Scalable, Flame-resistant, Self-cleaning Inorganic Nanofibers for Sustainable All-day Radiative Cooling

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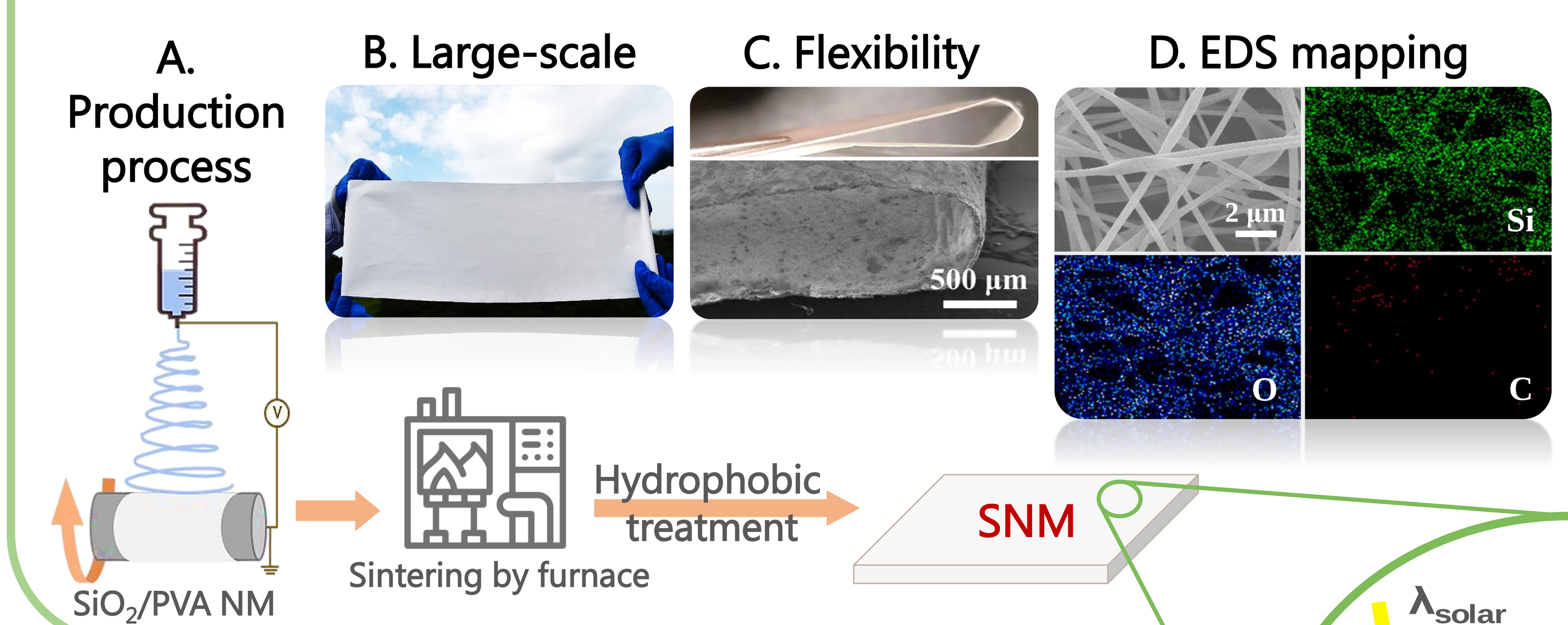
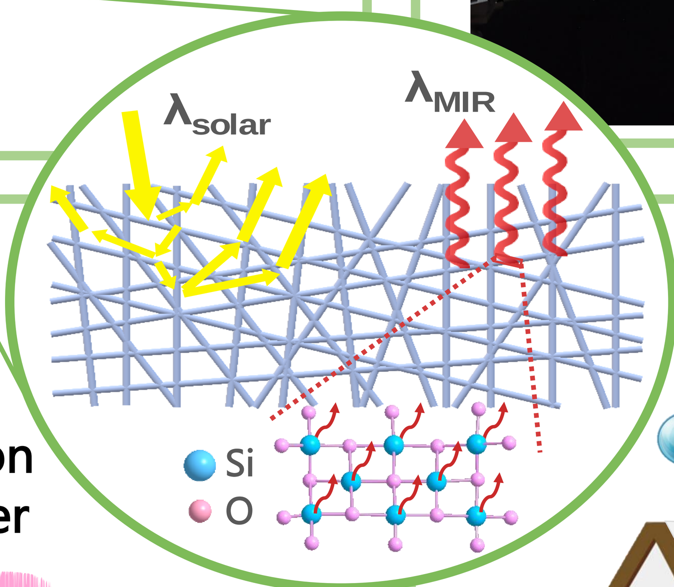
Abstract

