Electronic Supplementary Information (ESI):

High Reflective Superhydrophobic White-coating Inspired by Poplar Leaf Hairs toward Effective "Cool Roof"

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Morphology observation and spectral measurement: The surface morphology is observed by a field emission scanning electron microscope (SEM) (JEOL JSM-6700F) at 3 KV and an environmental scan electron microscopy (ESEM, FEI Quanta 200, ESEMTM vacuum mode, 500Pa pressure suits for biological observation of the leaf hairs) at a high magnification. The digital photos are taken by a digital camera (Nikon E5900). Reflectance spectra are measured by an Ocean Optic HR 4000 CG fiber optic UV-vis-IR spectrometer. The diameter of fiber probes is 400 μm. To investigate the single fiber reflectance, the Ocean fiber optic spectrometer is equipped on an optical microscope. $BaSO_4$ is chosen as the diffuse reflectance reference in the measurement here.

Coaxial electro-spinning of bio-mimic fibrous films: The materials are polystyrene (PSt) (ALDRICH®, Mw 170,000); polyvinylpyrrolidone (PVP) (ALDRICH®, Mw 1,300,000); poly(vinylidene fluoride) (PVDF) (ALDRICH®, Mw 530,000). PVDF solutions are prepared at a concentration of 20 wt% with mixed solvent N,N-dimethylformamide (DMF) / dimethylacetamide (DMAc) (1:1). PVP solutions are prepared at a concentration of 20 wt% with ethanol. PSt solutions are prepared at a concentration of 25 wt% with mixed solvent DMF / tetrahydrofuran (THF) (1:1).

The cross-section of the leaf hairs layer

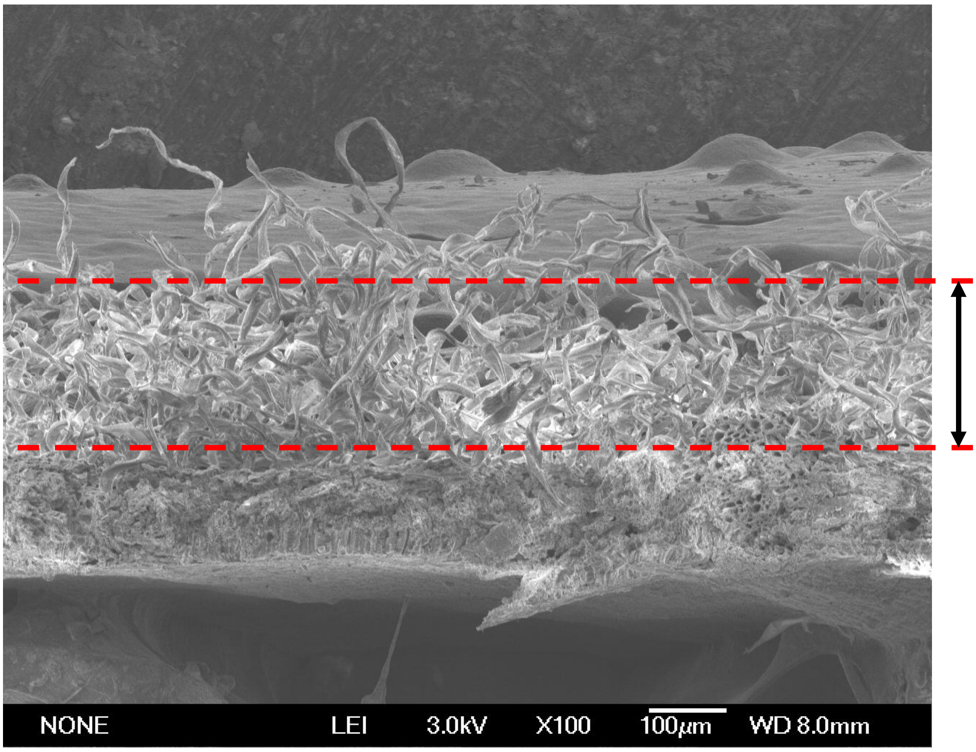

Fig. S1 SEM image of the cross section of the leaf. The thickness of the hairs layer is approximately 200 µm.

