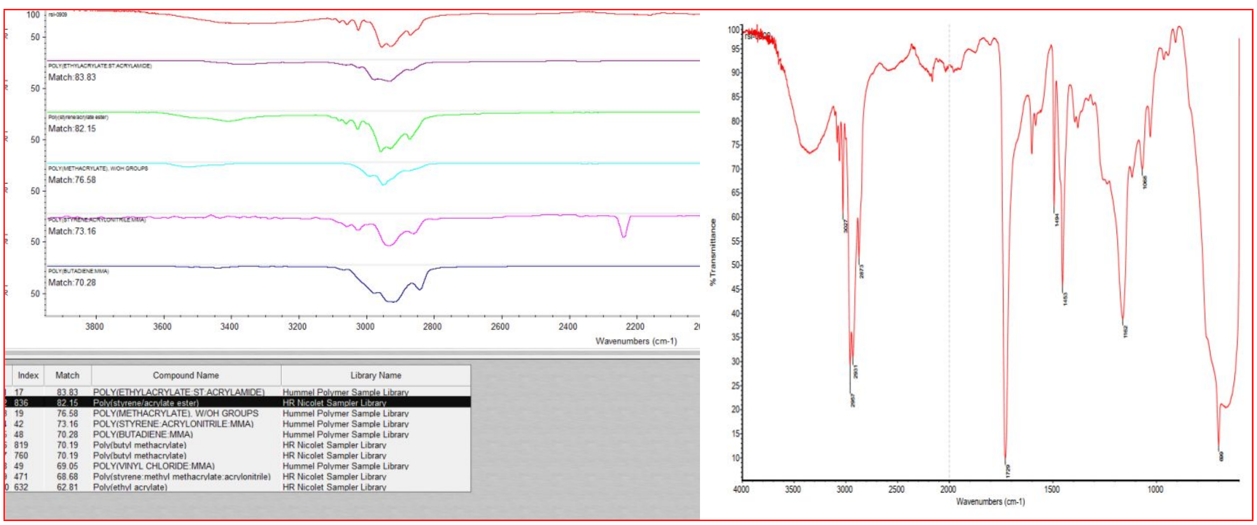

Figure S5. FTIR spectra of Paint/Oil.

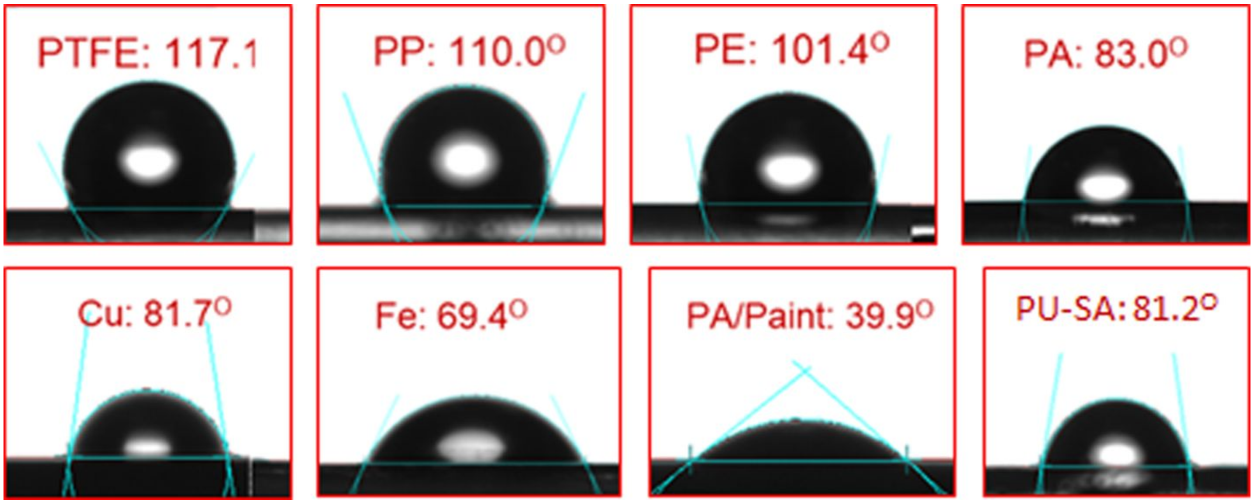

Figure S6. The static water contact angle of the different filaments, metal wires and materials.

Supplementary Discussion S2.

Test results for the water-harvesting rate of VFM and 3D VFM, Unit (ml/m2/h):

Table S1. Experiment Results for the water-harvesting rate of original polymer VFM (P = 2D)

	P = 2D

Different material of VFMs	Original single filaments (VFMs)				
	0.2 mm	0.3 mm	0.4 mm	0.5 mm	0.7 mm
PTFE	232.7	207.1	-	147.9	-
PP	-	191.8	159.0	-	-
PE	217.6	186.9	149.8	136.5	112.2
PA	195.0	166.4	135.4	116.9	95.7
Cu	186.5	163.9	-	-	-
Fe	166.7	141.7	-	-	-
PA/PAINT	175.4	149.7	-	-	-

Table S2. Experiment Results for the water-harvesting rate of VFM & 3D VFM (P = 2.5 mm, D = 0.3 mm)

Different material of VFMs & 3D VFMs	P = 2.5 mm, D = 0.3 mm	
	Original single filament (VFMs)	Bump / PU-SA (3D VFMs)
PTFE	80.0	144.2
PP	75.7	126.8
PET	66.7	113.7
PA	57.5	96.1
Cu	56.9	-
Fe	45.4	-
PA/PAINT	49.4	-

Table S3. Experiment Results for the water-harvesting rate of the 3 different types 3D VFM (P = 2D)

The 3 types PU-SA drops on filament of 3D VFM	PTFE	
	0.2mm	0.3mm
Rough/PU-SA	186.7	176.7
Bump/PU-SA	273.3	259.8
Spindle knot/ PU-SA	214.3	179.2

Table S4. Experiment Results for the water-harvesting rate of 3D VFM (P = 2D)

Different material of 3D VFMs	P = 2D Single filament / PU-SA (3D VFM)	
	0.2 mm	0.3 mm
PTFE	273.3	259.8
PP	-	237.1
PE	246.9	229.7
PA	217.6	195.8

Table S5. Experiment Results for the water-harvesting rate of mutil-layer VFM & 3D VFM (P = 2D, D = 0.2 mm)

Different material of VFMs & 3D VFMs	P = 2D, D = 0.2 mm		
	One layer	Two layer	Four layer
PTFE	174.3	232.7	253.8
PTFE/ PU-SA	211.3	273.3	287.6