Traditional cooling systems would consume tremendous amounts of energy and thus intensify global climate change and urban island effect. The passive daytime radiative cooling (PDRC), as a strategy to dissipate an object's heat through an atmospheric transparency window (8–13 μm) to outer space without any extra energy consumption, has recently attracted considerable attention.[1] In this research, a flexible large-area silica nanofiber membrane (SNM) was synthesized via a sol-gel method combined with electrospinning to exhibit an outstanding PRC ability. The SNM could attain a highly average reflectivity (97%) in the solar spectral region, due to the extremely strong scattering induced by the randomly dispersed nanofibers with a wide diameter distribution close to the solar wavelengths. Particularly, silica has a strong phonon resonance at 9 μm for emissivity in the atmospheric window via the abundant Si-O bonds. Therefore, the designed SNM realized a sub-ambient cooling performance of 7 ˚C and the maximum radiative cooling power of 112 W/m² under a solar irradiance of 788 W/m². Moreover, we observed that the temperatures in the interior space of vehicles and houses could drop to 15 ˚C and 8 ˚C, respectively, when they were covered by the SNM under sunlight exposure. In addition, the super-hydrophobic (contact angle=155˚) surface achieves an excellent self-cleaning ability for long-term outdoor uses, and the Si-O-Si bonds provide its robust flame resistance performance (~1200 ˚C), especially suitable for buildings. With its excellent PRC performance, flame-resistance, self-cleaning, flexibility and scalability, this designed SNM offers the possibility of all-day radiative cooling with zero energy consumption for multiple outdoor applications.

