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Supporting Information

High-Performance Meso-Macroporous SiO_2 Antireflective Coatings with Enhanced Optical and Mechanical Stability for Solar Energy Applications

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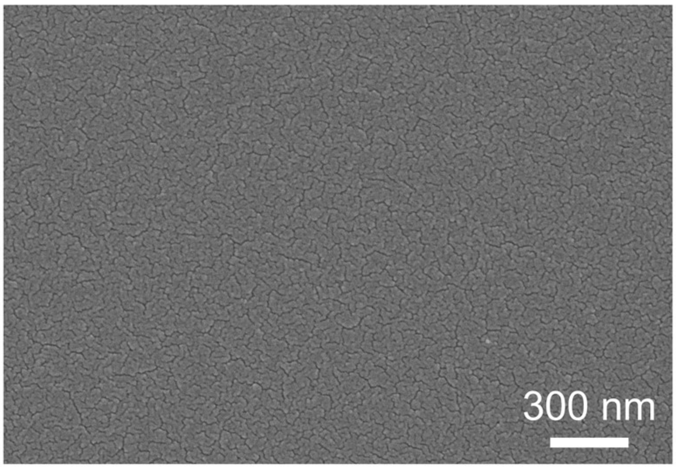

Fig. S1 SEM image of the coating before calcination.

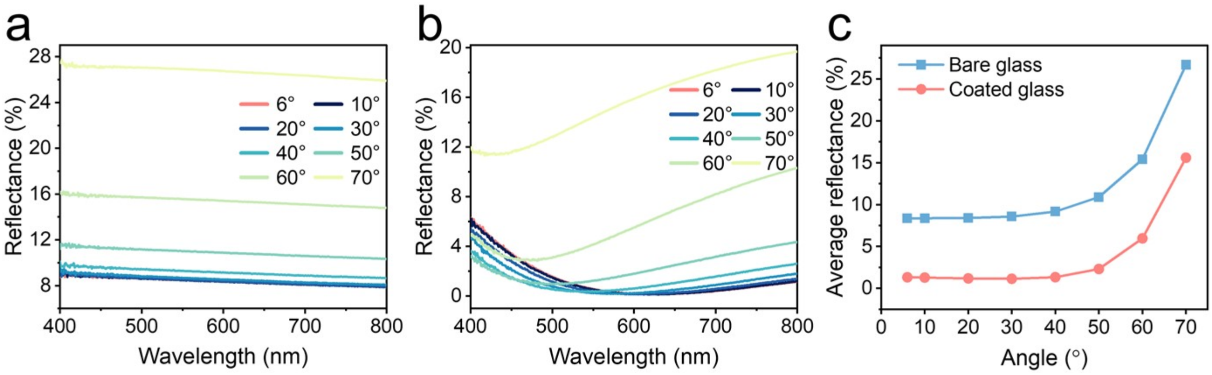

Fig. S2 Reflectance at different incident angles. (a) Reflectance on bare glass. (b) Reflectance on the coated glass. (c) Average reflectance at different incident angles.

