Scientists develop long-lasting, anti-fogging coating for plastic surfaces that self-cleans

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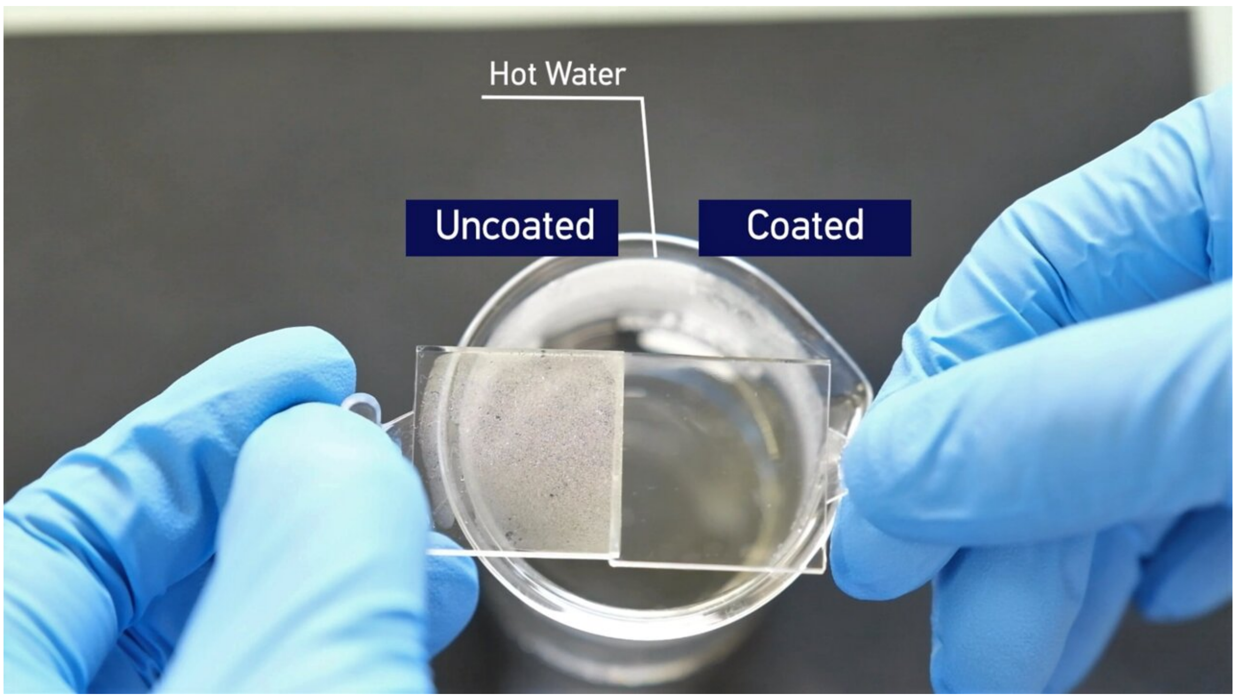

When exposed to steam from hot water, fogging is observed on the uncoated plastic substrate (left), while no water vapour condensation is seen on the coated sample (right). Credit: Nanyang Technological University

Scientists at Nanyang Technological University, Singapore (NTU Singapore) have developed a new type of coating that, when applied on a plastic surface, prevents fogging and "self-cleans," overcoming the need for frequent reapplications.

The durable coating of a thin double layered silicon dioxide—titanium dioxide film is applied through a two-step technique.

Firstly, the plastic surface is treated with oxygen plasma, which is a common industrial method to clean surfaces to improve adhesion. Then the thin double layered film is deposited on the plastic surface using pulse laser deposition—in which a laser beam is focused to vaporize material from the intended coating targets to achieve the desired level of thickness of the film.

The approach offers better control of the film's thickness and structure during fabrication, compared to similar industrial methods, and results in a higher quality film.

The coating showed excellent adherence to the plastic surface. When subjected to abrasion using a cheese cloth pad—a standard test for optical coating, and an adhesion test using cellophane tapes, the coating maintained good durability.

Fogging is observed when water vapor condenses as water droplets on a surface, and so the anti-fogging performance of coating is measured by the speed at which the condensed water droplets spread into a uniform film that does not block vision. In experiments on the new coating, digital fast frame imaging showed a water droplet spreading within 93 milliseconds, less than the duration of the average human eye blink of 100 milliseconds.

The findings by the NTU team were published in the peer-reviewed scientific journal *Applied Surface Science*, in December 2021.

Overcomes limitations of temporary anti-fogging coatings

Anti-fogging sprays and wipes are popular products among spectacle or eyeglass wearers, more so since the COVID-19 pandemic as mask wearing becomes the norm and wearers seek to prevent condensation obscuring their view.

Anti-fogging coatings are also used in solar panels, windshields and displays or lenses that are used in humid environments.

However, current solutions in the market, such as anti-fogging sprays and wipes are temporary as they cannot withstand washing and must be reapplied regularly. In addition, they are prone to surface contamination by dirt or bacteria, which means replacement or maintenance is necessary.

While researchers elsewhere have developed anti-fogging coatings for plastics, two of the biggest barriers to their widespread adoption are the long processing time for fabrication and poor durability—that is, weak adhesion between the plastic surface and the coating.

Co-principal investigator of the study, Professor Chen Zhong of the NTU School of Materials Science and Engineering (MSE) said, "Most anti-fogging solutions today are temporary and have limited efficacy. Our team has demonstrated an approach that is fast to fabricate, taking around an hour, and produces long-lasting results, proving its potential for wide-ranging practical applications."

As a result of the long-lasting anti-fogging and "self-cleaning" ability of the newly devised coating, the NTU research team believes their innovation offers an attractive, long-term solution to overcome issues of plastic fogging that may also reduce costs and waste.

Coating 'self-cleans' under sunlight exposure

Titanium dioxide—a chemical used in the coating developed by the NTU team, has photocatalytic ability, meaning it can "self-clean" by reacting with and removing organic residues under sunlight (ultraviolet light) exposure.

In lab tests, of its "self-cleaning" ability, the newly developed coating was able to break down contaminants (i.e., bacteria, dirt) on the plastic surface after a full day of ultraviolet light exposure.

Co-lead researcher, Professor Rajdeep Singh Rawat, Head, Natural Sciences & Science Education Academic Group at the National Institute of Education, NTU, said, "Our innovation is promising for use in industrial applications of various optical components, for example, on surveillance camera protective covers. The ability for the coating to 'self-clean' makes it a low-maintenance and trouble-free solution since the cover may be less obscured by surface dirt and grime, providing a clearer view for surveillance."

The newly developed coating is also anti-reflective with a superior visible light transmittance of up to 89% on a regular plastic lens, about 5% better than the same lens without a coating. This is particularly useful for use in eyeglasses, as higher visible light transmittance allows for more light to travel through the plastic and reach the eye, allowing greater clarity.

First author of the study Sun Ye, a Ph.D. student at the School of MSE, said, "The reported results prove the multifunctionality of our coating. It is antireflective, antifogging, and self-cleaning. Additionally, the fabrication approach is fast and easy to implement with great durability. This makes our innovation unique among other antifogging methods which tend to end up with coatings with limited functions."

More information: Ye Sun et al, Mechanically robust multifunctional

antifogging coating on transparent plastic substrates, *Applied Surface Science* (2021). DOI: 10.1016/j.apsusc.2021.152307

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