Cutting-Edge Environmental Cooling Technology Breaks Performance World Record

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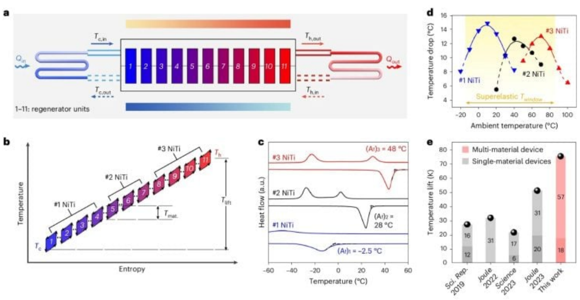
Courtesy of SynEvol

Scientists at the Hong Kong University of Science and Technology (HKUST) School of Engineering have created an environmentally friendly refrigerator that breaks records for cooling capacity. The novel elastocaloric cooling technology offers a viable path for expediting the commercialization of this disruptive technology and resolving the environmental issues related to conventional cooling systems, thanks to an efficiency improvement of over 48%.

High-global-warming potential refrigerants are used in conventional vapor compression refrigeration systems. With its features of greenhouse gas-free, 100% recyclable, and energy-efficient shape memory alloy (SMA) refrigerants, solid-state elastocaloric refrigeration based on latent heat in the cyclic phase transition of SMAs offers an environmentally benign substitute. The ability of the cooling device to transfer heat from a low-temperature source to a high-temperature sink is measured by a crucial performance indicator, but the relatively tiny temperature rise between 20 and 50 K has hampered the adoption of this developing technology.



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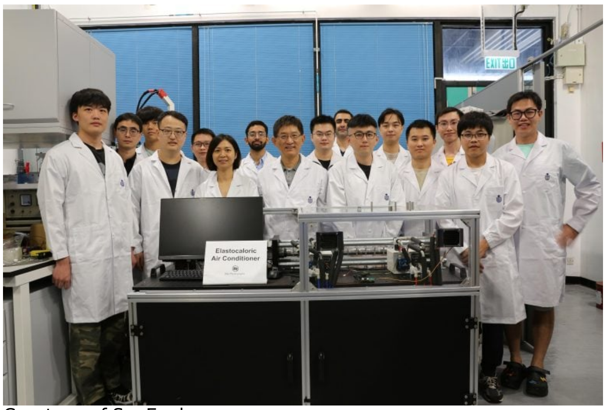
Credit:HKUST

The Department of Mechanical and Aerospace Engineering's research team, led by Professors Sun Qingping and Yao Shuhuai, overcame the obstacle by creating a multi-material cascading elastocaloric cooling device made of nickel-titanium (NiTi) shape memory alloys, which broke the previous record for cooling performance.

Three NiTi alloys were chosen to function at the cold end, intermediate end, and hot end, respectively, with varying phase transition temperatures. Each NiTi unit operated within its ideal temperature range, greatly increasing the cooling efficiency, and the device's superelastic temperature window was extended to over 100 K by matching the working temperatures of each unit with the associated phase transition temperatures. The previous world record of 50.6 K was surpassed by the multi-material cascade elastocaloric cooling mechanism, which reached a temperature lift of 75 K on the water side. Nature Energy published their research recently.



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The research team intends to continue developing high-performance shape memory alloys and devices for high-temperature heat pumping and sub-zero elastocaloric cooling applications, building on the success in developing elastocaloric cooling materials and architectures that has resulted in numerous patents and articles published in prestigious journals. They intend to further the commercialization of this cutting-edge technology by further refining material characteristics and creating highly energy-efficient refrigeration systems.

Twenty percent of the world's electricity is used for space heating and cooling, and by 2050, industry projections indicate that space will account for the second-largest share of worldwide electricity demand.

Prof. Sun stated, "We are confident that elastocaloric refrigeration can provide next-generation green and energy-efficient cooling and heating solutions to feed the huge worldwide refrigeration market, addressing the urgent task of decarbonization and global warming mitigation." This is in line with the ongoing advancements in materials science and mechanical engineering.

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