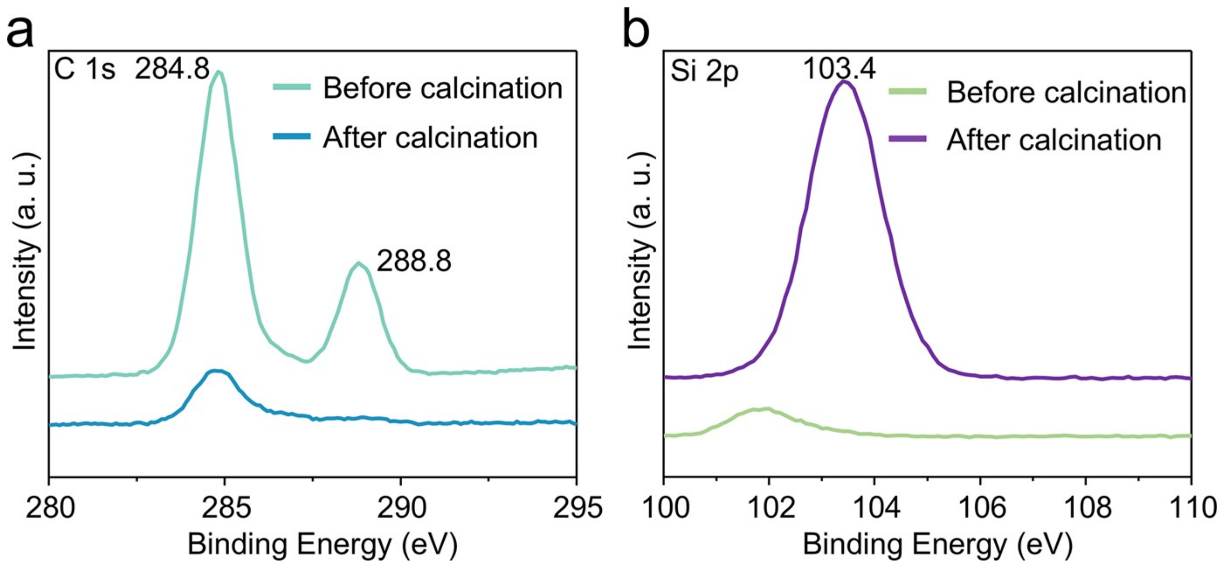

Fig. S3 XPS spectra analyzing the surface composition. (a) The C 1s fine spectrum of the coatings before and after calcination. The carboxyl peak at 288.8 eV disappeared after calcination. (b) The Si 2p fine spectrum of the coatings. The Si (IV) peak at 103.4 eV, originating from SiO_2, increased after calcination, indicating the formation of the SiO_2 coating.

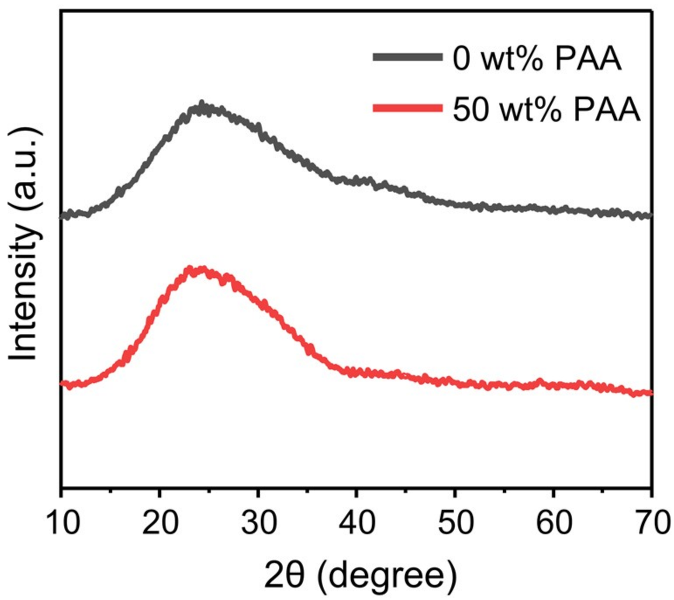

Fig. S4 Measured XRD patterns. A broad peak at approximately 23° indicates that the prepared coating was amorphous SiO_2 coating.

