Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Multifunctional Transparent Superhydrophobic Gel Nanocoating with Self-healing Property

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Experimental Section:

Materials: 3-hydroxytyramine hydrochloride (dopamine hydrochloride, 99.5%) was purchased from Sigma-Aldrich. 1,1,1,3,3,3-hexamethyl disilazane (HMDS, 98%) was obtained from Shanghai KEFENG Chemical Reagent Co. Lnc. All other chemicals were analytical-grade reagents and used as received. Millipore water (resistivity~18 MΩ.cm) was used throughout this study.

Preparation of DSTM gel: At first, 5 mL tetraethoxysilane (TEOS) was dissolved in 10 mL methanol, then a mixture of 7.5 mL NH_4OH (0.02 M) and 10 mL CH_3OH was added into this solution with stirring. 3.5 mL of HCl (0.1 M) was added dropwise to this mixture. Now, pH of this system was close to 5. 0.02 g dopamine hydrochloride was added and kept stirring for 3 h. Then, 1.5 mL NH_4OH (25~28%) was dropwise slowly to turn pH into 8~9. After aging for 12 h, the brown opaque DOPA-silica gel was formed. DOPA-silica gel, 50 mL of n-hexane and 7.5 mL of 1,1,1,3,3,3-hexamethyl disilazane (HMDS) were added into autoclave together and kept 80 °C for 10 h. After filtered and washed with n-propanol twice, the DSTM gel was obtained.

Preparation of DSTM gel nanocoating: The DSTM gel was dried at 60 °C in air condition for 6 h to remove solvent and residual reactants. Then the obtained dry gel was grinded to get DSTM gel powder. A certain amount of this powder was dispersed into ethanol and ultrasonicated for 30 min at room temperature. Finally, the DSTM gel nanocoating was prepared. Remove this nanocoating into a spray. The various substrates were sprayed one or a few times and dried at room temperature.

Characterization: Field emission scanning electron microscope (FESEM) images were obtained on JSM-6701F, both with Au-sputtered specimens. X-ray photoelectron spectroscopy (XPS, Thermo Scientific ESCALAB 250Xi) measurement using the Al Kα line as the excitation source. Transmission electron microscopy (TEM) measurements were carried out with a TechnaiG20 (FEI) operating at 300 kV. The UV-visible spectra were obtained with a Cary 60 scan spectrophotometer. TG/DTA measurements were done with NETZSCH STA 449 C using a dynamic heating rate of 10 °C min^{-1}. Fourier transformer infrared spectra (FTIR) spectroscopy was recorded using Thermo Scientific Nicolet iS10. The water contact angles (WCA) were measured with JC2000D with a 5 μL distilled water droplet at ambient temperature. The sliding angles (SA) were measured by a DSA100 contact angle meter. The average WCA and SA values were obtained by measuring the same sample at five different positions.

