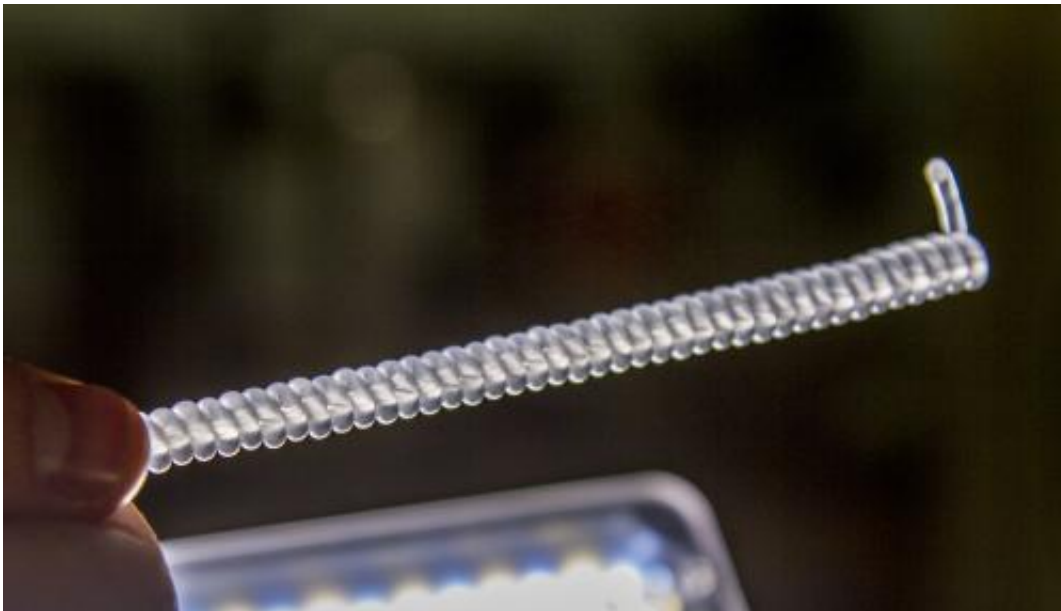


Researchers create powerful muscles from fishing line and sewing thread

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Researchers at the University of Texas at Dallas have created artificial muscles by twisting and coiling ordinary fishing line. Credit: University of Texas at Dallas

An international team led by The University of Texas at Dallas has discovered that ordinary fishing line and sewing thread can be cheaply converted to powerful artificial muscles.

The new muscles can lift a hundred times more weight and generate a hundred times higher mechanical power than the same length and weight

of human muscle. Per weight, they can generate 7.1 horsepower per kilogram, about the same mechanical power as a jet engine.

In a paper published Feb. 21 in the journal *Science*, researchers explain that the powerful muscles are produced by twisting and coiling high-strength polymer fishing line and sewing thread. Scientists at UT Dallas's Alan G. MacDiarmid NanoTech Institute teamed with scientists from universities in Australia, South Korea, Canada, Turkey and China to accomplish the advances.

The muscles are powered thermally by [temperature changes](#), which can be produced electrically, by the absorption of light or by the chemical reaction of fuels. Twisting the polymer fiber converts it to a torsional muscle that can spin a heavy rotor to more than 10,000 revolutions per minute. Subsequent additional twisting, so that the polymer fiber coils like a heavily twisted rubber band, produces a muscle that dramatically contracts along its length when heated, and returns to its initial length when cooled. If coiling is in a different twist direction than the initial polymer fiber twist, the muscles instead expand when heated.

Compared to natural muscles, which contract by only about 20 percent, these new muscles can contract by about 50 percent of their length. The muscle strokes also are reversible for millions of cycles as the muscles contract and expand under heavy mechanical loads.

"The application opportunities for these polymer muscles are vast," said corresponding author Dr. Ray Baughman, the Robert A. Welch Distinguished Chair in Chemistry at UT Dallas and director of the NanoTech Institute. "Today's most advanced humanoid robots, prosthetic limbs and wearable exoskeletons are limited by motors and hydraulic systems, whose size and weight restrict dexterity, force generation and work capability."