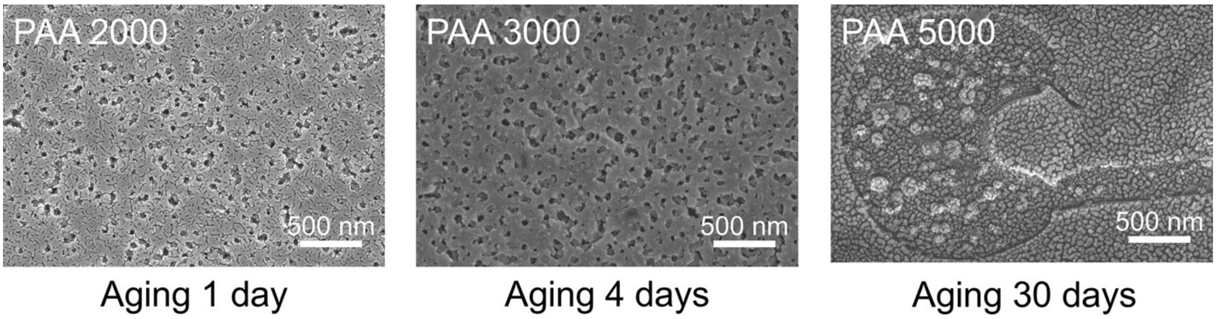

Fig. S5 SEM images of the coatings prepared with PAA of different molecular weights. The coatings fabricated with PAA molecular weights of 2000 and 3000 g mol^{-1} displayed nanoscale pores, whereas the coating prepared with PAA of 5000 g mol^{-1} formed microscale pores, which affected light transmittance.

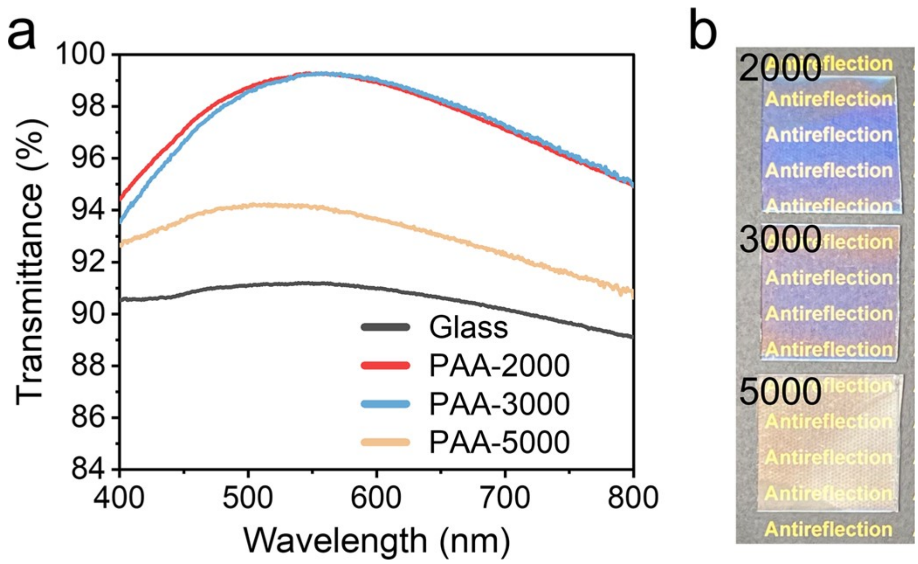

Fig. S6 Transmittance of the coatings prepared with PAA of different molecular weights. (a) Measured transmittance curves. The coating prepared with PAA of 5000 g mol^{-1} shows a relatively weak antireflective effect. (b) Image illustrating the transmittance effect.

