Research team develops anti-icing film that only requires sunlight

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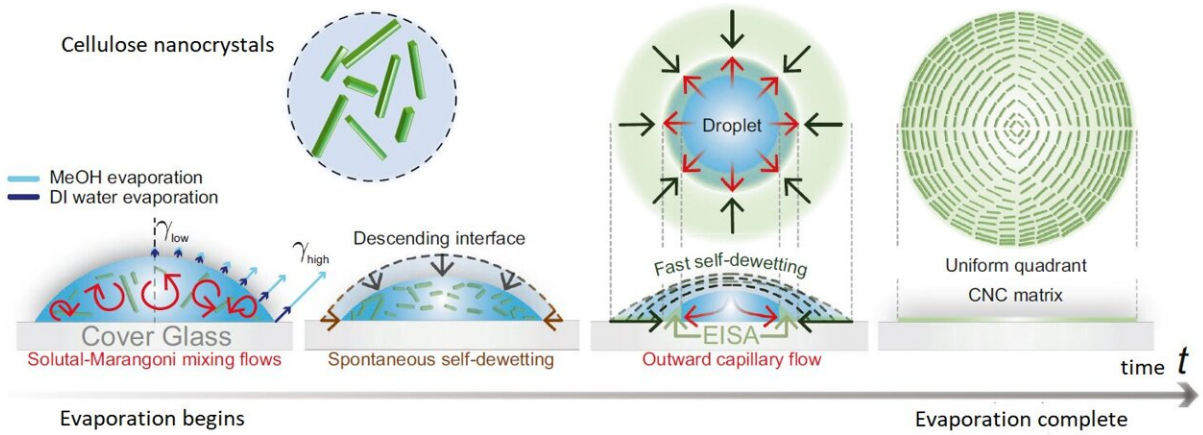


Conceptual image to display hydrodynamic mechanisms for the formation of a homogeneous quadrant cellulose nanocrystal (CNC) matrix. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-43511-9

A KAIST research team has developed an anti-icing and de-icing film coating technology that can apply the photothermal effect of gold nanoparticles to industrial sites without the need for heating wires, periodic spray or oil coating of anti-freeze substances, and substrate design alterations.

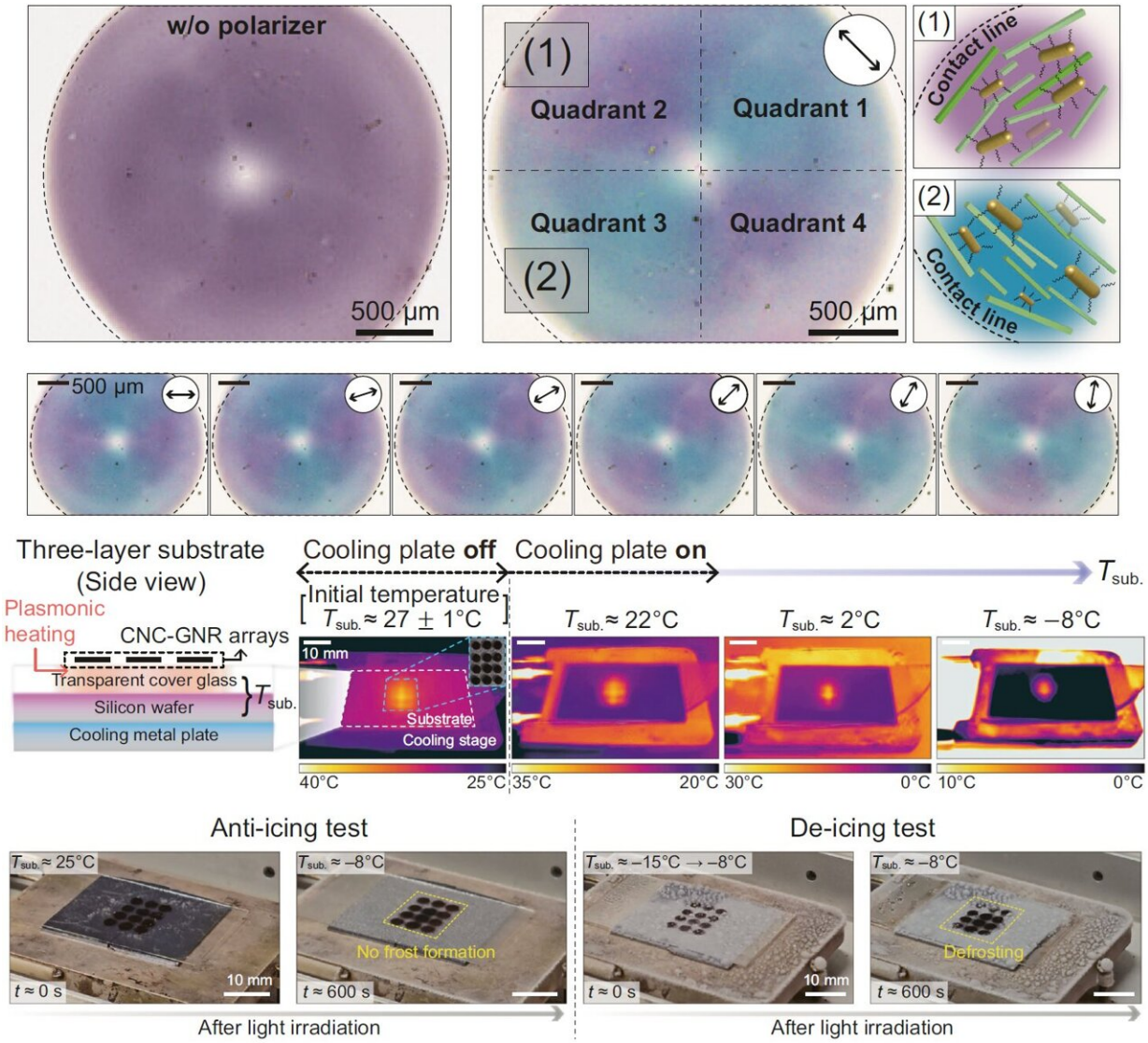
The group led by Professor Hyoungsoo Kim from the Department of Mechanical Engineering (Fluid & Interface Laboratory) and Professor Dong Ki Yoon from the Department of Chemistry (Soft Material

