Self-cooling textiles – energy-free method using radiative cooling technology

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ABSTRACT

Due to climate change, population increase and the urban heat island effect (UHI) the cooling energy demand in cities increased by 23% from 1970 to 2010. [1] Previous conventional cooling systems for buildings like air conditioners are based on thermodynamic cycles that account for a large share of electricity demand while dissipating waste heat and carbon dioxide (CO2) into the environment. [2]

Technologies such as radiative cooling offer a sustainable and energy-free solution by using the wavelength ranges of the atmosphere that are transparent to electromagnetic radiation, the socalled atmospheric window (8-13 µm), to emit thermal radiation into the colder (3K) outer space. [2] By adjusting the spectral curve via developing an adaptive and resource-saving cooling coating for technical textiles so that more heat is emitted than it is absorbed, cooling below the ambient temperatures even during the day is possible. Previous publications in the field of textile building cooling has focused on specific fiber structures and textile substrate materials as well as complex multi-layer constructions, which restricts the use for highly scaled outdoor applications. [3], [4]

The aim of this study is to develop a novel substrate-independent coating with spectrally selective radiation properties based on thermo-optically active particles to generate a selfcooling effect on the textile membrane surface. Additional properties such as simple application, sustainability and high scalability are to be fulfilled. Through the targeted analyses of the coating formulation and the combination of reflective particles in the solar spectrum and a matrix material emitting strongly in the mid-infrared (MIR), cooling below ambient temperature is achieved. In addition to the radiation effect, the matrix material has high UV and weather stability and is hydrophobic, making the coating suitable for outdoor membrane applications. Thus, this work contributes to a solution approach in the field of sustainable textile-based cooling technologies.

REFERENCES

[1] United Nations, Ed., *World urbanization prospects: The 2018 Revision*. New York: United Nations, 2019.

[2] A. P. Raman, M. A. Anoma, L. Zhu, E. Rephaeli, and S. Fan, “Passive radiative cooling below ambient air temperature under direct sunlight,” *Nature*, vol. 515, no. 7528, pp. 540–544, Jan. 2014, doi: 10.1038/nature13883.

[3] W. Li, Y. Li, and K. W. Shah, “A materials perspective on radiative cooling structures for buildings,” *Solar Energy*, vol. 207, pp. 247–269, Sep. 2020, doi: 10.1016/j.solener.2020.06.095.

[4] S. Wu, Y. Cao, Y. Li, and W. Sun, “Recent Advances in Material Engineering and Applications for Passive Daytime Radiative Cooling,” *Advanced Optical Materials*, p. 2202163, Nov. 2022, doi: 10.1002/adom.202202163.