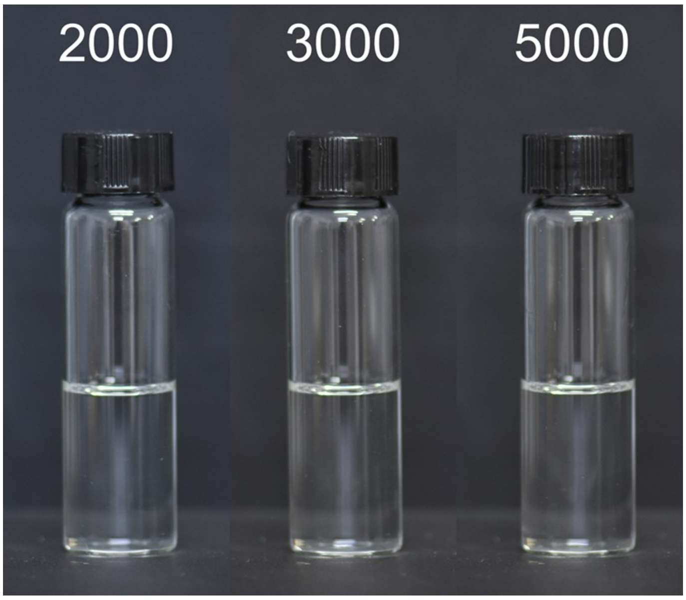

Fig. S7 The state of silica-PAA sol. The solution remained completely transparent after mixing silica sol and PAA. The molecular weight of PAA was 2000, 3000, and 5000 g mol^{-1}, respectively.

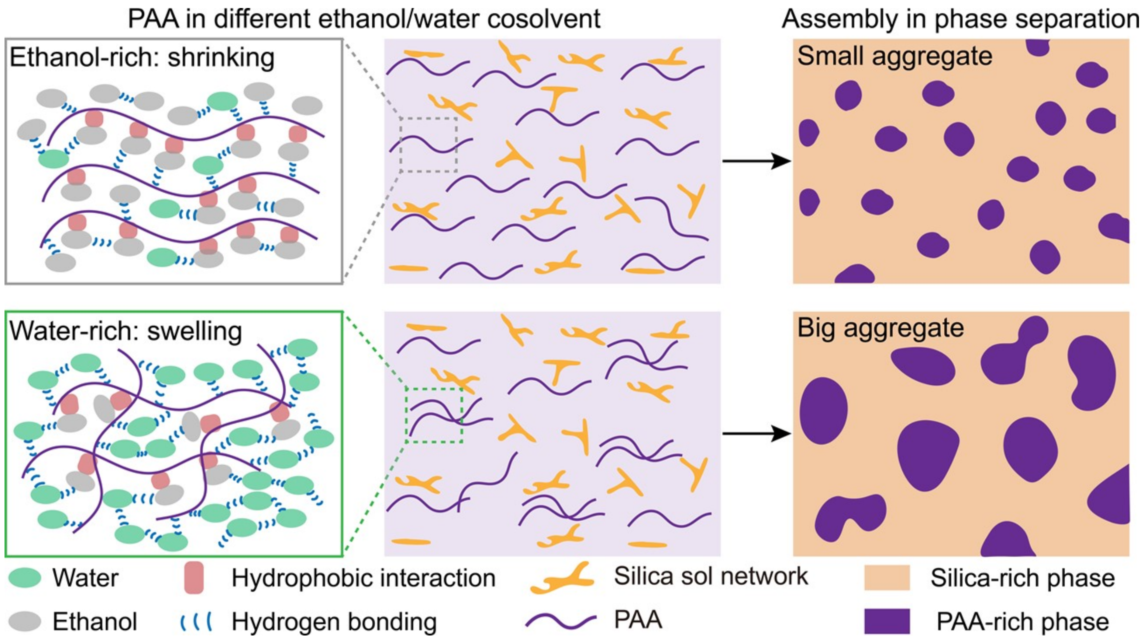

Fig. S8 The diagram explains the effect of the ratio of ethanol to water on pore formation. When the ethanol content was high, PAA tends to assemble through 2D layers to form small porous structures. In contrast, when the water content was high, the PAA attached to water can be freely assembled in 3D in a relatively large space.

