Shape-shifting carbon fiber could replace mechanical systems for aerodynamics, robotics and more

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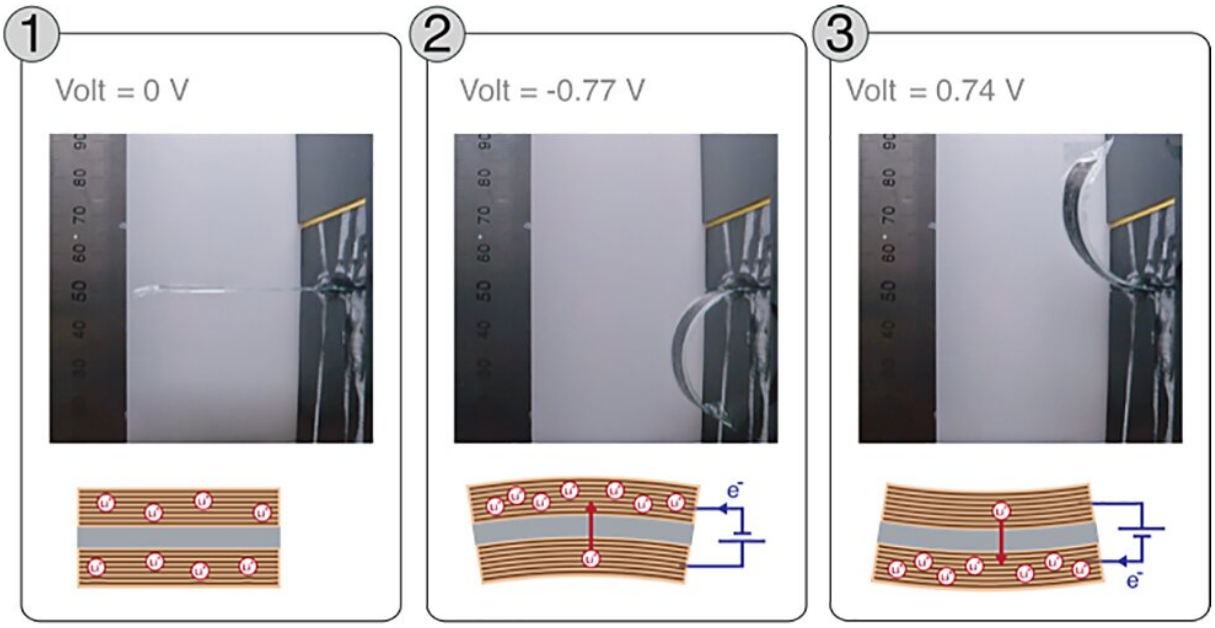

A new carbon fibre composite material which can be bent with electronic impulses was demonstrated in a recent proof-of-concept study. Credit: KTH The Royal Institute of Technology

Imagine wind turbine blades that change shape to achieve the most efficiency in varying wind speeds, or airplane wings that bend and alter their own form without hydraulic rudders and ailerons. These are two

potential uses for a carbon fiber material unveiled by researchers in Sweden.

Capable of changing form with the help of electronic impulses, the new solid state carbon fiber composite was demonstrated by researchers from KTH Royal Institute of Technology, in a proof-of-concept study published recently by *Proceedings of the National Academy of Sciences* (*PNAS*).

Co-author Dan Zenkert says the material exhibits all of the advantageous properties of a shape-morphing material—without the drawbacks that have prevented other development work from taking flight, such as weight and insufficient mechanical stiffness.

State-of-the-art morphing technologies, which can be used in robotics and satellite booms, rely on systems of heavy mechanical motors, hydraulic and pneumatic pumps, or solenoids to create shape changes, Zenkert says. These mechanically complicated systems add what is known as "parasitic weight" and are costly to maintain.

One way to reduce the mechanical complexity is to use solid-state morphing materials, he says.

"We have developed an entirely new concept," Zenkert says. "It's lightweight, stiffer than aluminum and the material changes shape using electric current." The material is capable of producing large deformations and holding them with no additional power, albeit at low rates, he says.

The composite consists of three layers—two of which are commercial carbon fiber doped with lithium-ions on each side of a thin separator. When the carbon fiber layers each have an equal distribution of ions, the material is straight. When electric current is applied the lithium ions

migrate from one side to the other causing the material to bend. Reversing the current enables the material to return to a state of equilibrium and regain its previous, unbent form.

"We have for some time worked with structural batteries, such as carbon fiber composites that also store energy like a lithium-ion battery," Zenkert says. "Now we have further developed the work. We expect it can lead to completely new concepts for materials that change shape only by electrical control, materials that are also light and rigid."

The researchers are now moving forward with lightweight and structural materials with even more functions and with the ultimate aim of resource efficiency and sustainability.

More information: Wilhelm Johannisson et al. Shape-morphing carbon fiber composite using electrochemical actuation, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.1921132117

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