Research team introduces roadmap to greener air conditioning for a warmer world

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A warmer world means growing reliance on air conditioning and cooling-related energy demands. Pacific Northwest National Laboratory researchers are studying the many facets of adsorption cooling, which offers a more energy efficient option for cooling systems. Credit: Shannon Colson / Pacific Northwest National Laboratory

When the heat of summer hits, air conditioners turn on and energy demand skyrockets, straining the grid. In a warmer world, more efficient cooling options will play an important role in curbing the increase of cooling-related energy demands. This will be particularly true for the nearly 80 percent of the global population living in countries surrounding the equator, where even small temperature increases could be life-threatening.

New research from Pacific Northwest National Laboratory (PNNL) provides a roadmap outlining how more efficient cooling systems are feasible with development and support from industry. The invited research study appeared in the journal *Accounts of Chemical Research*.

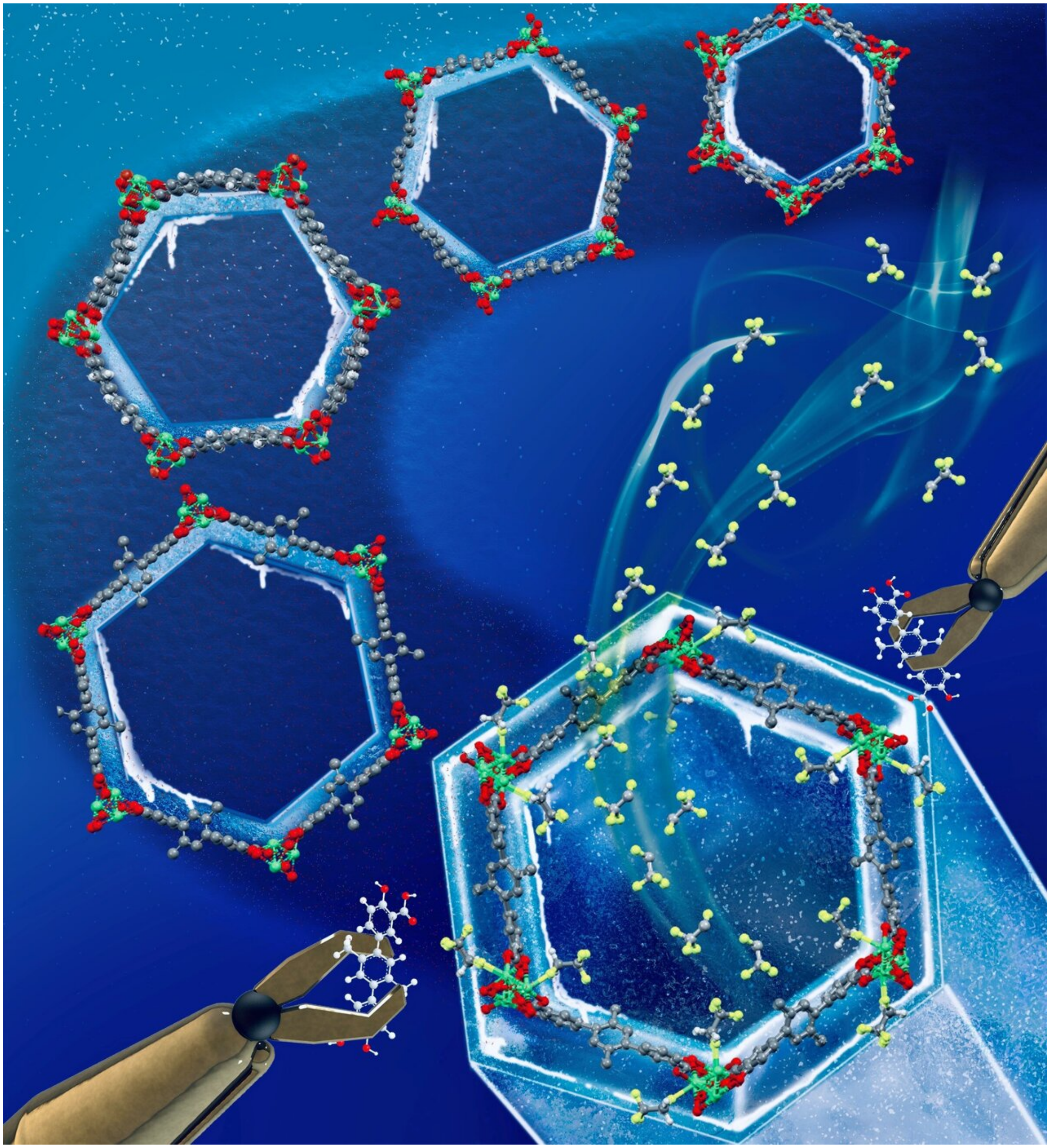
"Right now, this is fundamental science. However, this could be a game-changer for industry," said Radha Motkuri, PNNL chemical engineer and corresponding author.

