Rubbery carbon aerogels greatly expand applications

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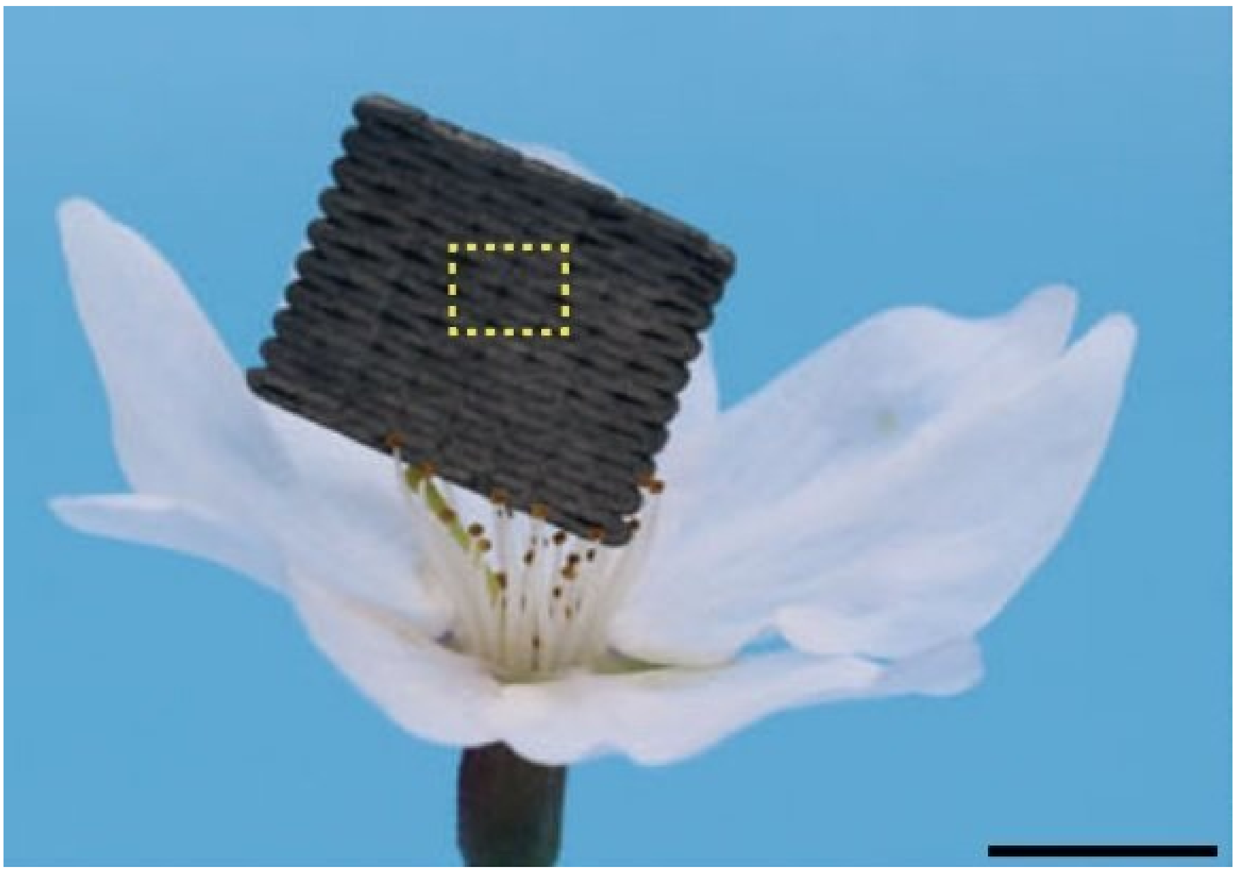

An ultralight stretchable carbon aerogel floats on a flower. Credit: Guo et al. Published in *Nature Communications*

Researchers have designed carbon aerogels that can be reversibly stretched to more than three times their original length, displaying elasticity similar to that of a rubber band. By adding reversible stretchability to aerogels' existing properties (which already include an ultralow density, light weight, high porosity, and high conductivity), the results may lead to a host of new applications of carbon aerogels.

The researchers, led by Chao Gao, Zhen Xu, and others at Zhejiang University, have published a paper on the highly stretchable carbon aerogels in a recent issue of *Nature Communications*.

"We showed the possibility that neat inorganic materials can also possess rubbery elasticity," coauthor Fan Guo at Zhejiang University told *Phys.org*. "The rubbery carbon aerogel opens a new material species that combines ultra-lightness, temperature-invariant high elasticity, and robust mechanical performance."

Due to the growing demand for stretchable electronics, researchers have recently been investigating methods to improve the elasticity of carbon aerogels, which typically are not very elastic.

In the new work, the scientists designed carbon aerogels consisting of both graphene (a two-dimensional material) and multi-walled carbon nanotubes (CNTs, a one-dimensional material), assembled into four orders of hierarchical structures ranging from the nanometer to centimeter scale. To fabricate the material into aerogels, the researchers created an ink composed of graphene oxide and nanotubes, and then formed the aerogels via inkjet printing.

In tests, the researchers demonstrated that the new aerogels exhibit a tensile strength that is 5 times higher than that of previous aerogels. They found that strong atomic bonding between the graphene and CNTs results in a synergistic effect, leading to greater stretching elasticity and stability. In addition, the new aerogels can withstand extreme temperatures, unlike most previous attempts at stretchable aerogels in which the aerogels become viscous or brittle when exposed to heat or cold.

To demonstrate one possible application, the researchers attached three of the new stretchable aerogels onto the joints of a snake-like robot. The aerogels function as sensors to monitor the robot's movements and configurations. Unlike conventional sensors that can detect only one-way deformation, the aerogel sensors can distinguish between multiple configurations, suggesting the possibility of a new generation of sensors with the ability for logic identification of sophisticated shape changes.

Other potential applications of the stretchable aerogels include wearable electronic devices, aerospace applications, energy generation and storage, as well as using them as lightweight mechanical devices, especially in extreme temperature conditions.

"This rubbery carbon aerogel opens many possibilities," Guo said. "First, the strength and Young's modulus [a measure of tensile elasticity] of carbon rubbers are lower than that of polymer elastomers. In general, the Young's modulus of polymer rubbers are 1-2 orders of magnitude higher than our carbon rubbers.

"Second, we are striving to make carbon aerogels more mechanically robust in order to bear extreme and complicated deformations, such as higher elongation and torsion. Meanwhile, more applications of this new carbon rubber can be explored and other types of inorganic rubbers can be achieved by means of this hierarchical synergistic assembly methodology."

More information: Fan Guo et al. "Highly stretchable carbon aerogels." *Nature Communications*. DOI: 10.1038/s41467-018-03268-y