The reflectance comparisons of the two sides of the leaf

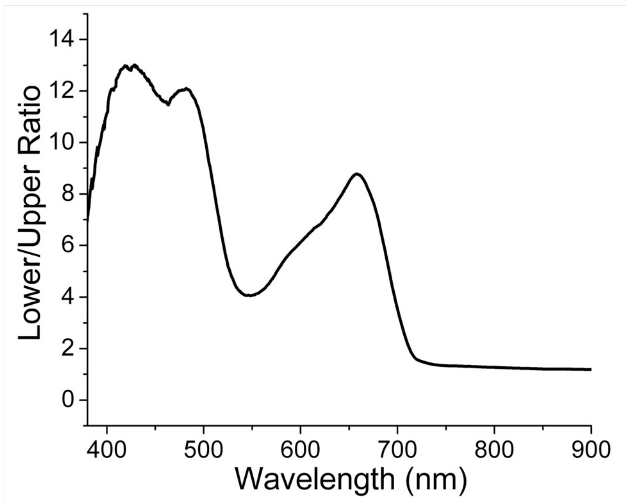

Fig. S2 The reflectance ratio of the lower surface to the upper surface. The reflectance of the lower surface is larger than that of the upper surface particularly in the absorption of the chlorophyll. In the wavelength range from 393 nm to 502 nm, the reflectance of the lower surface is more than ten times higher than that of the upper surface.

Different extent of radiation damage under high-extent radiation:

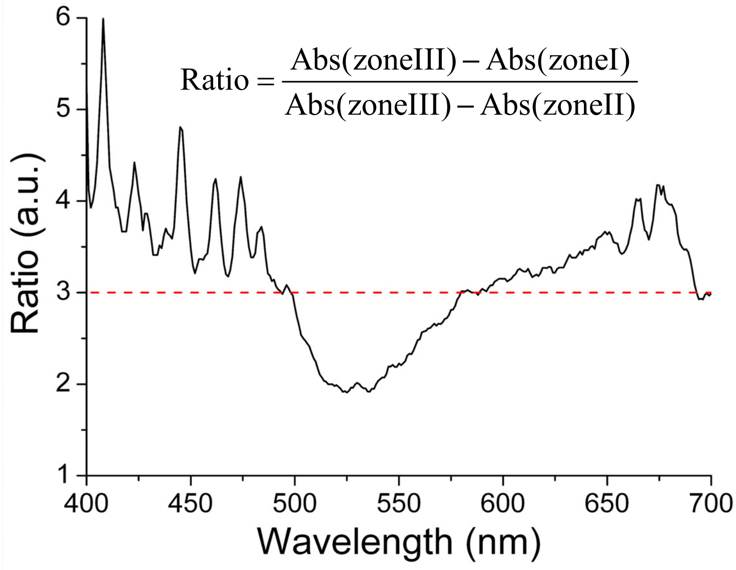

Fig. S3 The ratio of the absorbance decrement of the zone I to that of zone II. The decrement of zone I more than three times larger than that of the zone II, in the wavelength range from 400 nm to 494 nm and from 586 nm to 690 nm.

Fresh leaves in response to adverse physical situations:

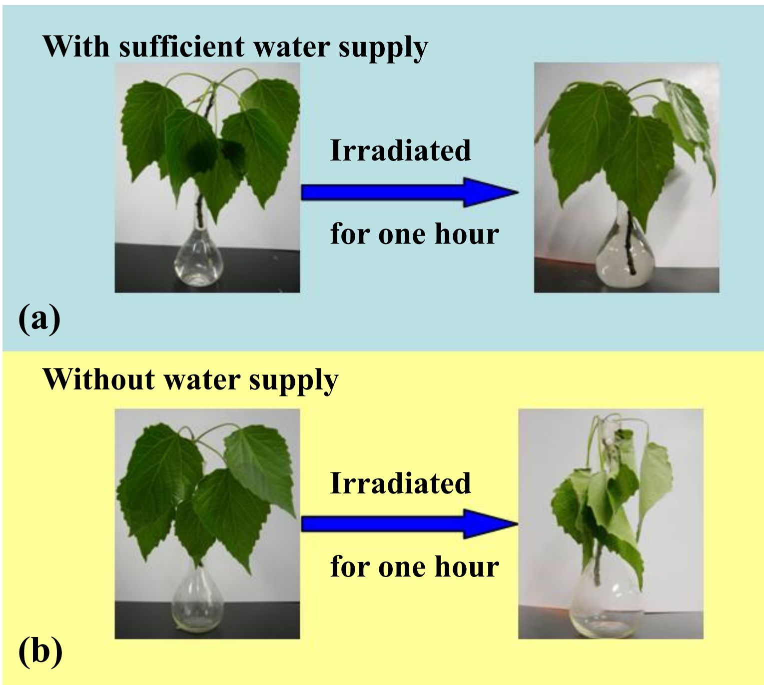

Fig. S4 Fresh twigs are exposed under a strong light radiation of 4.62 mW cm^{-2} for one hour. (a) The leaves on the twig remain no obvious change. The water level in the vase sharply falls, indicating the water consume in transpiration is quite high. (b) The leaves without water supply are wrapped up.

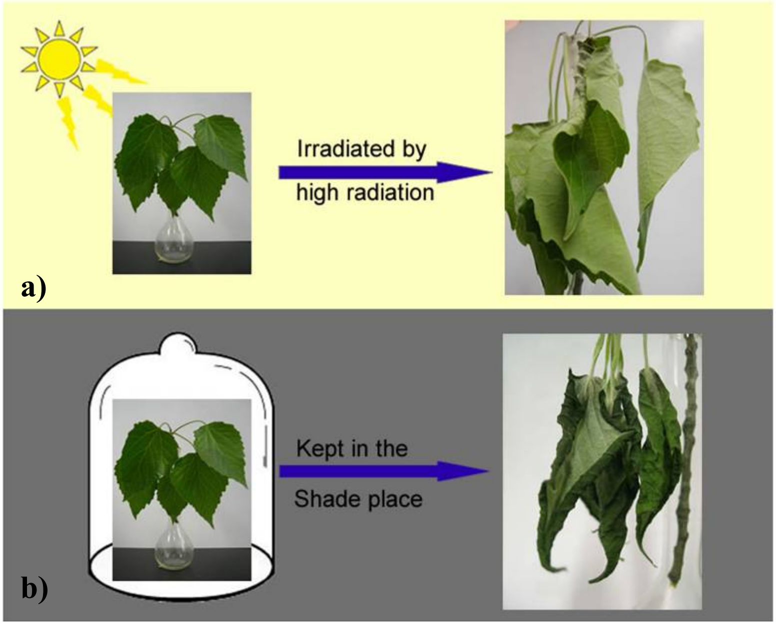

Fig. S5 (a) Fresh twigs are kept in a high radiation environment without water supply. The leaves turn over with their lower surfaces outwards. (b) Fresh twig is kept in shade place without water supply. The leaves curl with the ventral side wrapped inside.

Normally the white poplar tree looks in green color by naked eyes, but sometimes in summer midday with strong light radiation, the tree shows a white cast. Based on our observations in Fig. S4, 5, a smart and sufficient defense strategy against strong light stress is proposed.

In the ordinary situation, the water evaporation in the transpiration could protect the leaf by effectively cooling the surface of the leaf and transferring the heat generated by the radiation to the environment (Fig. S4a). However, in summer midday with strong light radiation, the transpiration is so high that the water supply rate from the root could not catch up with the water evaporation rate of the topmost branches. Therefore the topmost branches are short of water. The heat load can not be efficiently dissipated. The reflectance distinction of the both surface of the leaf could result in the heat energy absorption difference between the upper and lower surfaces in strong light radiation. The upper surface absorbs more heat energy than the lower surface, leading to the cell turgor pressure distinction and the leaf scrolling with its lower surface outwards.[1, 2]. However, the leaves of the control sample (Fig. S5b) are kept in the shade place for a week. The twig wilts due to a lack of water. The leaves curl with the ventral side wrapped inside.

The hairs layer on the lower surface may constitute an effective external advance guard against excess radiation. It functions as a shelter, scatters light, and attenuates the amount of light entering the leaf. Therefore hairs may be a kind of adaptive benefit for leaves by reflecting light and lowering heat load in high radiation situation.