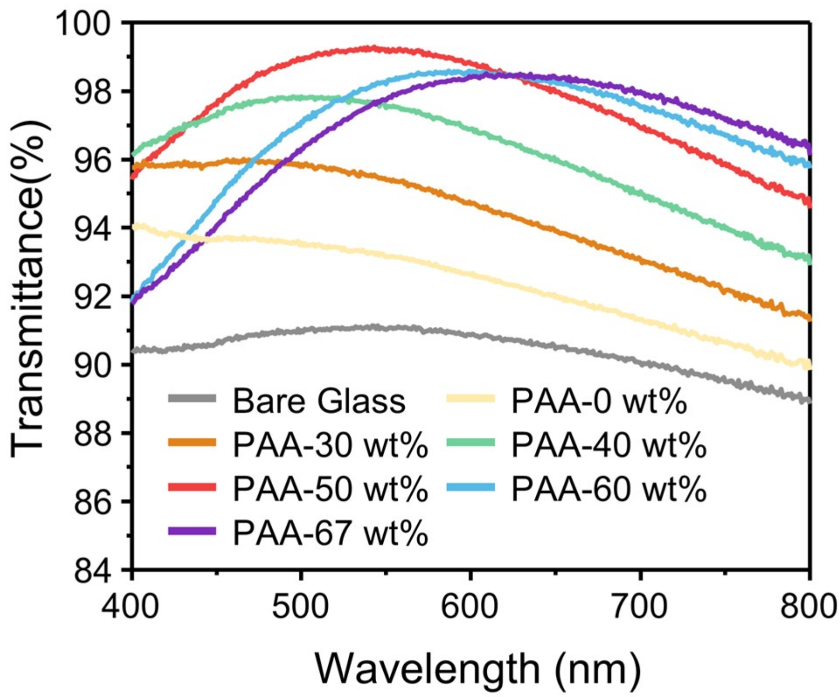

Fig. S9 Measured transmittance curves of the coatings prepared with different PAA contents. The transmittance was the highest when the PAA content was 50 wt%.

Fig. S10 Images of the coated glass samples. The AR effect becomes significant when the PAA weight content reaches 50 wt%.

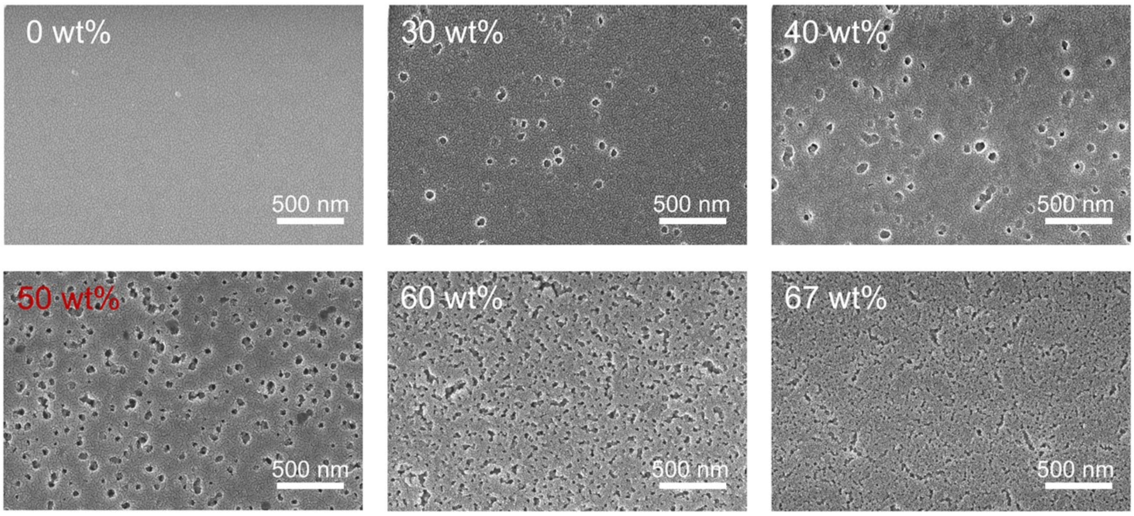

Fig. S11 SEM images of the coated glass prepared with different PAA content. The porous structure became denser with the increase of PAA content.

