Nanomaterials can help make windows more efficient

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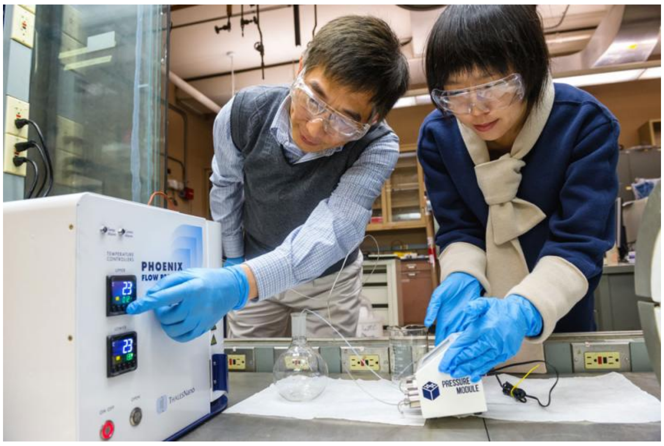

Principal chemical engineer Jie Li, left, and postdoctoral researcher Alina Yan create coated nanoparticles in a continuous flow reactor. Nanoparticles are key to an ongoing effort at Argonne to create more efficient window films. Credit: Argonne National Laboratory

A team of researchers at the U.S. Department of Energy's (DOE's) Argonne National Laboratory is using nanomaterials to improve the energy efficiency of existing single-pane windows in commercial and residential buildings. The team was recently awarded a $3.1 million grant from DOE's Advanced Research Projects Agency-Energy (ARPA-E) to develop a technology that could help achieve that goal. The nanofoam the team is developing—known as a nanocellular composite with superthermal insulation and soundproofing—uses gas bubbles less than 100 nanometers in diameter to block the transfer of heat and sound through glass windows while allowing visible light to pass through and maintain a clarity similar to normal windows.

"That's really the trick, blocking the heat and sound transfer while maintaining transparency," said Ralph Muehleisen, principal building scientist at Argonne. "It's fairly simple to develop a coating that insulates, but getting one that is thin and you can still see through is a substantial technical challenge."

The nanofoam, which will be extruded into sheets about three millimeters thick, creates a thermal insulation effect by using the tiny bubbles to reduce collisions among gas molecules, thereby reducing the transfer of heat energy. When the bubbles are reduced to that scale, superthermal insulation becomes possible.

A foam with larger bubbles could perform a similar function, but those bubbles would scatter visible light, making the window hazy and less transparent. The bubbles need to be created with a size of around 100 nanometers or less, distributed properly and then sculpted within the host medium to achieve an acceptable level of clarity. By way of comparison, a human hair is about 60,000 nanometers wide and a DNA molecule is 2-3 nanometers wide.

According to ARPA-E, single-pane windows make up 30-40 percent of windows in the United States, depending on the region. Single-pane windows conduct at least twice as much heat as double paned, so retrofitting all those windows could save consumers about $12 billion a year in energy costs.

The nanofoam team combines expertise from nanomaterial scientists, polymer scientists, chemical, process and building engineers, along with the expertise of Argonne's Center for Nanoscale Materials, a DOE Office of Science user facility. The team also includes researchers from the University of Chicago's Institute for Molecular Engineering, Lawrence Berkeley National Laboratory (LBNL) and Temple University's Department of Chemistry.

"This effort really shows the power of cross-cutting scientific collaboration," said Matt Tirrell, who is Argonne's Deputy Laboratory Director for Science and holds a joint appointment with the University of Chicago. "By bringing together these unique skillsets and facilities, we have the ability to make substantial breakthroughs that hold the promise to make a big difference in building energy efficiency."

The team will not be satisfied with creating laboratory versions of the materials, however. Researchers are also developing processes that can be economically scaled up to commercial production. Jie Li, a principal chemical engineer at Argonne and the principal investigator on the project, recently completed the DOE's Lab-Corps program, which aims to accelerate the transfer of clean energy technologies from national laboratories to the marketplace.

"We know that commercial production is the key step to having a positive effect on building efficiency," Li said. "There are billions of square feet of windows in the United States. Imagine the impact of making all those windows more efficient. That's when you really start to see benefit from your science."

The team also includes Leah Guzowski, director of strategic programs at Argonne; Yugang Sun, formerly of Argonne and now a professor at Temple University; and Stephen Selkowitz and Charlie Curcija from the Windows and Daylighting Group at LBNL.

This nanofoam research builds upon another nanomaterial being developed at Argonne. Several members of the ARPA-E team are working on a new nanoparticle coating of vanadium dioxide, which is a phase-change material that behaves differently at different temperatures. At low temperatures, vanadium dioxide is a semiconductor that allows both near-infrared light (the portion of the solar spectrum that contains approximately half of all solar energy) and visible light to pass through. When it gets hot, however, it develops metallic properties and begins to block out near-infrared light, which helps reflect solar radiation during the summer. Current versions of vanadium dioxide do not block much solar heat gain, so the film must be very thick, which makes for a darker window that consumers are reluctant to adopt.

By using nanoparticles of vanadium dioxide, the team has created a film that can boost near-infrared blocking and is more efficient at reflecting solar radiation, all while maintaining visible transparency.

The Argonne researchers hope that by combining the nanofoam and the vanadium dioxide, they may be able to create a single-pane window that could achieve efficiencies similar to multipane low-emission (low-E) units. Low-E windows usually have multiple coated panes of glass with inert gas suspended between them. By using only one pane of glass without the costly and complicated sealing system required by multipaned windows, the new windows would become more affordable, allowing more widespread adoption.

Provided by Argonne National Laboratory

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