UV-vis spectra of extracts of the surface hairs

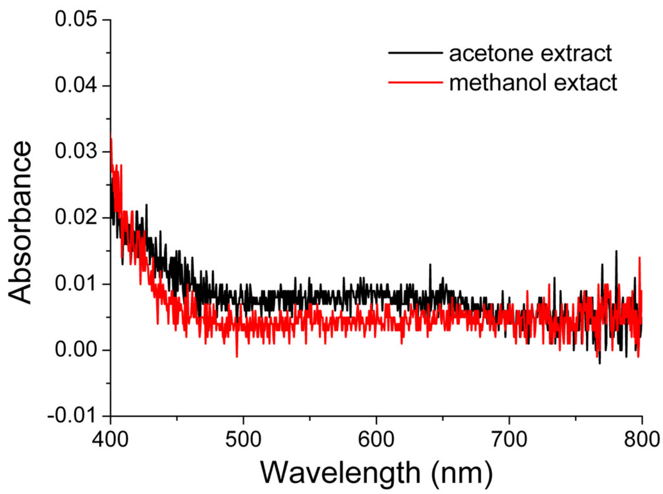

Fig. S6 Absorbance spectra of acetone and methanol extracts of the hairs removed from the poplar leaf.

Possible compositions in the hairs, which could have influence on the optical properties such as pigments, are tried to be extracted. Hairs are extracted with methanol or acetone solvent in a small mortar (ref. 13,14). Three consecutive extractions are carried out and pooled extracts are cleared by centrifugation and concentration. The absorbance spectra are measured by Hitachi U-4100 spectrophotometer equipped with an integrating sphere. As far as our investigation, there is no significant absorbance peak corresponding to any pigments.

The cross-section of the fibrous film and the control film

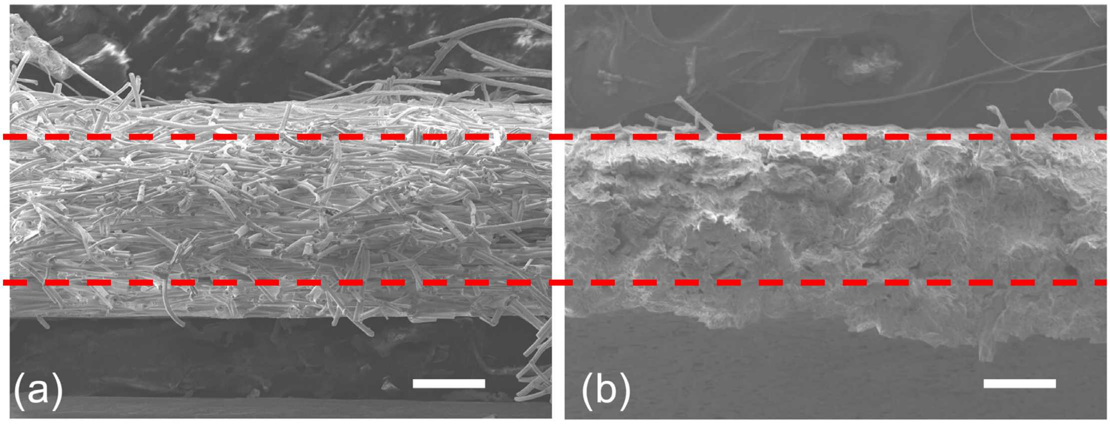

Fig. S7 (a) The cross-section of the fibrous film.(b) The cross-section of the control film. They have similar thickness around 400 μm. Bars: 100 μm