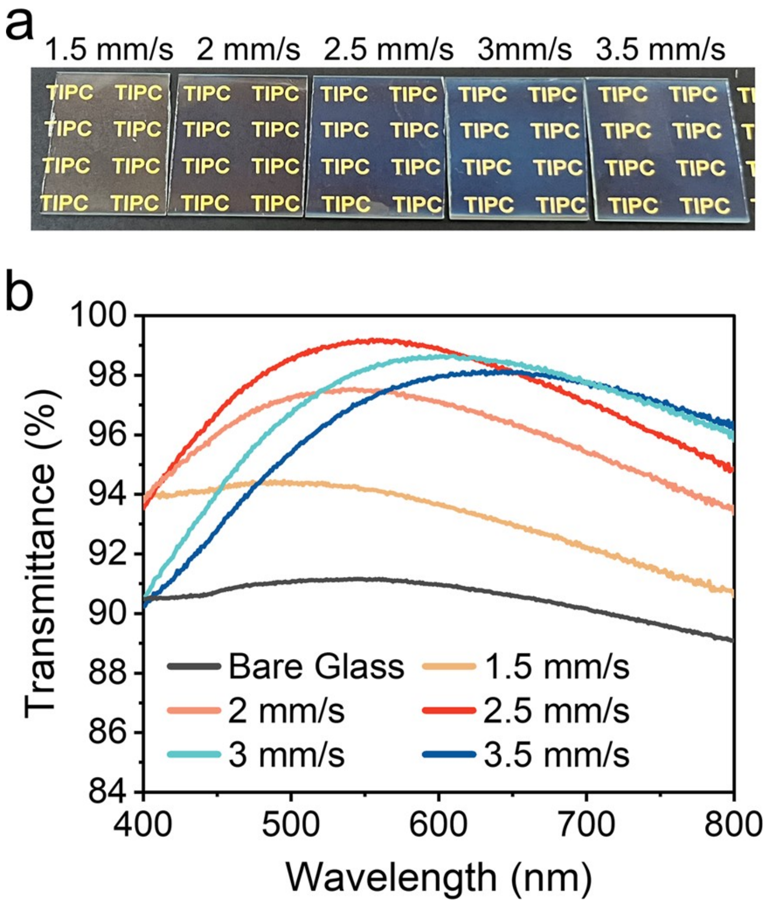

Fig. S12 The effect of dipping speeds. (a) AR effect images of the coatings prepared with different dipping speeds. (b) The change in transmittance with dipping speed. The coatings showed better transmittance at a dipping speed of 2.5 mm s^{-1}.

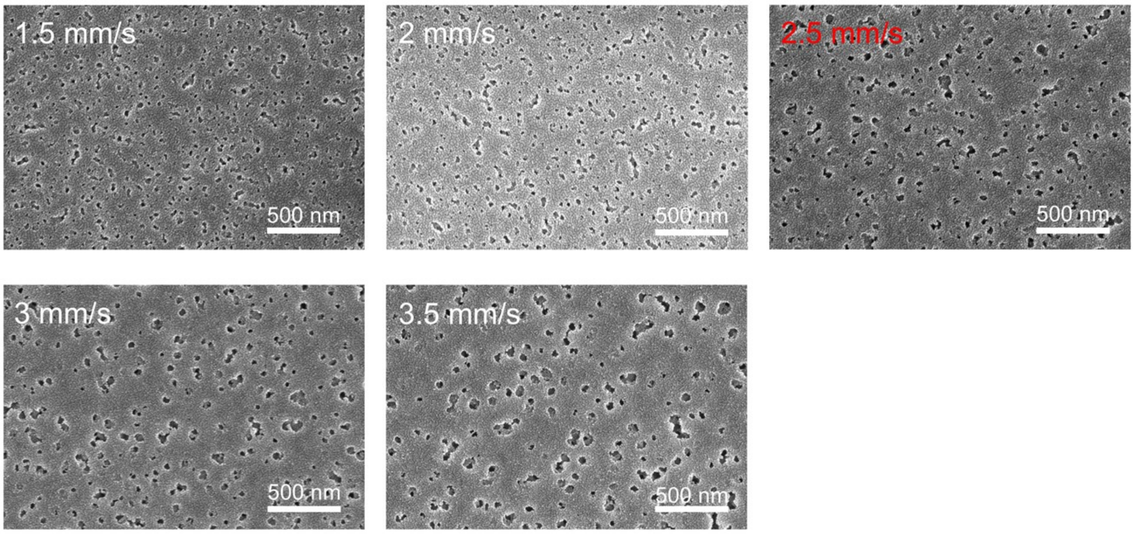

Fig. S13 SEM images of coated glass prepared with different dipping speeds. The coatings had a porous structure at different dipping speeds.