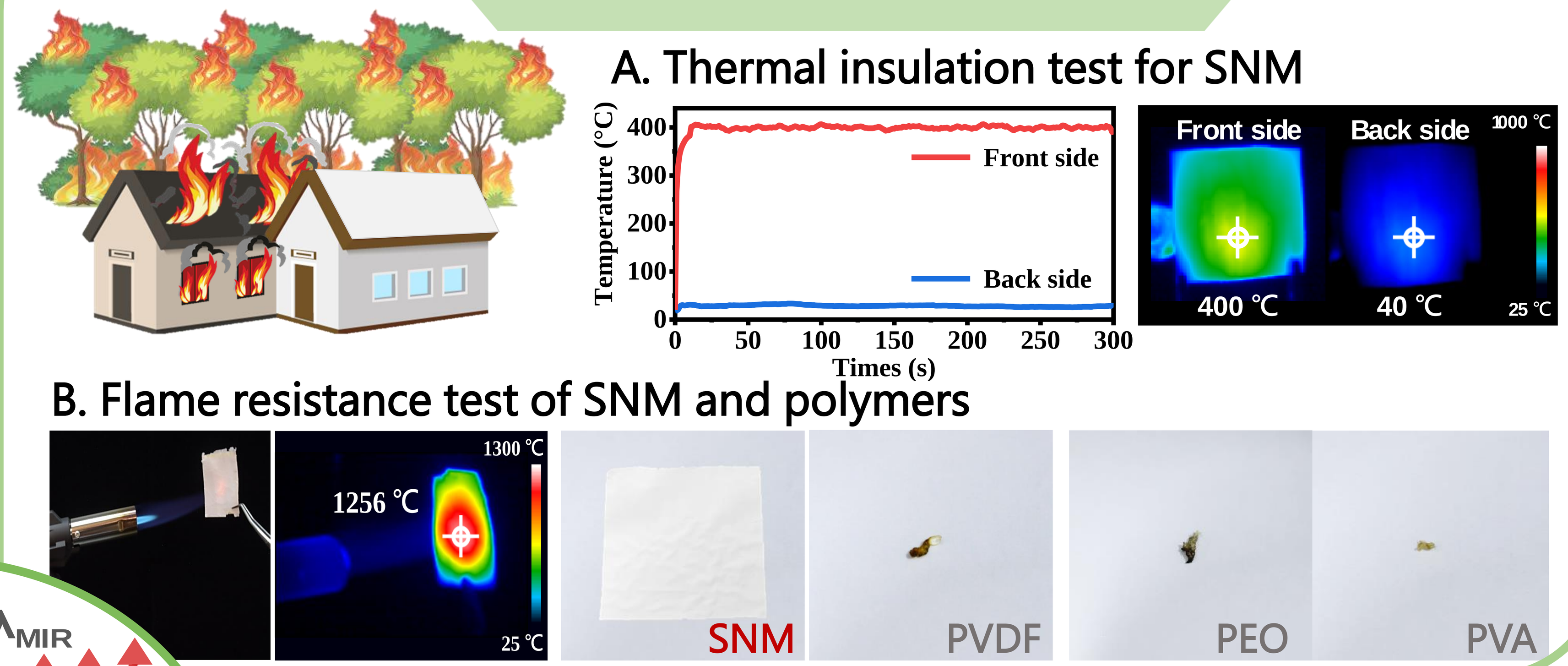
Results and Discussion

I. Characterization

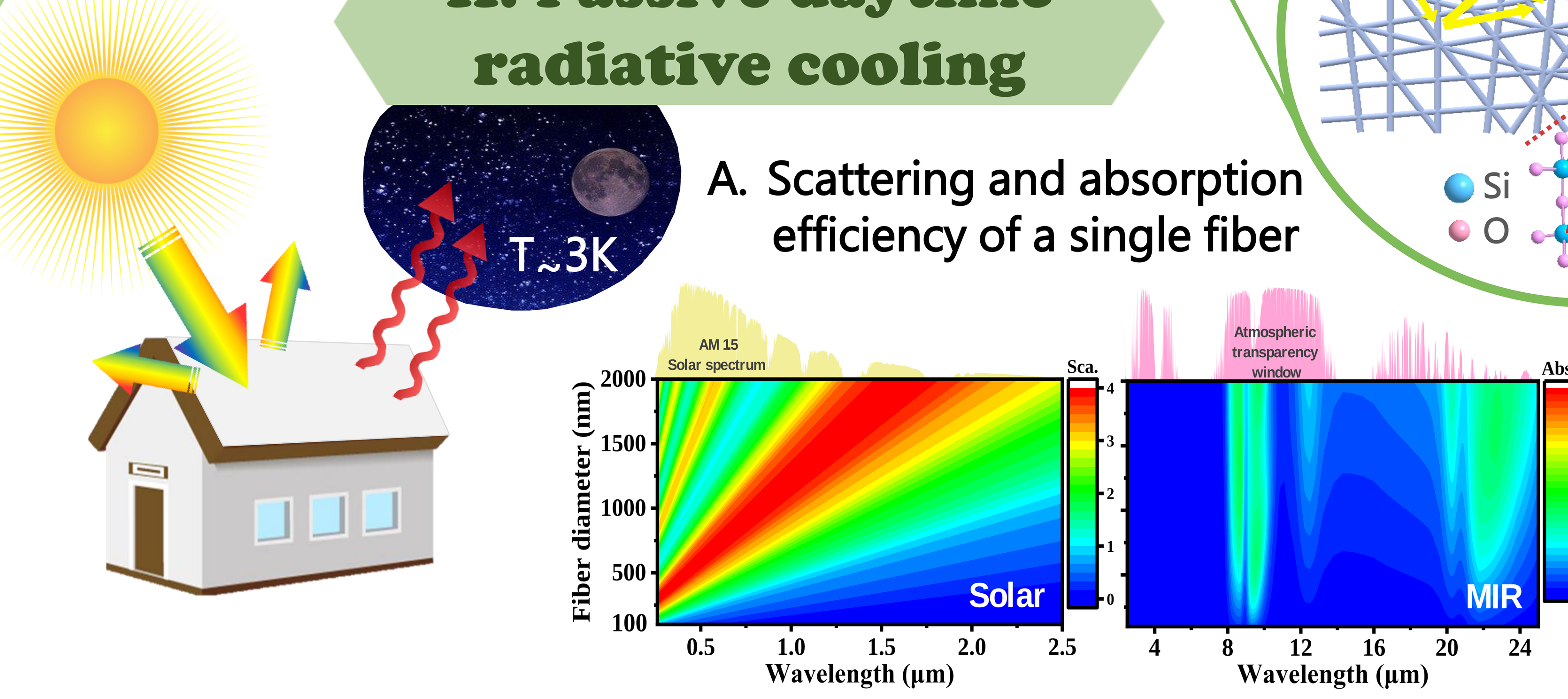


