Multifunctional, Transparent Superhydrophobic Coatings Based on Nanoscale Porous Structure Spontaneously Assembled from Branched Silica Nanoparticles

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Introduction

In the latest 20 years, superhydrophobic surfaces have attracted enormous attention in both academic, commercial and industrial areas. Among them, most superhydrophobic surfaces possess only one or two properties such as mechanical robustness, thermal stability, or acidic/alkaline repellency. Meanwhile, construction of proper surface structure which could fulfill all the requirements for these additional functions were very difficult and tedious. How to conveniently and effectively fabricate a multifunctional transparent and superhydrophobic coating still remains a challenge.

Herein, we report a coating with an ideal and promising structure that could synchronously achieve both excellent transparency and superhydrophobicity based on the analysis of the requirements for both transparency and superhydrophobicity. A facile and green wipe-coating method was developed to fabricate these coatings on versatile planar and curved substrates.

Schematic Illustration

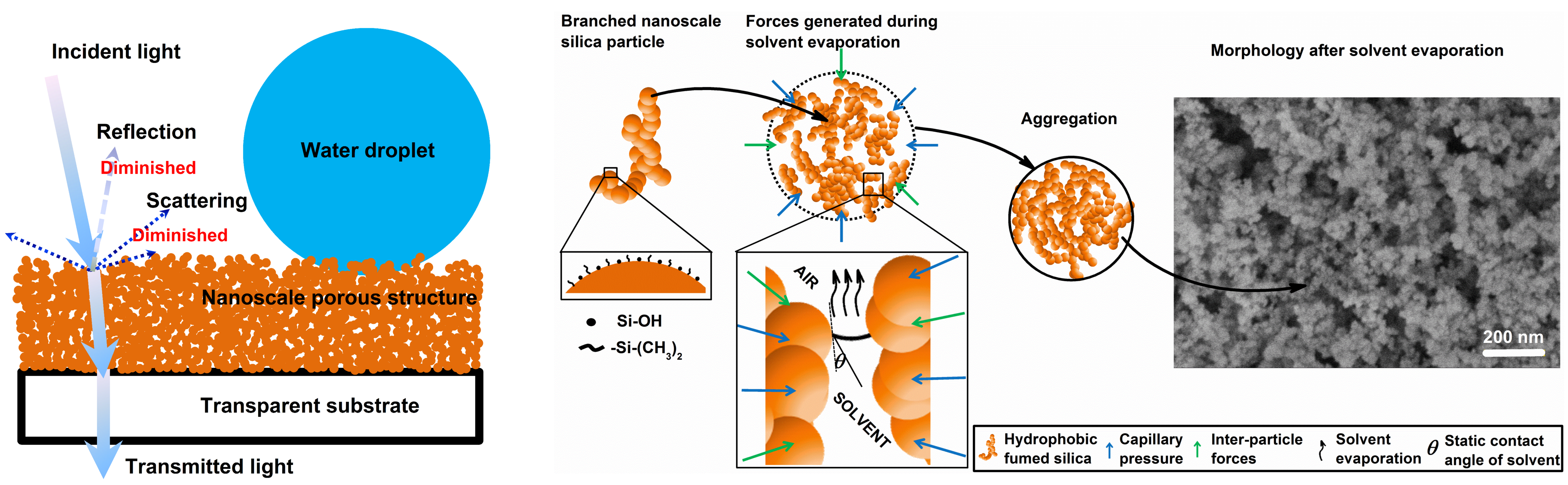

Figure 1. Schematic illustration of silica nanoparticle assembled nanoscale porous structure, SNANPS (left) and formation of SNANPS (right).

Left, SNANPS is capable of diminishing light absorption, light reflection and light scattering.

Right, sketch of a branched silica nanoparticle, the force generated during solvent evaporation, aggregation of branched silica nanoparticles, and morphology of SNANPS after solvent evaporation.