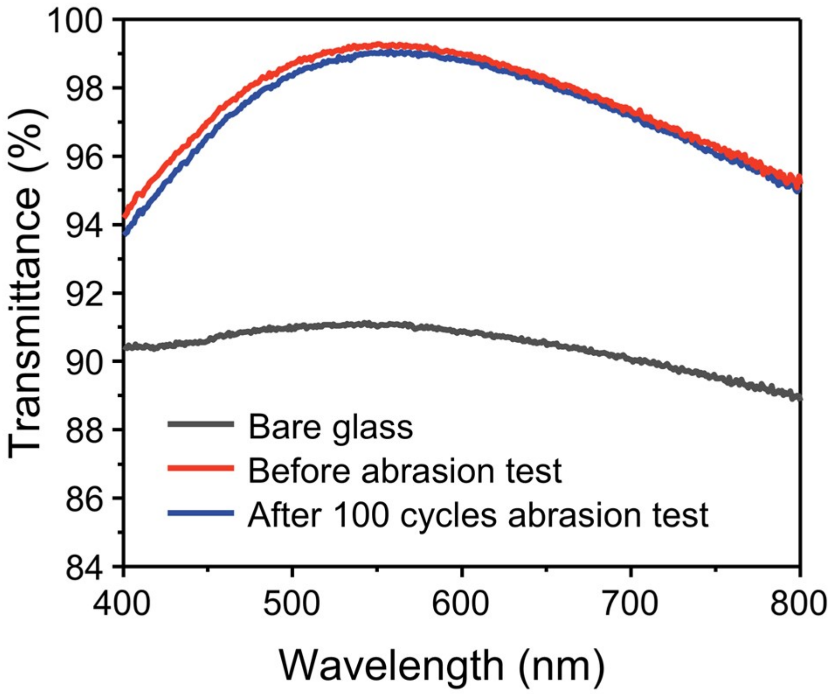

Fig. S14 Measured transmittance curves before and after the abrasion test, showing that the coating maintained high transmittance after 100 abrasion cycles.