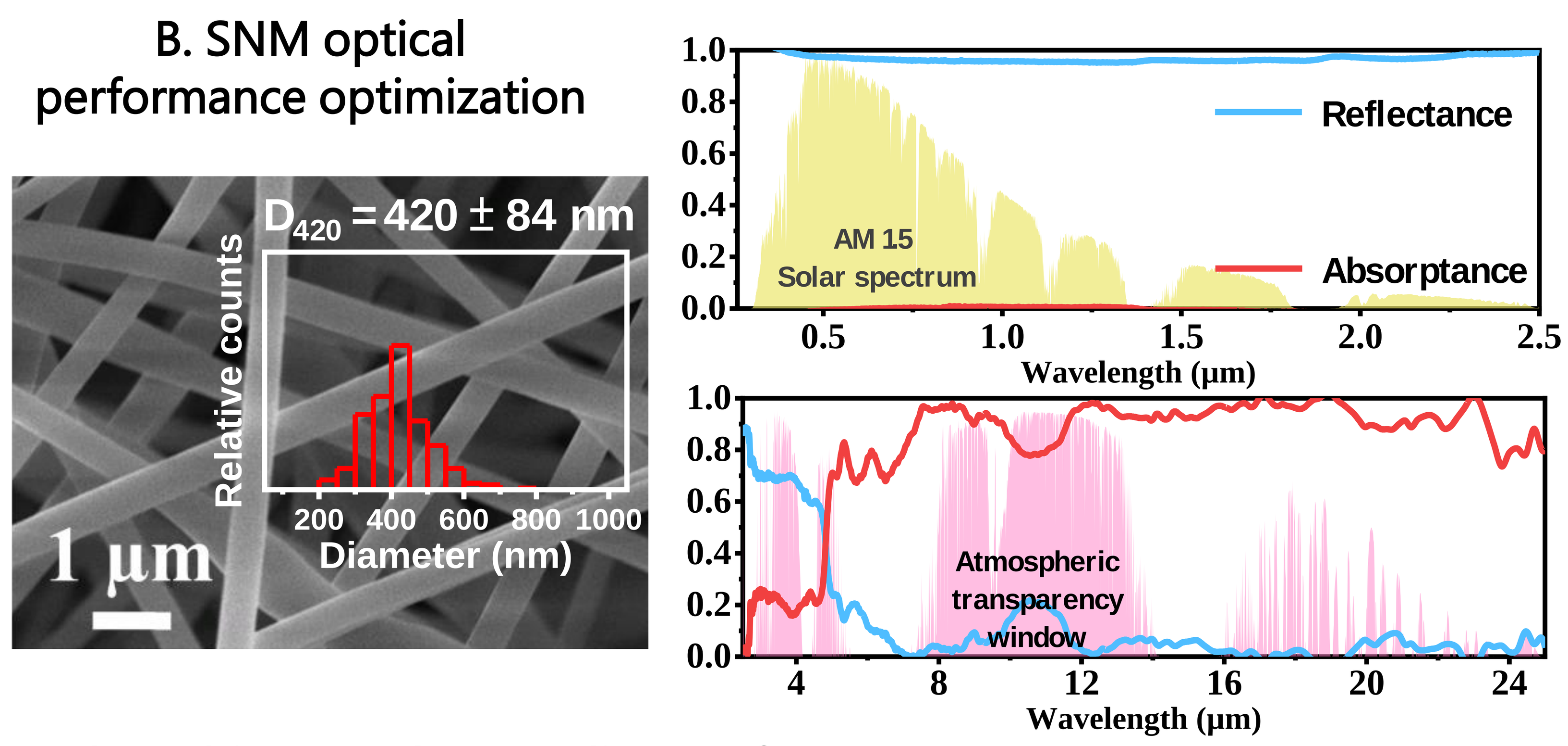


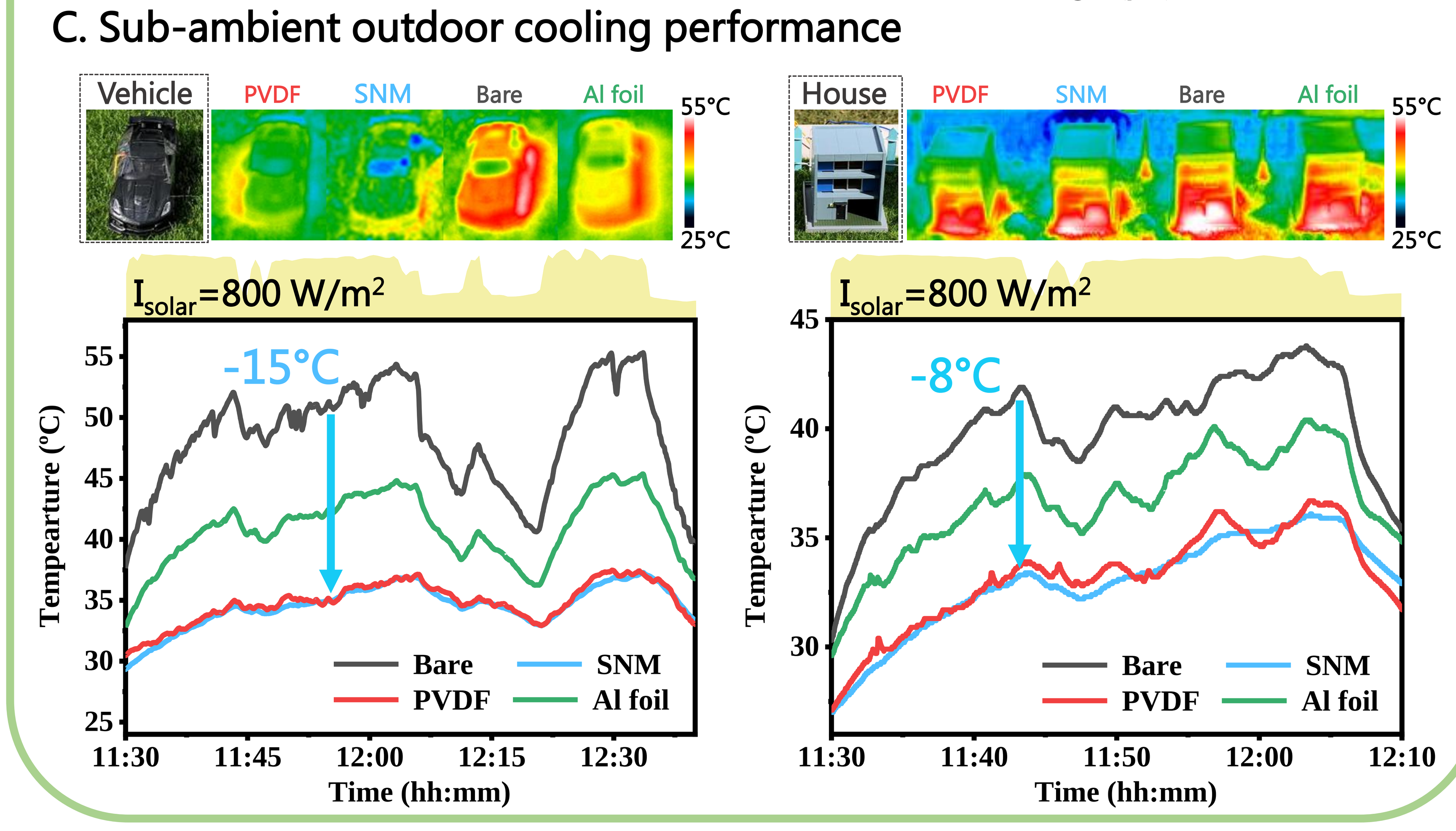
III. Flame-resistance



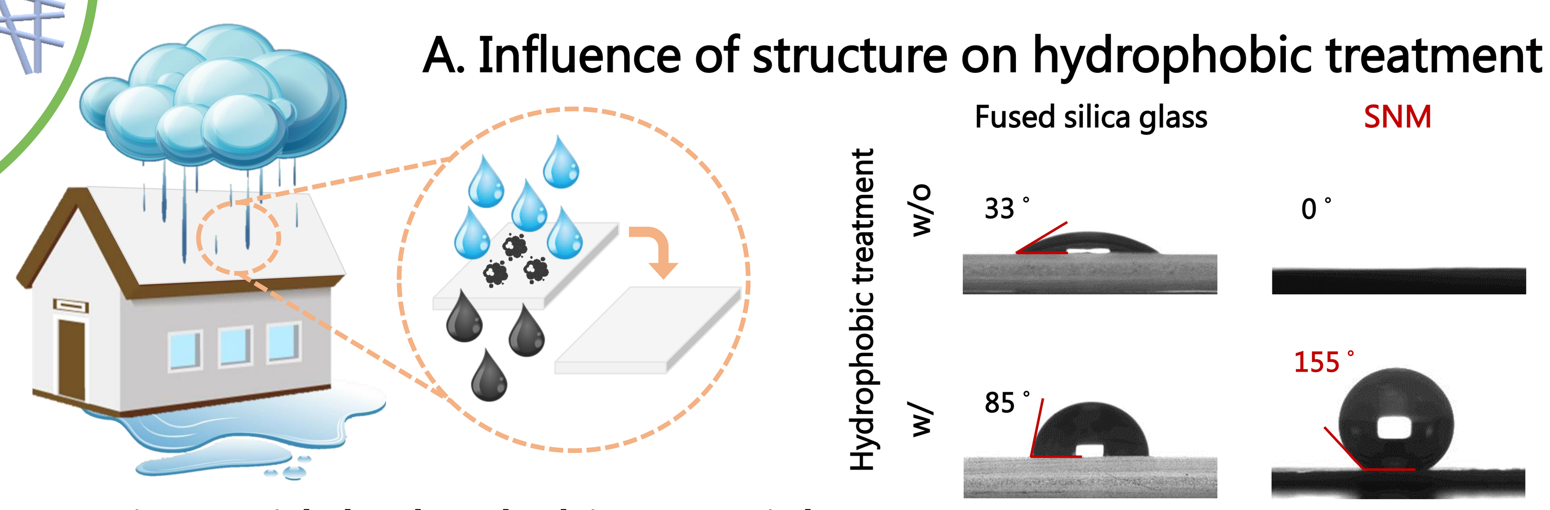
