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Biomimetic Electrospun Films for Effective Radiative Cooling Under Sunlight

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ABSTRACT : We demonstrate that natural silk can be restructured by electrospinning into nanoscale morphology mimicking white beetle scales for enhanced radiative cooling. While natural silk cocoons exhibit strong broadband light scattering by Anderson localization, for exceptionally strong scattering, white beetle scales rely on different physics that remains largely unclear. By electrospinning regenerated silk, we create silk films where the fibers are a quarter micron in mean diameter and randomly oriented in the plane directions, similar to white beetle scale structures. Relative to raw silk films, the restructured silk films substantially increase optical scattering strength in the visible spectrum and emissivity in the atmospheric transparency window. As a result, our restructured silk film lowers average temperature of a black substrate underneath by 7.5 °C relative to a raw silk film during daytime of intense solar radiation. Our work suggests that scattering physics hidden in white beetle scales achieves even stronger sunlight rejection than that in natural silk cocoons which ingeniously embodies Anderson localization. Moreover, the strong scattering in our electrospun fibrous films points to highly efficient cooling fabrics that mimic nanostructures in white beetle scales with synthetic polymers.