Bio-mimic fibrous films fabricated by two other polymers

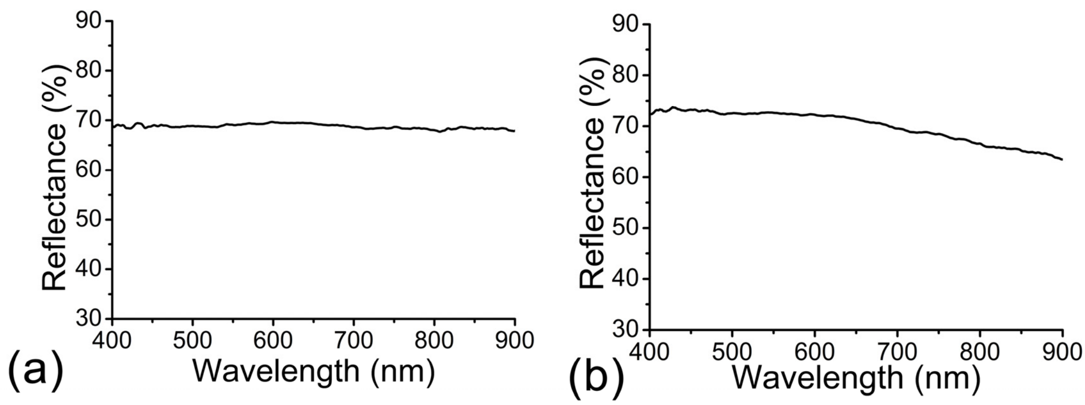

Fig. S8 Two common polymers are also suitable for such a mimic fabrication of the fibrous films: **(a)** poly- vinylpyrrolidone (PVP); **(b)** poly(vinylidene fluoride (PVDF). The size of the prepared fibrous films is around 16 μm in fiber width and 400-450 μm in film thickness. The bio-mimic fibrous films made of these two polymers also have a high reflectance property.

The mechanical properties of the fibrous film

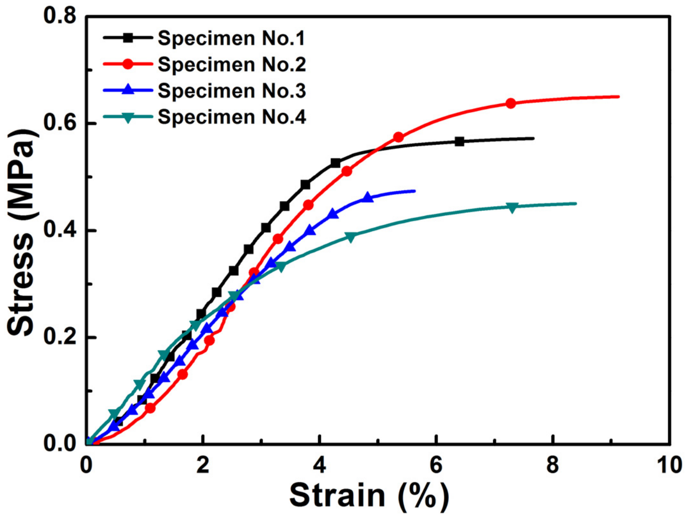

Fig. S9 The typical stress-strain curves of PSt fibrous films. The PSt fibrous films were cut into 7 mm wide and 40 mm long strips for tensile tests. The mechanical properties were performed on a dynamic mechanical analysis machine (DMA Q800, TA instrument Inc.), using the controlled-force mode with a speed of 0.01 N/min and gauge length of 10 mm under room temperature.

Elucidating the shield application of the fibrous film

A classical diarylethene (DTE) compound (1,2-Bis[2-methylbenzo[b]thiophen -3-yl]- 3,3,4,4,5,5-hexafluoro-1-cyclopentene), was bought from TOYKO CHEMICAL INDUSTRY Co., LTD. The solution was prepared at a concentration of 10^{-4} mol ml^{-1} in methylene dichloride.

At the beginning, three cuvettes containing the DTE solution are irradiated by a UV light lamp (365 nm) for 3 min. All the solutions in the three cuvettes turn into red color and have the same absorbance of 0.244 at 520 nm wavelength (Fig. 5a, upper row and Fig. 5b black line). Then they are directly irradiated by the high-intensity visible light by the solar simulator (80 mW cm^{-2}) from the top for 30s irradiation. The absorbances of the solution in three cuvettes after the visible radiation are measured immediately (Fig. 5b).

Reference

1. T. C. Hsiao, Annu. Rev. Plant. Physiol., 1973, **24**, 519-570.
2. D. M. Gates, H. J. Keegan, J. C. Schleter and V. R. Weidner, Appl. Opt., 1965, **4**, 11-20.