Chameleon Skins Slash Building Energy Use

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Heating and cooling buildings consumes around 15 percent of the world's energy supply, and this use is slated to go up in coming decades. The International Energy Agency predicts that the energy demand for cooling will more than triple by 2050 if nothing is done to address energy efficiency.

Now, taking inspiration from the color-changing skins of chameleons, two research groups have made dynamic, color-changing materials for building facades that could significantly reduce the energy footprint of air-conditioning and heating.

One idea out of the University of Chicago is a device that, with a flip of a switch, changes how much infrared heat it emits, helping to keep indoor spaces comfortable year-round without using much energy. The other device, developed by a team at the University of Toronto, controls the amount, type, and direction of infrared and visible light entering buildings. Both technologies use electricity themselves, but the significant reduction in energy use they achieve more than makes up for that consumption.

The energy efficiency of buildings has come into the spotlight recently as climate change makes extreme weather spells longer and more frequent. Technologies that reduce the load on air-conditioning include electrochromic windows, which darken when triggered by electricity or the sun's heat to reduce the amount of sunlight entering offices, and passive radiation cooling systems that send infrared heat rays into space. Researchers have also recently reported a device that can provide either solar heating or radiative cooling based on temperature.

Molecular engineer Po-Chun Hsu and colleagues at the University of Chicago wanted to make such a dual-mode device, one that could be dynamically controlled as opposed to triggered by temperature. "Instead of pumping energy into heating or cooling, we're modulating the insulation of buildings, like people do on a human-body scale when they add or remove layers," Hsu says.

Their thin, battery-like device consists of a nonflammable, copper-containing watery electrolyte sandwiched between two electrodes. The electrode that would face the outside of a building is a plastic film coated with a grid of gold nanowires, a single layer of graphene, and some platinum. The other electrode is a copper foil.

In heating mode, an applied voltage pushes copper nanoparticles out of the electrolyte to the platinum-graphene film. They form a thick metal layer that reflects infrared radiation "like the metallic thermal blankets that suppress heat loss from runners," Hsu says.

When the voltage is reversed, the metal dissolves back into the electrolyte, which emits infrared heat through the see-through plastic electrode, creating a cooling state. The material can emit up to 92 percent of infrared radiation to help cool buildings, while in heating mode it emits just 7 percent of infrared.

The researchers used EnergyPlus, an open-source energy simulation software to calculate the energy use of a building in 15 different U.S. cities, with the new device used as a facade for the entire structure. On average, the device uses less than 0.2 percent of the total electricity consumption of the building, but it saves 8.4 percent of the building's annual HVAC energy consumption, they report in the journal Nature Sustainability.

Hsu says that the use of graphene and copper makes the device expensive right now, but the team is assessing the use of alternative materials to reduce cost.

The "optofluidic" device reported by materials science and engineering professor Benjamin Hatton and colleagues at the University of Toronto might have an advantage when it comes to cost. The researchers put three thin plexiglass sheets together. Each layer is patterned with 2- to 3-millimeter-high channels, through which they pump different fluids: a dyed water- or alcohol-based suspension that can absorb both visible and near-infrared wavelengths; a carbon black suspension that provides shading; and a titania nanoparticle suspension that scatters and directs the light passing through it.

Combining the three effects allows for “simultaneously tuning the intensity, spectrum, and dispersion of transmitted sunlight within buildings over time,” Hatton says. The liquid-filled panels could be incorporated into new windows or retrofitted in old panes. The system would affect the appearance of buildings, and it would require careful management of fluid volumes and leakage. But because it controls sunlight in both visible and infrared regimes, it can have a bigger impact on energy use compared with only a heat-management approach.

Read the original article on IEEE Spectrum.