The chemistry of cool

Motkuri and the research team examined one approach that could offer significant energy savings: adsorption cooling. These systems can run on small amounts of waste heat from a building or industrial plant to power reactions between a vapor refrigerant and a solid material.

"Once we input power the first time, that's it," explained Motkuri. "Then, the system keeps on cycling—adsorption, desorption, adsorption, desorption—with very little power input."

This is in direct contrast to conventional cooling systems that use a compressor and require regular inputs of energy.



In adsorption cooling systems, molecules of vapor refrigerant (the guest) are adsorbed in the nanopores of a solid material (the host). Motkuri and his collaborators have studied how changing the geometry of the nanopores (pore engineering) and the speed of host-guest chemical interactions affect the cooling capacity and energy efficiency of adsorption cooling systems. Credit: Rose Perry / Pacific Northwest National Laboratory

Tuning an adsorption cooling system to achieve ideal cooling capacity and energy efficiency requires understanding the complex chemistry between the system's vapor refrigerant, called the guest, and solid absorbent material, called the host. Motkuri and his collaborators dug into these details—adjusting the pore geometry of the solid sorbent, the speed of chemical interactions, and even the impact of tiny defects in the solid material—to understand how they affect the entire system. Recently, the team was invited to compile their work into an efficient ensemble that can help developers in the cooling industry trying to meet the demand for more energy efficient options.

"Refrigerant-based adsorption cooling eliminates the major cost, efficiency, and reliability issues that have limited adoption of current water-based adsorption cooling systems in commercial and residential buildings," said Pete McGrail, Laboratory fellow and chemical engineer who led PNNL's adsorption cooling effort for several years. "This journal article represents a synopsis of years of research into novel sorbent-refrigerant pairs that significantly advanced adsorption cooling technology."

Environmentally conscious components

With global heatwaves on the rise and cooling-related energy demands expected to triple by 2050, there is a push for cooling systems with smaller environmental footprints. In addition to more energy efficient systems, this includes changing standards for refrigerants.

Commonly used hydrofluorocarbon refrigerants will be phased out in the next few years in favor of more environmentally friendly hydrofluoro-olefins (HFOs). HFOs have a global warming potential near zero, which means that emissions of HFOs hold much less relative heat in the atmosphere compared to emissions of hydrofluorocarbon refrigerants.

Aware of this transition, Motkuri and his collaborators conducted their testing using the readily available, inexpensive hydrofluorocarbon refrigerant R-134a. This hydrofluorocarbon refrigerant has a high global warming potential, but a similar chemical behavior to HFOs, which makes it a suitable alternative for studying the molecular interactions of adsorption cooling systems that will use HFOs in the future. The researchers look forward to integrating HFOs in future adsorption cooling research as the next step in green cooling systems.

PNNL researchers Dushyant Barpaga, Jian Zheng, Peter McGrail, and Radha Motkuri contributed to the article in *Accounts of Chemical Research*.

More information: Dushyant Barpaga et al, Manipulating Pore Topology and Functionality to Promote Fluorocarbon-Based Adsorption Cooling, *Accounts of Chemical Research* (2021). DOI: 10.1021/acs.accounts.1c00615

Provided by Pacific Northwest National Laboratory

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