New method helps exfoliate hexagonal boron nitride nanosheets

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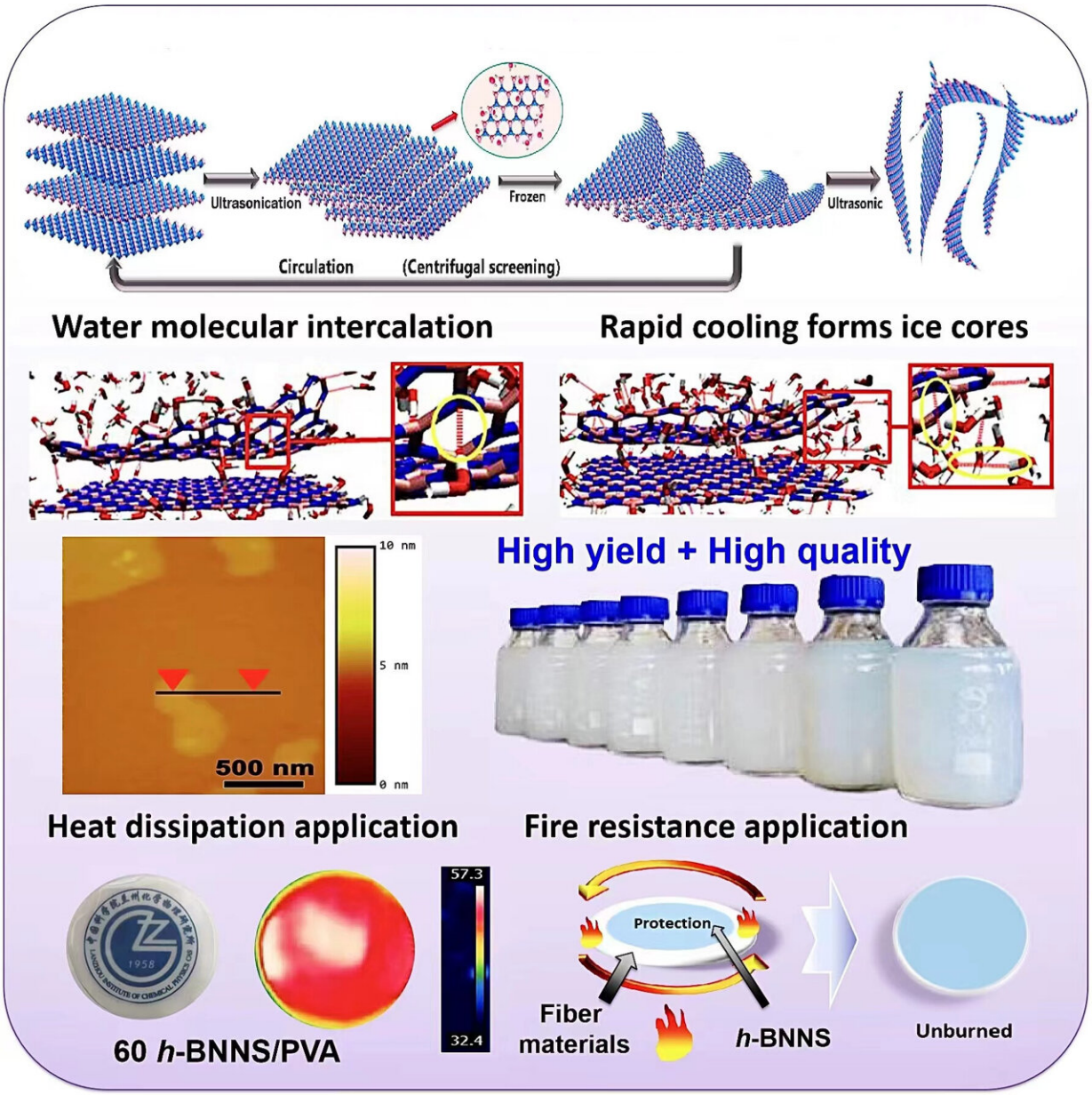

Freezing and ultrasonication assisted exfoliation. Credit: LICP

Chinese researchers recently reported an innovative mechanical process for controllably exfoliating hexagonal boron nitride nanosheets (h-BNNSs).This method, known as the "water-icing triggered exfoliation process," was proposed by Prof. Zhang Junyan's group from the Lanzhou Institute of Chemical Physics (LICP) of the Chinese Academy of Sciences (CAS).

h-BNNSs, with a honeycomb-like structure similar to graphene, show excellent chemical and physical properties, such as high thermal conductivity, good resistance to oxidation, remarkable mechanical strength, a low dielectric constant, outstanding lubricity, excellent biocompatibility, and optical properties.

Given these characteristics, h-BNNSs are promising materials for various applications, including high-performance electronic devices, dielectric substrates, thermal management, lubrication, sensors, catalysts, and sorbents. As a result, developing a simple, controllable, and scalable method to produce high-quality h-BNNSs for commercial applications is an urgent need.

In their new research, ZHANG and his team proposed a scalable and controllable approach to exfoliate high-quality h-BNNSs from h-BN flakes.

"This method relies on efficient reduction of h-BNNS interlayer interaction by rapid volume expansion of water in icing," said Zhang.

Generally, h-BNNSs can be prepared using a process of chemical vapor deposition (CVD) and physical exfoliation. CVD can produce wafer-

scale, single-crystal monolayer h-BNNSs while the physical exfoliation process can achieve scalable production of small-sized h-BNNSs.

Based on molecular dynamics simulations, the researchers suggested that -OH groups can cause local structural distortion in the defects/edges of h-BN flakes to form an "entrance" for water molecules coming into the h-BNNS interlayer. This in turn presents a sufficient number of relatively long-lived hydrogen bonds that can generate fairly compact initial nuclei for ice nucleation.

The initial nuclei then slowly change in shape and size until they reach a stage that allows rapid expansion as the temperature drops sharply. This results in an increase in interlayer spacing and reduction of interlayer forces between adjacent h-BNNS layers as well as efficient exfoliation of h-BNNSs during subsequent ultrasonication.

"By adjusting the parameters, this exfoliation process can be used to produce large quantities of different high-quality h-BNNSs," said Dr. An Lulu, first author of the study.

"This method offers an environmentally friendly method to exfoliate h-BNNSs with controllable thickness by a rapid water freezing and subsequent ultrasonication process. These as-obtained h-BNNSs can be used as polymer additives, thermal conductive fillers, and flame retardants," said Prof. Yu Yuanlie, corresponding author of the study.

This study was published in *Cell Reports Physical Science*.

More information: Lulu An et al, Water-icing-triggered scalable and controllable exfoliation of hexagonal boron nitride nanosheets, *Cell Reports Physical Science* (2022). DOI: 10.1016/j.xcrp.2022.100941