II. Passive daytime radiative cooling

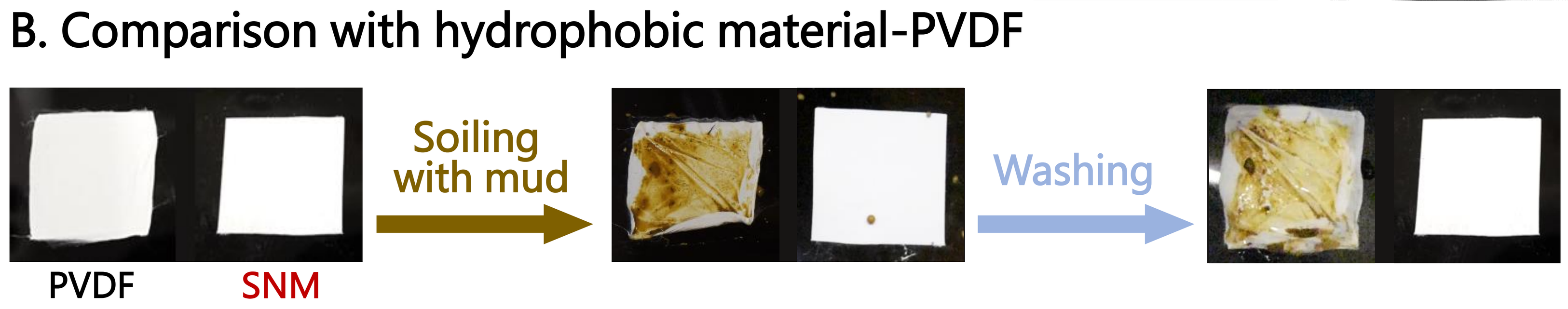


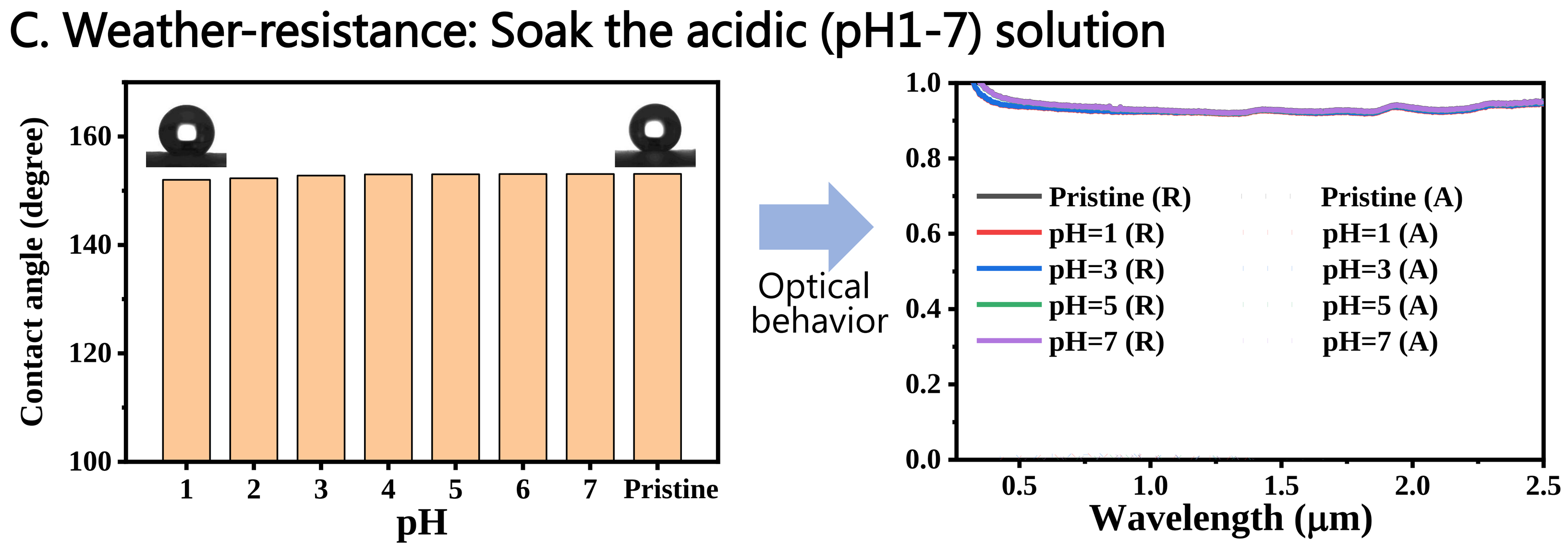