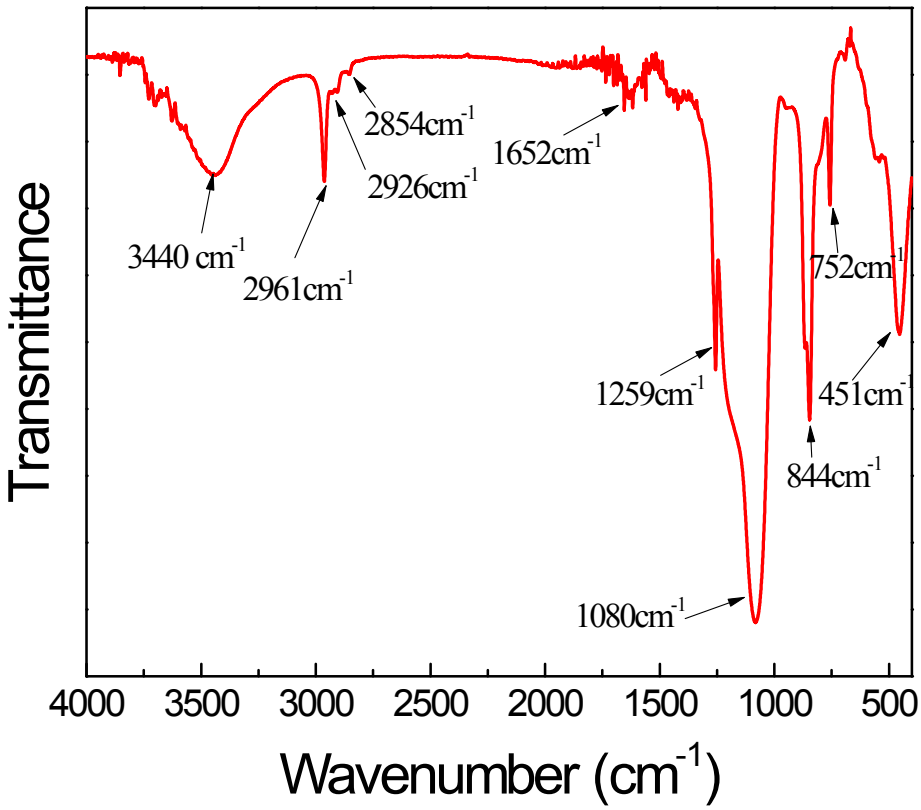

Figure S1. FTIR spectra of the DSTM gel powder.

Si-$(CH_3)_3$ related at 2961 cm^{-1} (C-H), 1259 cm^{-1} (Si-C) and 752 cm^{-1} (C-H). The band at 1080 cm^{-1}, 844 cm^{-1} and 451 cm^{-1} are related to the Si-O-Si. The absorptions band at 2926 cm^{-1} and 2854 cm^{-1} are assigned to the vibrations of -CH_2 and -CH_3 groups. Several peaks at 1400-1600 cm^{-1} that can be assigned to C=C resonance vibrations in the aromatic rings of PDA. -N-H originated bands at 1652 cm^{-1}. The strong absorption band at 3440 cm^{-1} assigned to -OH stretching vibrations is likely to remaining water. These results indicate the presence of the nanocoating.