Morphology, Superhydrophobicity and Transparency

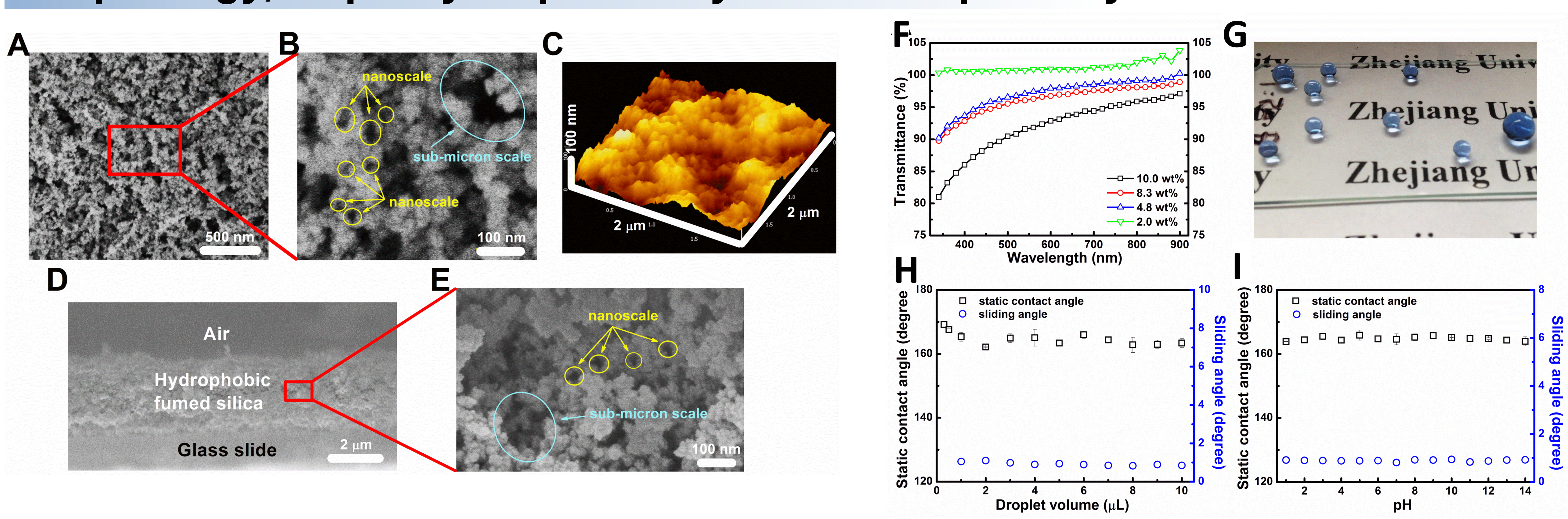

Figure 2. Morphology, transmittance , and superhydrophobicity of the coating. (A) Lower-resolution and (B) High-resolution SEM images of the SNANPS. (C) AFM 3D image of the SNANPS. (D) Lower-resolution and (E) High-resolution SEM images of the cross-section of the SNANPS. (F) Transmittance spectra for a series of super-hydrophobic coatings. (G) Photograph of water droplets (blue ink dyed) on the super-hydrophobic glass slide. (H) SCAs and SAs for water droplets (0.3 μL to 10 μL) on a superhydrophobic coating. (I) SCAs and SAs for aqueous droplets with pH ranging from 1 to 14 on the superhydrophobic coating.

