A little soap simplifies making 2D nanoflakes
Rice lab's experiments refine processing of hexagonal boron nitride

29.01.2021 - Just a little soap helps clean up the challenging process of preparing two-dimensional hexagonal boron nitride (hBN).

Rice University chemists have found a way to get the maximum amount of quality 2D hBN nanosheets from its natural bulk form by processing it with surfactant (aka soap) and water. The surfactant surrounds and stabilizes the microscopic flakes, preserving their properties.

Experiments by the lab of Rice chemist Angel Martí identified the "sweet spot" for making stable dispersions of hBN, which can be processed into very thin antibacterial films that handle temperatures up to 900 degrees Celsius (1,652 degrees Fahrenheit).

The work led by Martí, alumna Ashleigh Smith McWilliams and graduate student Cecilia Martínez-Jiménez is detailed in the American Chemical Society journal *ACS Applied Nano Materials*.

"Boron nitride materials are interesting, particularly because they are extremely resistant to heat," Martí said. "They are as light as graphene and carbon nanotubes, but you can put hBN in a flame and nothing happens to it."

He said bulk hBN is cheap and easy to obtain, but processing it into microscopic building blocks has been a challenge. "The first step is to be able to exfoliate and disperse them, but research on how to do that has been scattered," Martí said. "When we decided to set a benchmark, we found the processes that have been extremely useful for graphene and nanotubes don't work as well for boron nitride."

Sonicating bulk hBN in water successfully exfoliated the material and made it soluble. "That surprised us, because nanotubes or graphene just float on top," Martí said. "The hBN dispersed throughout, though they weren't particularly stable.

"It turned out the borders of boron nitride crystals are made of amine and nitric oxide groups and boric acid, and all of these groups are polar (with posi-
The researchers explained that the key to successful exfoliation lies in the careful selection of surfactants and the optimization of their concentration. They found that nine surfactants, when used in a specific proportion (1% by weight in water), could prevent 2D hBN from clumping, while ensuring that individual flakes were not cut during sonication. The experiments showed that PF88 produced the highest yield under 100-gravity centrifugation, while the highest-quality nanosheets came from ionic surfactants under 8,000 g centrifugation, with SDS and CTAC proving most stable.

DTAB, which stands for dodecyltrimethylammonium bromide, was particularly effective at balancing yield and quality under high centrifugation conditions. The researchers also demonstrated the ability to produce a transparent film from hBN nanosheets dispersed in SDS and water, showcasing their potential for further processing.

"We describe the steps you need to do to produce high-quality hBN flakes," Martí said. "All of the steps are important, and we were able to bring to light the consequences of each one."

Original publication:

Ashleigh D. Smith McWilliams et al.; "Understanding the Exfoliation and Dispersion of Hexagonal Boron Nitride Nanosheets by Surfactants: Implications for Antibacterial and Thermally Resistant Coatings"; ACS Appl. Nano Mater.; 2021