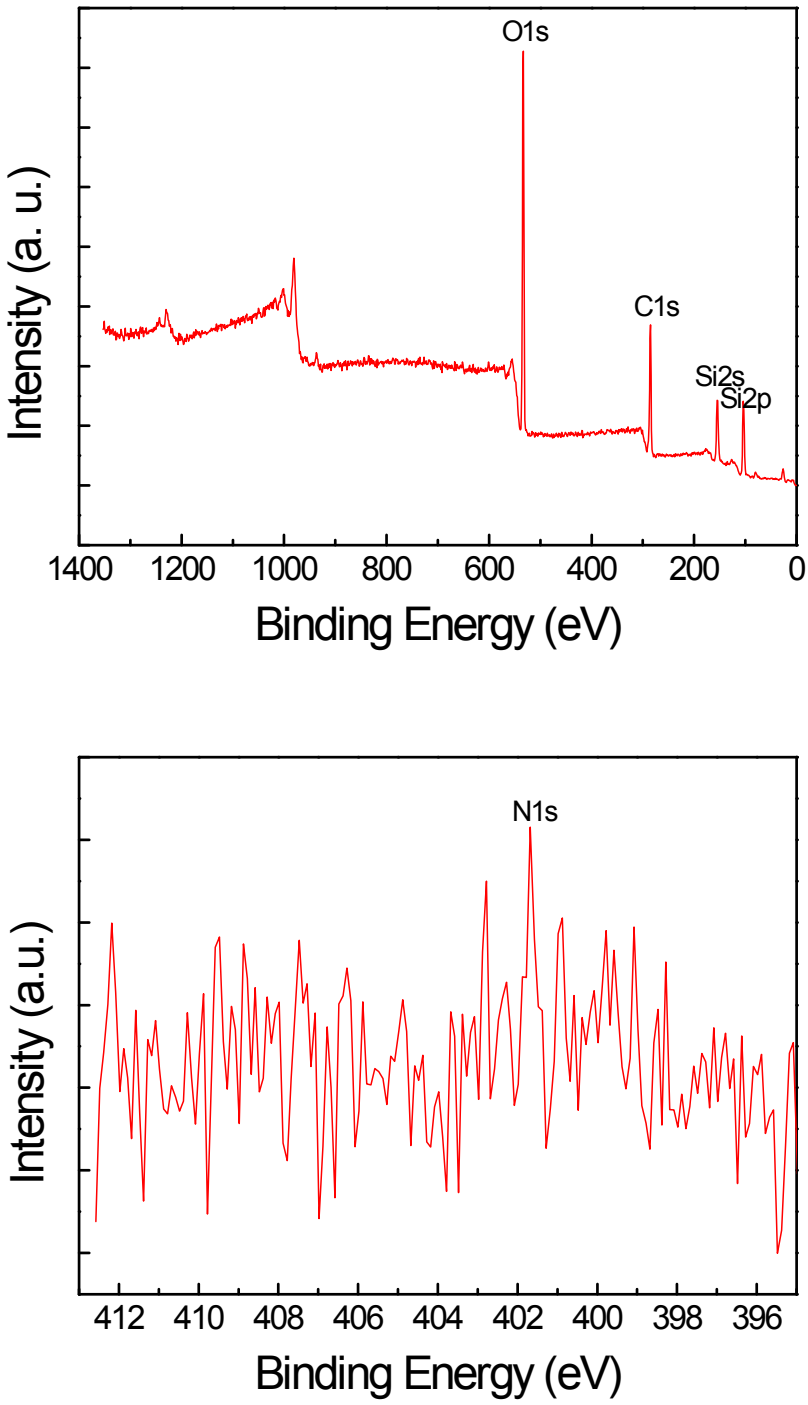

Figure S2. XPS spectra of DSTM gel nanocoating (up) and N1s spectra of DSTM gel nanocoating (down).

The four main peaks at 532 eV, 284.8, 105.8 eV, 155.1 eV and 101.5 eV are respectively labeled as O 1s, C 1s, Si 2s and Si 2p in the spectra of DSTM gel nanocoating. Note that, the peak assigned to N 1s almost disappears in spectra, because the atomic ratio of N in DSTM gel nanocoating at a very low level. We can find a weak peak at 401.6 eV in N1s spectra of DSTM gel nanocoating, which indicated the existence of PDA.

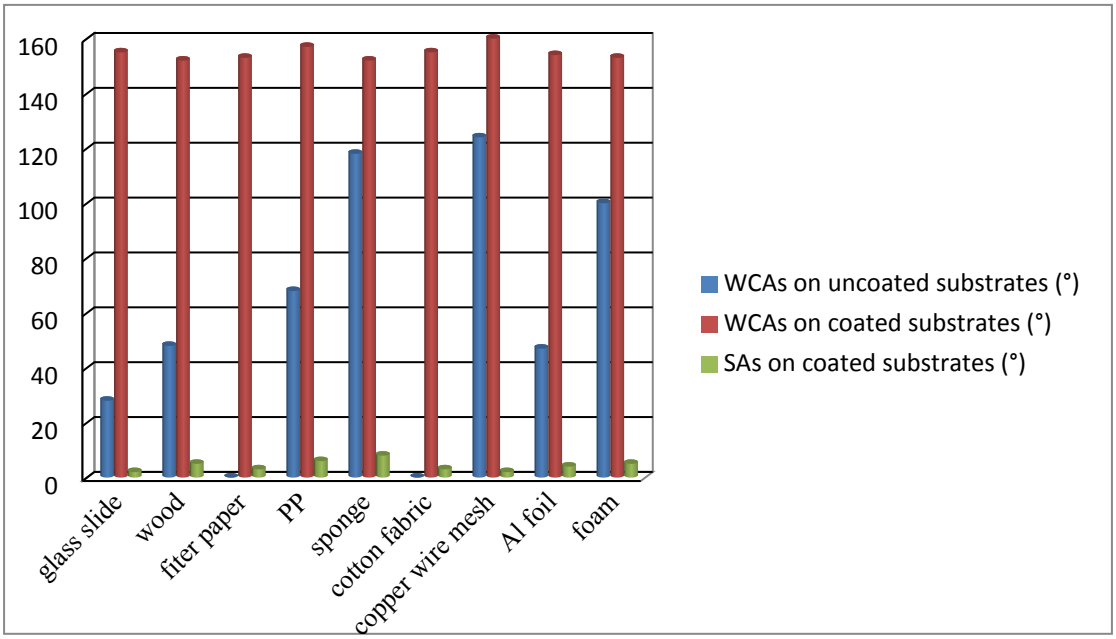

Figure S3. WCA of various primitive substrates (blue cylinder) and WCA/SA of various coated substrates (red/green cylinder).

The materials with macro-asperity are easily to be modified into superhydrophobicity Coated wood and copper wire mesh exhibit WCA of 152° and 160° respectively. Even for substrates with good infiltrability, for example, filter paper and cotton fabric also show WCA of 153° and 155° after modification. The DSTM gel nanocoating is applicable to smooth surfaces as well. The WCAs on the coated glass slide and Al foil as large as 155° and 154° respectively. It is worth mentioning that the SA values of all the examined substrates are lower than 10°.

