Supporting Information for High buoyancy and antifouling property through a simple superamphiphobic cotton fabric

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Experimental Section

Materials.

3-Amiopropyltrimethoxysilane(APTMS),1H,1H,2H,2H-Perfluorodecyltrimethoxyslaine (PFDTMS) (AR 97%) were purchased from Sigma-Aldrich. Dopamine hydrochloride (DA HCl) was obtained from Beijing Balinwei Technology Co,Ltd, China. KOH, glycerol, ethylene glycol, hexadecane, and methyl blue were provided by Aladdin Reagent Co. Ltd, China. The cotton fabric and rapeseed oil was purchased from the local supermarket in Lanzhou, Gansu province, China. the cotton fabric was cut to 2.5 cm × 2.5cm and washed sequentially by ethanol, deionized water and dried before being used. All other chemicals were all of analytical grade without any further purification. All aqueous solutions were prepared using deionized water.

Preparation of F-DA-APTMS fabric.

40 mL of ethanol was dissolved in 40 mL of deionized water as the reaction solvent at room temperature. Then, a certain amount of dopamine, APTMS and PFDTMS were successively added into above mixed solution. At the same time, a small amount of KOH was added to adjust the pH value of the reaction system (pH=9). Finally, the clean fabrics was placed in the solution and stirred at 300 rpm for 24 hours. The fabric was then removed and washed with ethanol and deionized water. Finally, the modified F-DA-APTMS fabric was obtained after drying in the oven at 60 °C.

Characterization.

All digital photographs were taken by a cellphone (Iphone XR). The surface topography and microstructure of all the samples were observed using an environmental scanning electron microscopy (ESEM, QUANTA FEG 650, FEI) with a 30 kV accelerated voltage and 10 μA. Energy dispersive spectroscopy (EDS) mapping and element distributing was obtained from an EDAX system attached on FESEM. Fourier transform infrared (FTIR) spectra were performed on a Bruker Vertex 70 instrument at attenuated total reflectance (ATR) mode to study the chemical functional moieties of the original and modified fabric. The surface outside chemical component was investigated using X-ray photoelectron spectroscopy (XPS, Thermo Scientific ESCA-LAB 250 Xi). All the contact angles were recorded by a JC20001 contact angle system (Zhongchen digital equipment Co., Ltd. Shanghai, China). The average values of contact angles in various medium were investigated on the specimens at three different positions.

FT-IR.

In order to explore the changes of characteristic functional groups on the surface of samples, the original and modified fabrics were characterized by FT-IR. (Figure 2g) Compared with the original fabric, the stretching vibration peaks of C-F bound appears at 1207, 1113and 1023 cm^{-1}, indicating that the surfaces of the modified fabric was successfully introduced with PFDTMS. In the meanwhile, the vibration caused by C-H at 2928 and 2841 cm^{-1} is significantly enhanced, which is due to the introduction of abundant alkyl chains on the modified fabric. The alkyl chain is derived from the reaction products of PFDTMS and benzoquinone with APTMS. The intensity of stretching vibration peak of C=O appears at 1710 cm^{-1}, which is attributed to the presence of C=O in benzoquinone, illustrating that DA was successfully grafted on the surfaces of modified fabrics. The Schiff base reaction between benzoquinone and APTMS resulted in the C=N stretching vibration peak appearing at 1506 cm^{-1}. Additionally, the stretching vibration peak of O−H was observed at 3338 cm^{-1}, which is clearly weakened, indicating that the hydroxyl groups on the surface of the modified fabric were indeed bonded to the low-surface-energy modifier.

XPS.

From the results of XPS, it can be clearly seen that the original fabric is made up of C and O elements, and no F, Si and N elements are observed. (Figure 2h) However, an obvious characteristic peak of F, N, Si element appears in the spectrum of modified fabric, demonstrating that PFDTMS, APTMS, and DA was successfully introduced on the surface of modified cotton fabric. As is shown in (Figure 2i), it can be observed that multielement spectra of C 1s centered at 284.3, 285.9, 286.7, 287.9, 291.3and 293.1 eV fitted to C−Si, C−N, C=N, C=O, CF_2, and CF_3, respectively, which further indicates that all reagents (DA, APTMS, and PFDTMS) were successfully introduced into the coating of cotton fabric, demonstrating the successful polymerization of DA and the occurrence of the Schiff base reaction between APTMS and benzoquinone. In addition, the new peaks Si−O and C=O in the O 1s peak spectra reflected the bonding of APTMS and PFDTMS and the formation of benzoquinone respectively. (Figure 2 j).

Mechanical Stability.