Versatility

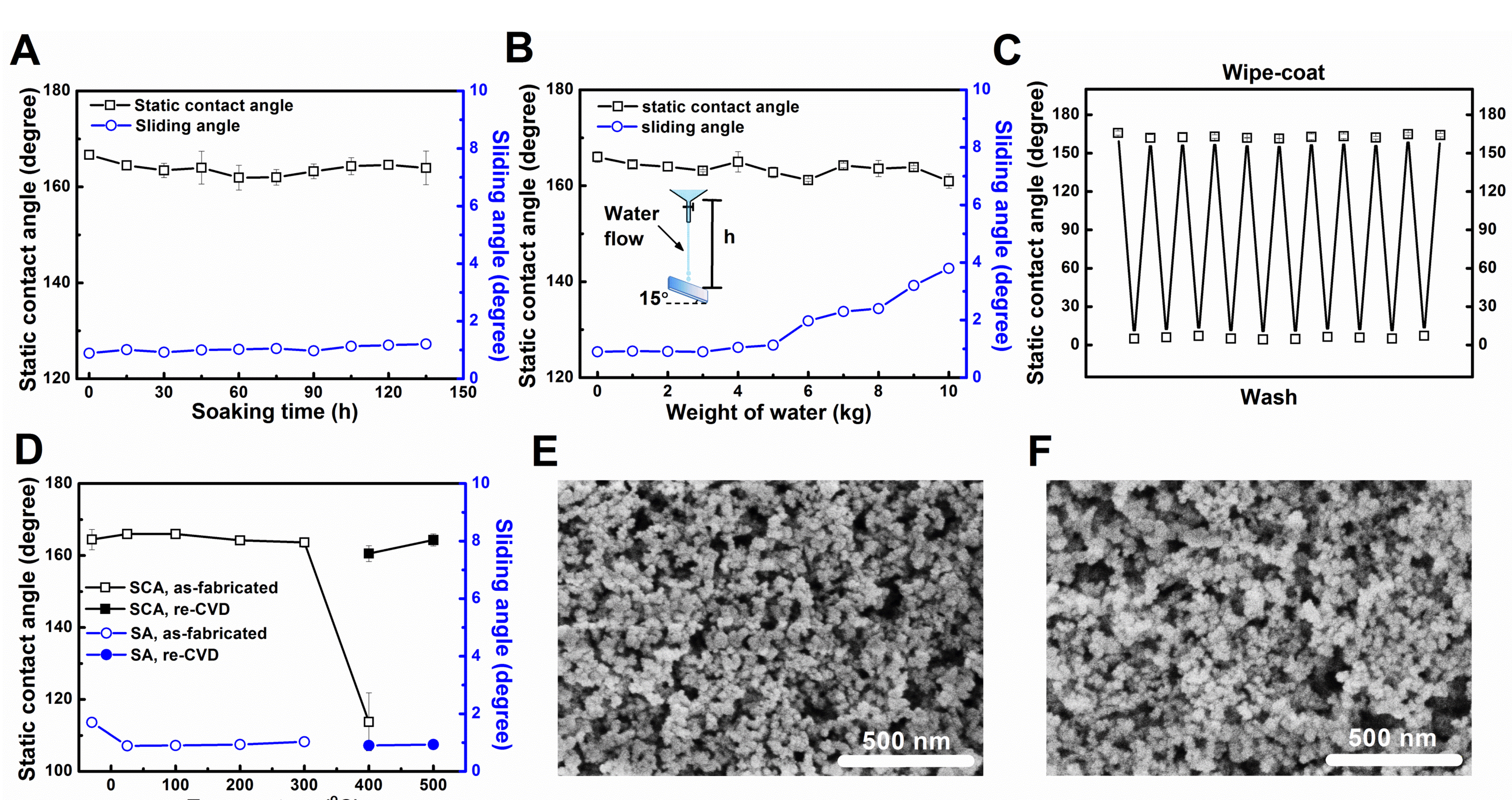

Figure 3. (A) Soaking time dependence of the superhydrophobicity. (B) Superhydrophobicity of the coating after each impinge of 1kg water. Inset is the schematic illustration of the water impinge test. (C) Cyclic measurement of SCAs for a glass slide switching between coating and washing. (D) SCAs and SAs of water droplets on a superhydrophobic glass slide after annealing for 2 h at various temperatures. Morphology of the superhydrophobic coating (E) before and (F) after annealing at 500 °C. The porous structure remains after annealing. After re-CVD, the surface becomes superhydrophobic again.