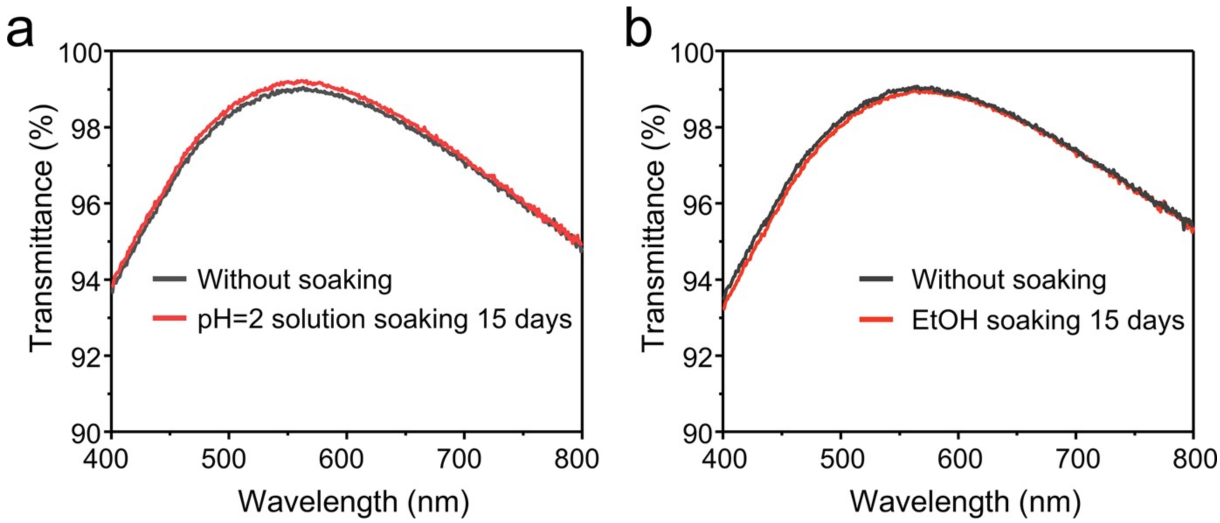

Fig. S15 Measured transmittance after solution soaking. (a) Soaking test with pH=2 HCl solution. (b) Soaking test with EtOH. There were no significant changes in light transmittance even after soaking for 15 days.

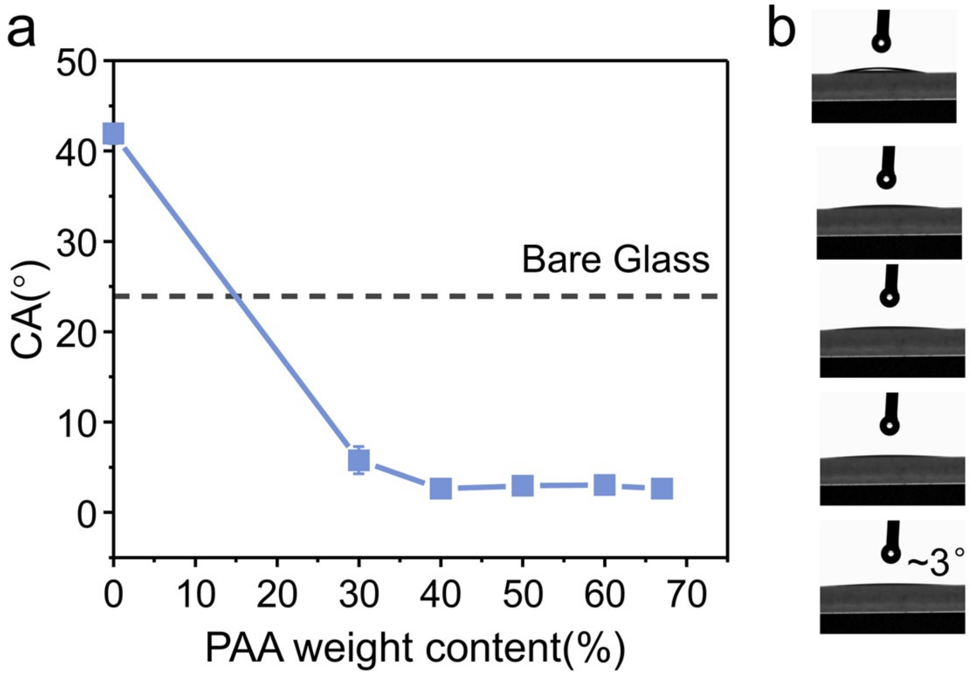

Fig. S16 Contact angles (CA) of coatings prepared with different PAA contents. The coating exhibits superhydrophilicity when the PAA weight content reached 40%, and the CA drops below 5° within 0.5 s when the PAA weight content was 50%.

Table S1 Photovoltaic data of the solar cells: the open-circuit voltage (V_{OC}), short-circuit current density (J_{SC}), fill factor (FF), and the energy conversion efficiency (Efficiency).

Samples	V_{OC} (V)	J_{SC} (mA cm^{-2})	FF (%)	Efficiency (%)
Without cover glass	0.52	34.57	69.77	12.58
Bare glass	0.53	31.43	69.33	11.52
AR glass	0.53	33.93	69.01	12.42
1-year AR glass	0.53	33.90	68.78	12.37