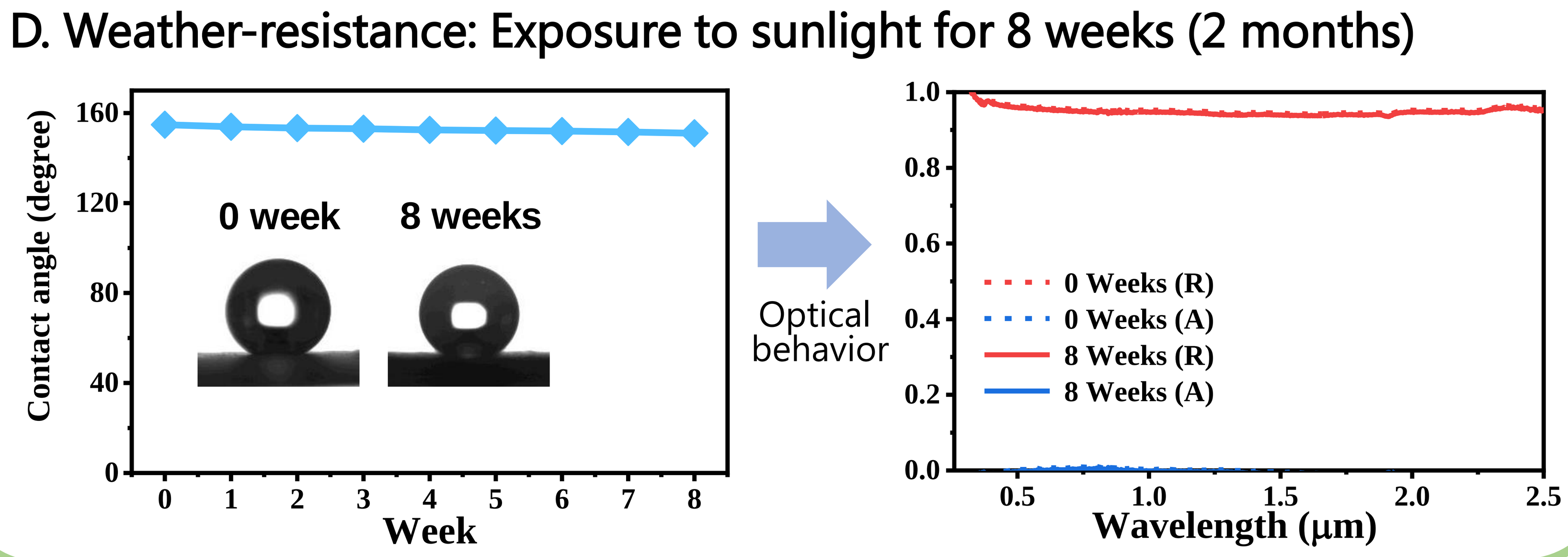


IV. Self-cleaning









Reference

[1] Meng-Ting Tsai, Sih-Wei Chang, Yen-Jen Chen, Hsuen-Li Chen, Pin-Hui Lan, Dai-chi Chen, Fu-Hsiang Ko, Yu-Chieh Lo, Hsueh-Cheng Wang, Dehui Wan, Scalable, flame-resistant, superhydrophobic ceramic metafibers for sustainable all-day radiative cooling, *Nano Today*, 2023, 48, 101745.

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