Innovative Space Cooling Solutions: Evaporative Technologies with Radiative Enhancements

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Space cooling in buildings is expected to increase due to the growing demand for thermal comfort worldwide, requiring increasingly more sustainable and cost-effective cooling technologies. Nowadays vapor compression technologies are used for fulfilling most of the cooling demand despite their significant electricity consumption and their possibility of causing seasonal peaks. In addition, vapor compression technologies typically involve refrigerants with high global warming potential. In this talk, we will focus instead on evaporative cooling technologies, eventually integrated with radiative cooling enhancements, as well as some fundamental underlying phenomena deeply rooted in non-equilibrium thermodynamics.

In this work, we model and design, realize, and experimentally test a passive multi-stage proof-of-concept cooling device, which operates without moving mechanical parts or auxiliary equipment [1]. The net cooling load is generated, at a nearly ambient pressure, by a salinity disparity between two aqueous solutions (here represented by distilled water and brine). The developed laboratory-scale prototype is able to provide a maximum cooling capacity of nearly 100 W/m^2 when it operates with a sodium chloride solution at 3.1 mol/kg and a maximum cooling capacity of approximately 170 W/m^2 with a calcium chloride solution at the same concentration, with zero temperature difference. Prototype design and its performance estimation requires to model the heat and mass transfer phenomena regulating the water dynamics in complex porous components [2]. Moreover, the possible integration with radiative cooling technologies is currently under investigation [3].

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References

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