Assembly Group) revealed that they have developed an original technique that can uniformly pattern gold nanorod (GNR) particles in quadrants through simple evaporation and have used this to develop an anti-icing and de-icing surface.

The study is titled "Plasmonic Metasurfaces of Cellulose Nanocrystal Matrices with Quadrants of Aligned Gold Nanorods for Photothermal Anti-Icing" and is published in the journal *Nature Communications*.

Many scientists in recent years have tried to control substrate surfaces through various coating techniques, and those involving the patterning of functional nanomaterials have gained special attention. In particular, GNR is considered a promising candidate nanomaterial for its biocompatibility, chemical stability, relatively simple synthesis, and its stable and unique property of surface plasmon resonance.

To maximize the performance of GNR, it is important to achieve a high uniformity during film deposition, and a high level of rod alignment. However, achieving both criteria has thus far been a difficult challenge.



Optical and thermal performance evaluation results of gold nanorod film and demonstration of plasmonic heater for anti-icing and de-icing. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-43511-9

To solve this, the joint research team utilized cellulose nanocrystal (CNC), a next-generation functional nanomaterial that can easily be extracted from nature. By co-assembling GNR on CNC quadrant templates, the team could uniformly dry the film and successfully obtain

a GNR film with a uniform alignment in a ring-shape.

Compared to existing coffee-ring films, the highly uniform and aligned GNR film developed through this research showed enhanced plasmonic photothermal properties, and the team showed that it could carry out anti-icing and de-icing functions by simply irradiating light in the visible wavelength range.

Professor Kim said, "This technique can be applied to plastic, as well as flexible surfaces. By using it on exterior materials and films, it can generate its own heat energy, which would greatly save energy through voluntary thermal energy harvesting across various applications including cars, aircraft, and windows in residential or commercial spaces, where frosting becomes a serious issue in the winter."

Professor Yoon added, "This research is significant in that we can now freely pattern the CNC-GNR composite, which was previously difficult to create into films, over a large area. We can utilize this as an anti-icing material, and if we were to take advantage of the plasmonic properties of gold, we can also use it like stained-glass to decorate glass surfaces."

More information: Jeongsu Pyeon et al, Plasmonic metasurfaces of cellulose nanocrystal matrices with quadrants of aligned gold nanorods for photothermal anti-icing, *Nature Communications* (2023). DOI: 10.1038/s41467-023-43511-9

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