Scientists develop environmentally safe, frost-resistant coatings

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Sushant Anand, UIC assistant professor of mechanical engineering, and Rukmava Chatterjee, a UIC Ph.D. student. Credit: Jim Young/UIC Engineering

Airports are busy, especially during the winter. As passengers wait to board, delays get longer when airplanes need to be dowsed with

thousands of gallons of deicing fluids that help them fight the frigid winter. But as soon as the plane takes off, most of the liquid is gone from the surface of the aircraft and ends up polluting freshwater streams and lakes.

In an endeavor to make a more efficient product immune to ice for such demanding industries and consumers, Sushant Anand, UIC assistant professor of mechanical engineering, and Rukmava Chatterjee, a UIC Ph.D. student, have developed a longer-lasting alternative to conventional deicers. They say it could also benefit other industries.

"We questioned the lifetime of the cryoprotectants and looked at new ways to increase their effectivity," Anand said. "Glycols dissolve very fast in the water and get washed away before the plane takes off, and it's a serious problem that costs hundreds of millions of dollars –- most of which literally ends up in the drain. We thought, why not improve such chemicals themselves, and make alternatives that can last longer while being more biofriendly. And that is what we ended up doing."

To accomplish their goal, the researchers developed an extensive family of more than 80 anti-freezing coatings, which can be classified as polymeric solutions, emulsions, creams and gels. The formulations can be easily applied to aluminum, steel, copper, glass, plastic or any industrial surface without preconditioning or expensive surface treatments.

"Our coatings are an all-in-one package which can delay formation of frost for extended hours and simultaneously cause any ice formed on its surface to easily shed off by a gentle breeze or simple substrate tilting," Chatterjee said.

Their work is reported in an *Advanced Materials* article titled "A family of frost-resistant and icephobic coatings."

The coatings are a family of phase change material-based formulations and multifunctional coatings which can tailor solid foulant adhesion on functional surfaces, ranging from ice to bacteria, irrespective of their inherent material structure and chemistry. This was engineered by regulating how chemicals leach out of the material system and by creating a lubricating surface layer that is both slippery and non-freezing in nature.

The anti-freezing gels are also transparent, which is critical for applications like traffic signals, runway lights that assist pilots during landings, automotive windshields or building windows.

"Imagine coating your smartwatch with our gel that can inhibit ice accretion in the chilly negatives while simultaneously preventing any bacterial contamination," Chatterjee said.

"Since our anti-icing sprays are bio-friendly and anti-bacterial, we even think there is a potential to use them in agriculture to prevent crops from being ruined by severe frost," Anand said. "But that is a pipe dream, and we need to do more studies to see if there will be any long-term adverse effect on the plants."

A worldwide patent application titled "Compositions and Methods for Inhibiting Ice Formation on Surfaces" has been filed by UIC's Office of Technology Management.

"There is great potential in these materials for many applications, and I think the day when commercial versions of our materials come out just got closer," Anand said.

Anand Research Group members Hassan Bararnia and Umesh Chaudhuri collaborated with Chatterjee on the experiments.

More information: Rukmava Chatterjee et al, A family of frost-resistant and icephobic coatings, *Advanced Materials* (2022). DOI: 10.1002/adma.202109930

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