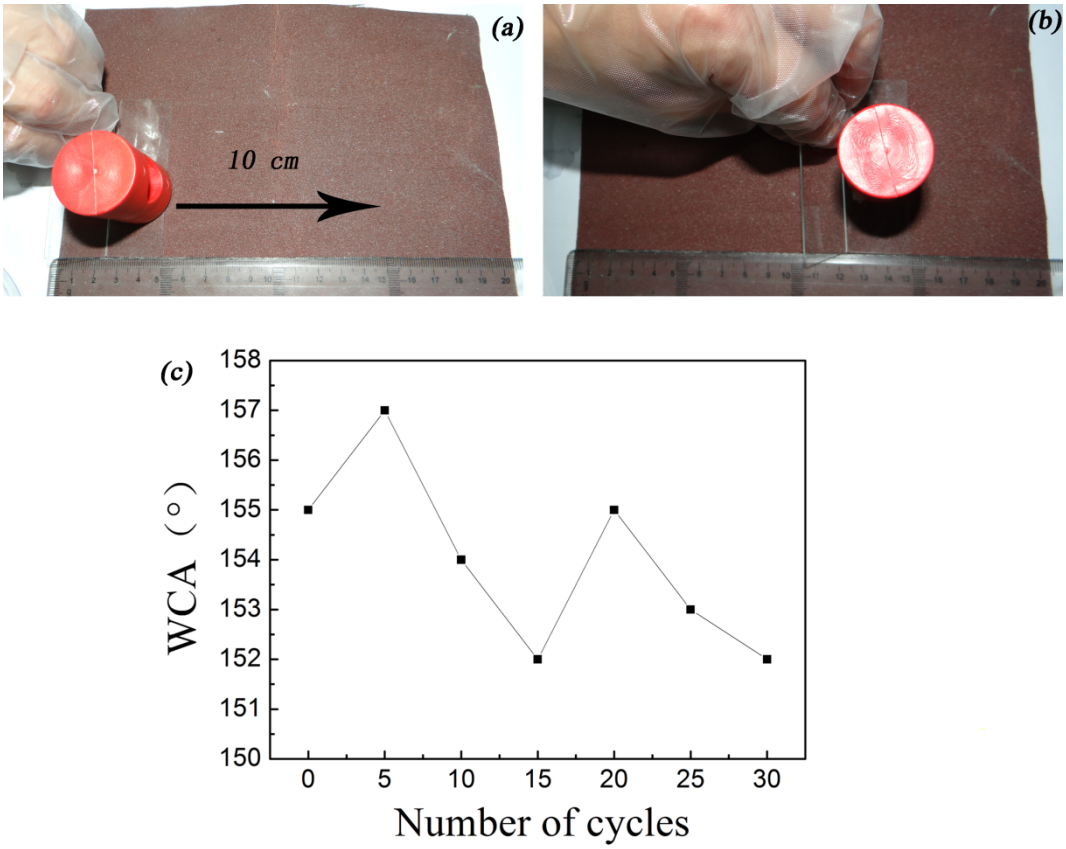

Figure S4. (a-b) Photograph of one cycle experiment of the sandpaper abrasion. (c) WCA of every five sandpaper abrasion test with 30 cycles.

Experiment detail: The sample (modified fabric 1 cm * 1 cm) was adhered to a slide with double side adhesive tape and then the sample was attached to the surface of sandpaper. 100 g load was placed on the slide and the slide was propelled for 10 cm on the sandpaper.