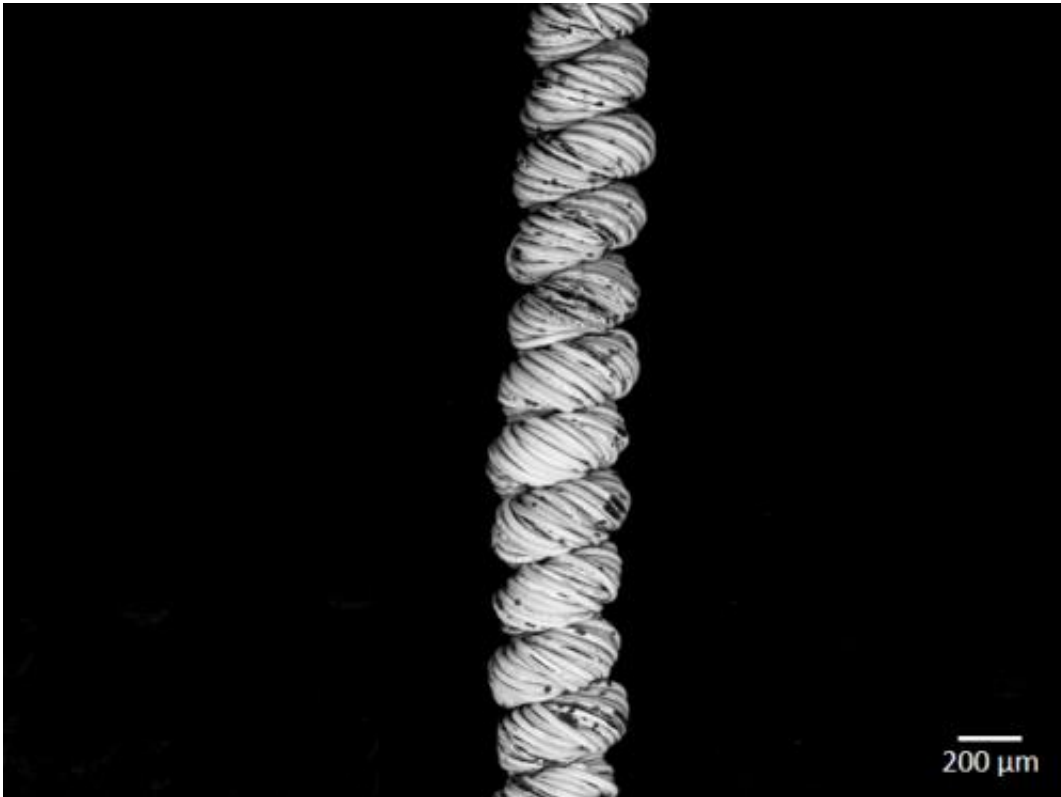


University of Texas at Dallas researchers and their international collaborators have made artificial muscles in a variety of sizes from ordinary polymer fishing line. Credit: University of Texas at Dallas

Baughman said the muscles could be used for applications where superhuman strengths are sought, such as robots and exoskeletons. Twisting together a bundle of polyethylene fishing lines, whose total diameter is only about 10 times larger than a human hair, produces a coiled polymer muscle that can lift 16 pounds. Operated in parallel,

similar to how natural muscles are configured, a hundred of these polymer muscles could lift about 0.8 tons, Baughman said.

On the opposite extreme, independently operated coiled polymer muscles having a diameter less than a human hair could bring life-like facial expressions to humanoid companion robots for the elderly and dexterous capabilities for minimally invasive robotic microsurgery. Also, they could power miniature "laboratories on a chip," as well as devices for communicating the sense of touch from sensors on a remote robotic hand to a human hand.



This is a scanning electron microscope image of metal coated nylon fibers used in design of the new artificial muscle. Credit: Seyed Mohammad Mirvakili

The polymer muscles are normally electrically powered by resistive heating using the metal coating on commercially available sewing thread or by using metal wires that are twisted together with the [muscle](#). For other applications, however, the muscles can be self-powered by environmental temperature changes, said Carter Haines, lead author of the study.

"We have woven textiles from the polymer muscles whose pores reversibly open and close with changes in temperature. This offers the future possibility of comfort-adjusting clothing," said Haines, who started his research career in Baughman's lab as a high school student doing summer research through the NanoExplorers program, which Baughman initiated. Haines earned an undergraduate physics degree from UT Dallas and is now a doctoral student in materials science and engineering.

The research team also has demonstrated the feasibility of using environmentally powered muscles to automatically open and close the windows of greenhouses or buildings in response to ambient temperature changes, thereby eliminating the need for electricity or noisy and costly motors.

More information: "Artificial Muscles from Fishing Line and Sewing Thread," by C.S. Haines et al. *Science*, 2014.

Provided by University of Texas at Dallas

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