It has been reported that water strider legs have a unique micro−nano multiscale structure and thus can effectively trap air with the water surface to form an air film, which allows water striders to walk and jump on the water surface without getting their legs and feet wet. Therefore, to determine the buoyancy boost induced by the superamphiphobic fabric, a load capacity test of F-DA-APTMS fabric was conducted by placing modified fabric on the water or oil surface and slowly placing SiO_2 powder on top of it. The original fabric (2. 5× 2.5cm, ~0.1648 g) without any loading sinks into the water and rapeseed oil. In contrast, the F-DA-APTMS fabric (2.5 × 2.5 cm, 0.1774 g) can load ~4.6791 g SiO_2 and ~ 4.0244g SiO_2 and float on the surface of water and rapeseed oil, respectively. (Figure The weight loading capacity of the fabric on water and rapeseed oil is about 26.38 times and 22.69 times of its own respectively. Moreover, the F-DA-APTMS fabric could automatically float back to the water surface when the mass of silica added exceeds the maximum load of the modified fabric itself. The main reason is that there is a significant amount of air bubbles entrapped between F-DA-APTMS fabric and liquid, and the gas pocket created on the interface supports F-DA-APTMS fabric. This phenomenon shows that the superamphiphobic coating can be widely used in water transportation facilities and other fields.

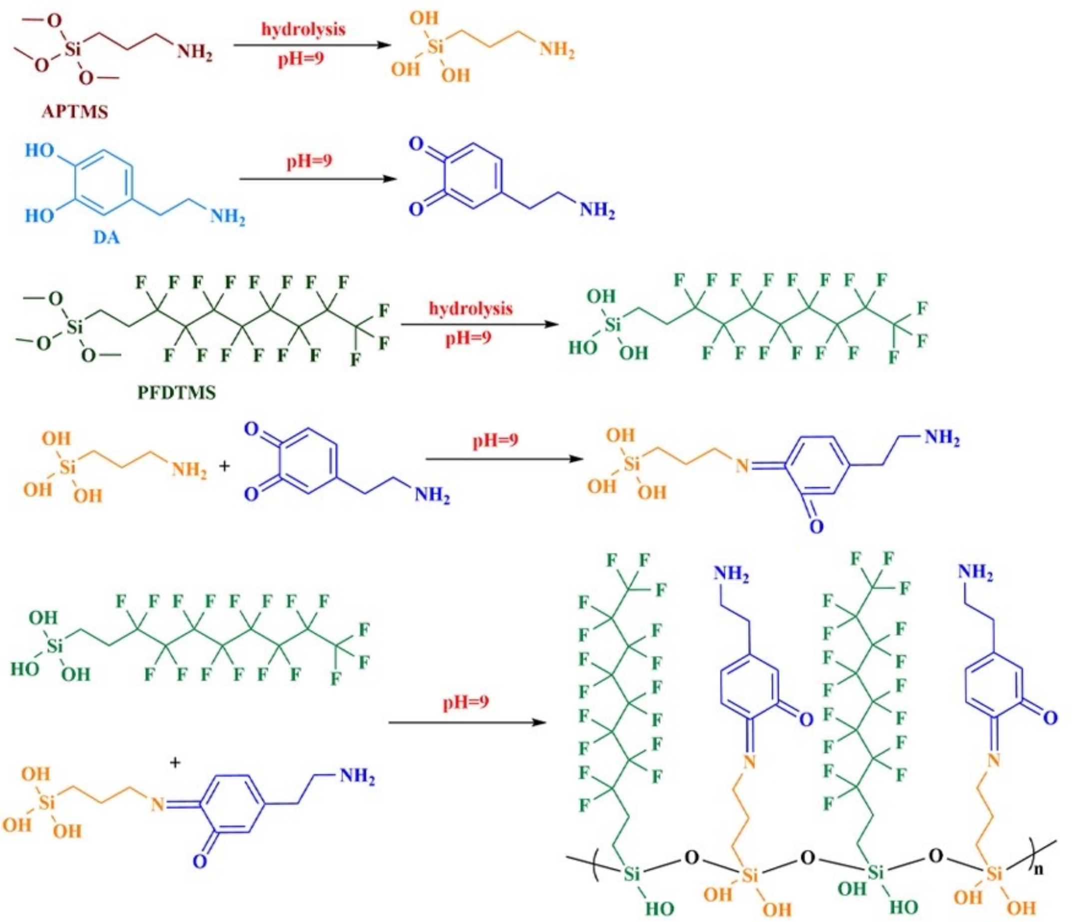

Figure S1 Synthetic pathway and reaction mechanism of F-DA-APTMS fabric.