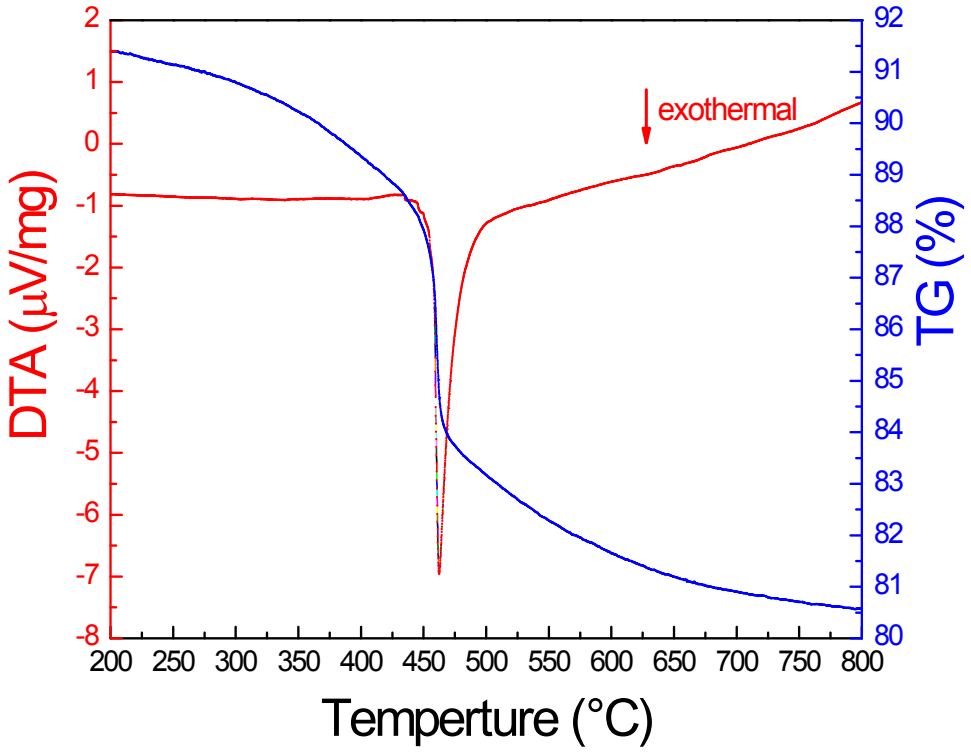

Figure S5. TG/DTA of the DSTM gel powder.

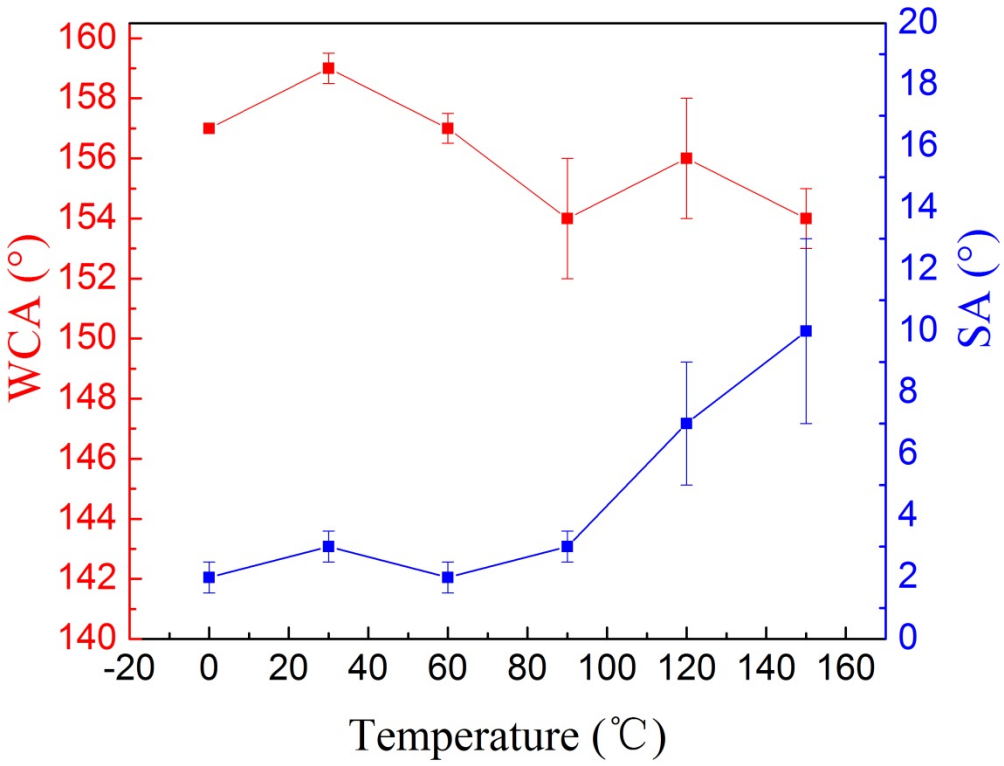

Figure S6. WCA/SA of coated copper wire mesh after annealing at different temperatures.

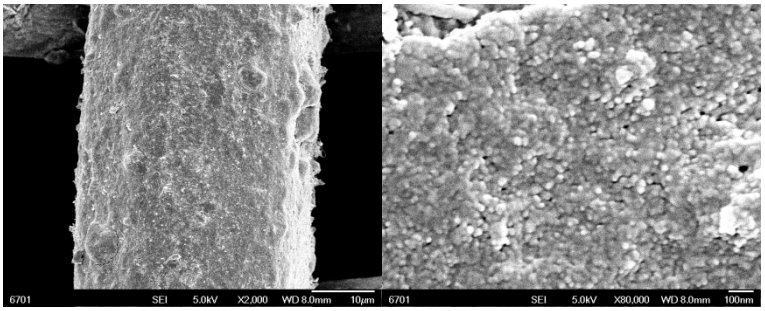

Figure S7. Low and high (left to right) resolution FESEM images of copper wire mesh with DSTM gel nanocoating after damaged by 1M HCl.

Compared to Figure 2(c) and (d), the microstructure of copper wire mesh with DSTM gel nanocoating after damaged by 1M HCl does not show a clear change, no matter low resolution image or high resolution image.