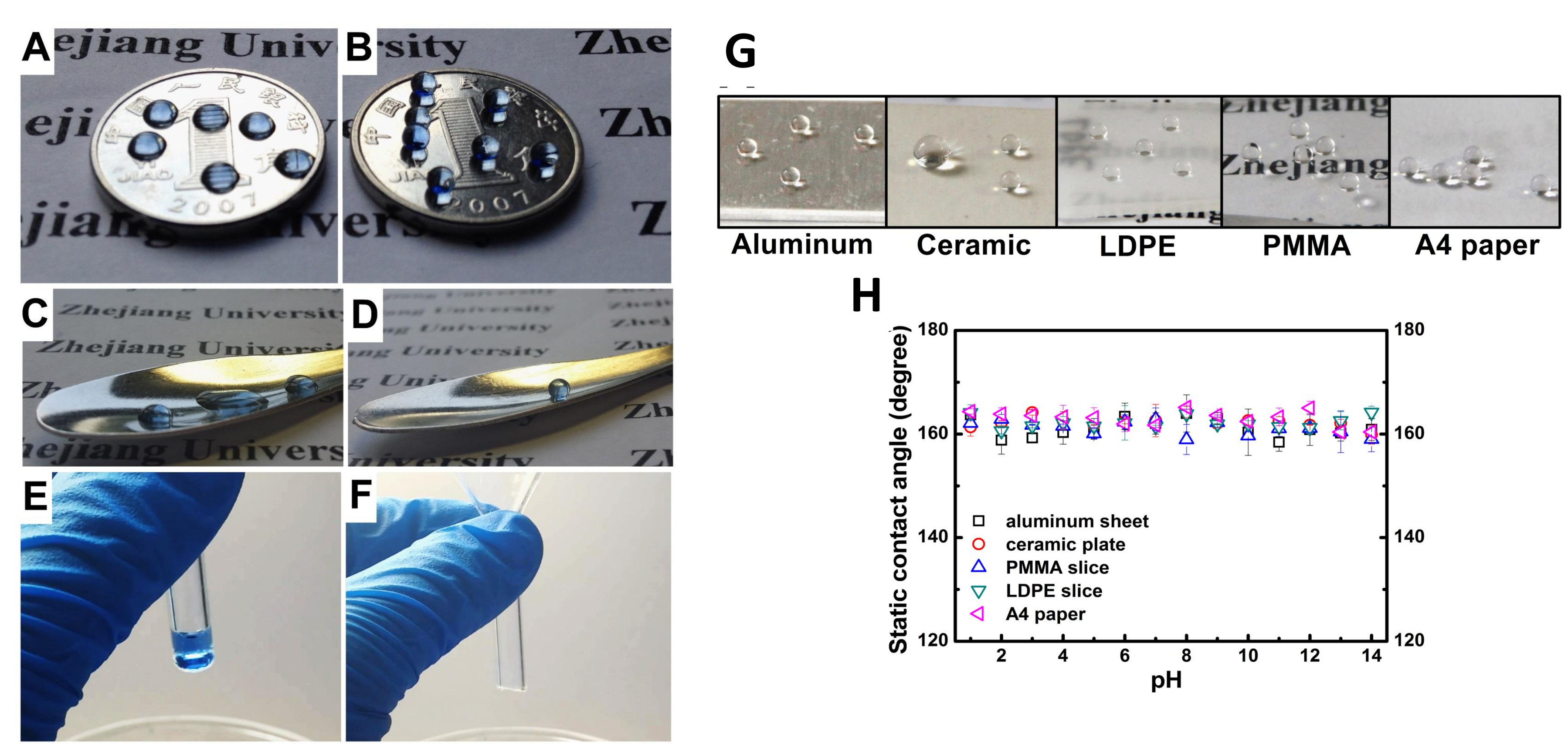

Figure 4. Versatility of the superhydrophobic coating as it can be fabricated onto planar, curved, inner surfaces and various material surfaces. Water droplets (blue ink dyed) deposited onto (A) uncoated and (B) superhydrophobic macroscopic-patterned coins. Water droplets deposited onto (C) uncoated and (D) superhydrophobic medicine spoons. (E) Residual water in an uncoated funnel. (F) No residual water in a superhydrophobic funnel. (G) Photographs of water droplets on the coated superhydrophobic aluminum, ceramic, LDPE, PMMA, and A4 paper. (H) SCAs of aqueous droplets with pH ranging from 1 to 14 on superhydrophobic aluminum, ceramic, LDPE, PMMA, and A4 paper.

Conclusion

In summary, we designed an ideal structure, i.e., SNANPS, to achieve both transparency and superhydrophobicity after analyzing the research status and the requirements for both properties. Then, we developed a facile, effective, and green method to fabricate multifunctional superhydrophobic coatings onto different planar and curved surfaces and various substrates.

Reference

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