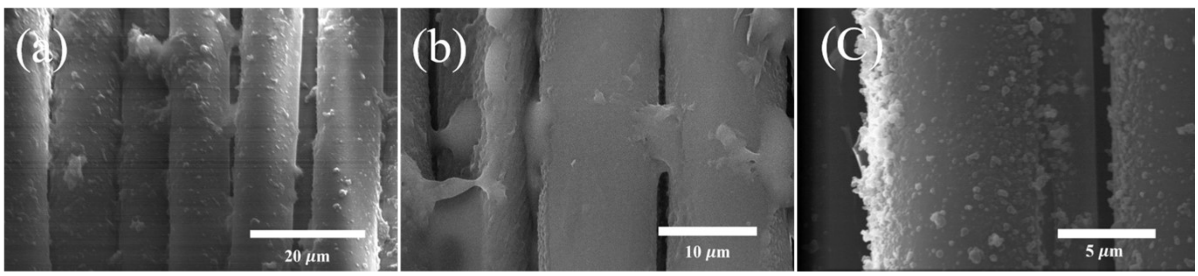

Figure S2. Scanning electron microscopy (SEM) images of (a) No APTMS (b) No DA (c) No PFDTMS.

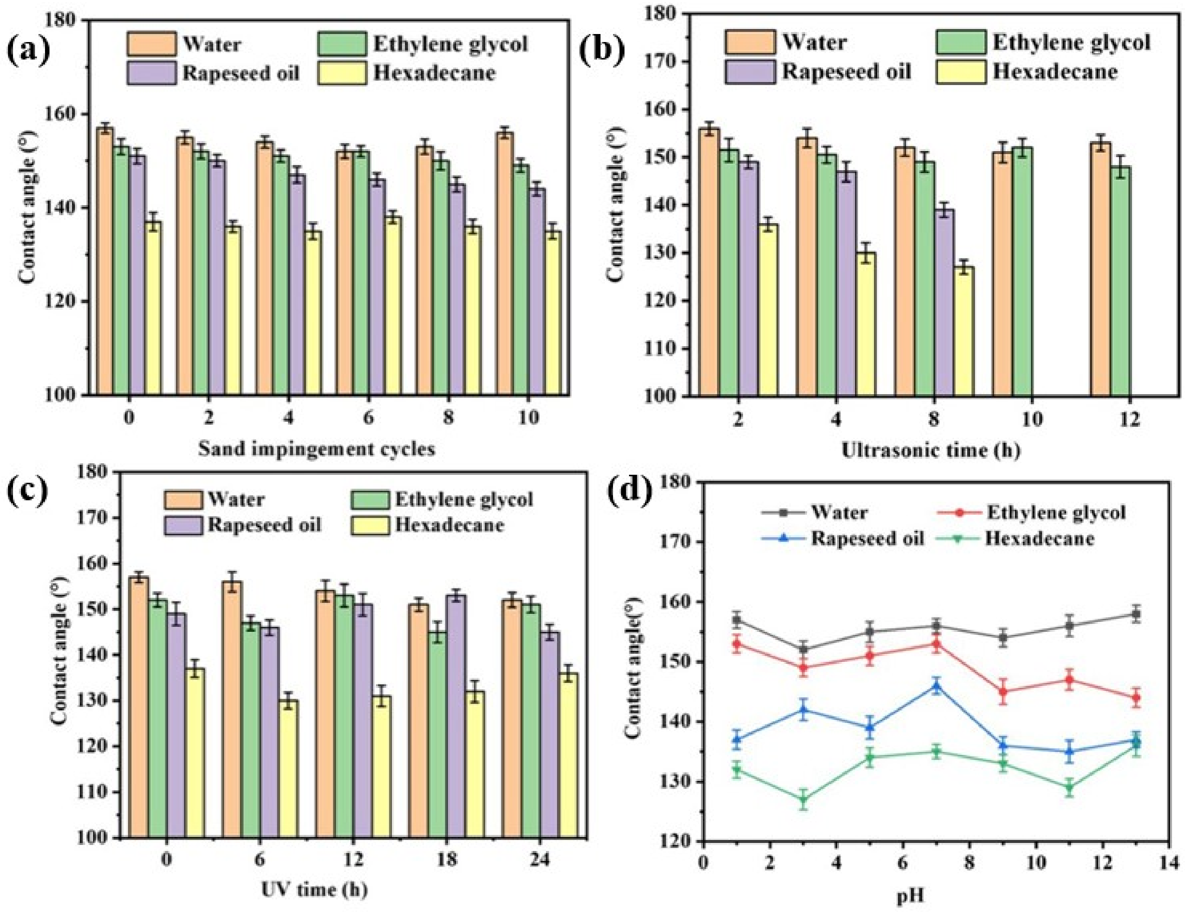

Figure S3. Water contact angle, ehtyle glycol conatct angle, rapeseed oil contact angle, and hexadecane contact angle of the modified cotton fabric (a) after 10 sand impingement cycles, (b) different ultrasonic time (c) UV irradiation for different time (d) and after being soaked in acid and alkali solutions with different pH for 1 h.