Silk proteins paired with renewable wood nanocellulose to produce the strongest artificial spider silk yet

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A filament of hybrid silk showing cell growth. Credit: KTH The Royal Institute of Technology

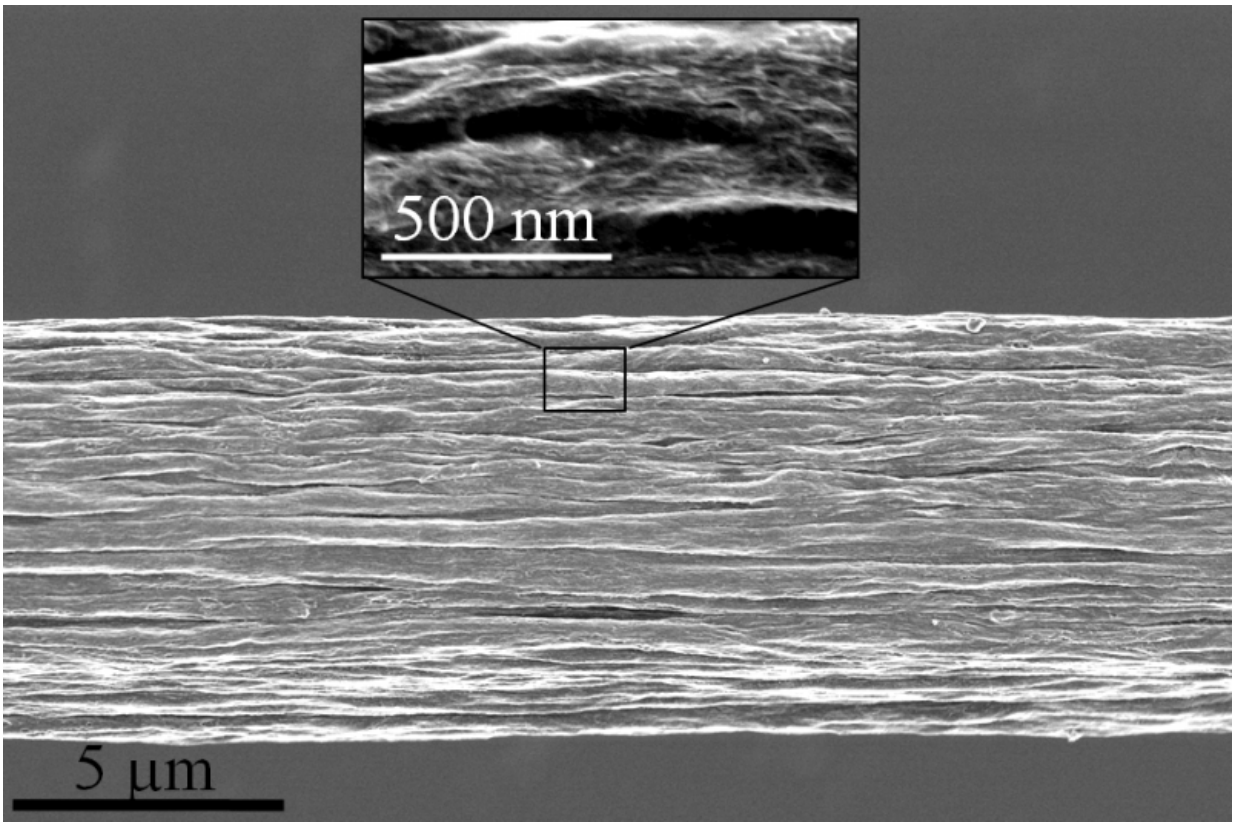
Possibly the strongest hybrid silk fibers to date have been created by scientists in Sweden using all-renewable resources. Combining spider silk proteins with nanocellulose from wood, the process offers a low-cost and scalable way to make bioactive materials for a wide range of medical uses.

Published in *ACS Nano* by researchers from KTH Royal Institute of Technology in Stockholm, the technique brings together the structural and mechanical performance of inexpensive cellulose nanofibrils with the medicinal properties of spider silk, which is difficult and expensive to fabricate on a large scale.

The bioactive properties of spider silk have been known for centuries. In ancient Rome, spider webs were used to dress soldiers' battle wounds. But producing large-scale amounts of spider silk material today is an expensive process that often relies on fossil-based sources.

KTH Researcher My Hedhammar says that by comparison, wood-based nanocellulose is cheap and sustainable. Furthermore, the technique of combining it with only small amounts of spider silk protein yields a biofunctional material that can be used for such medical purposes as promoting cell growth.

"The strength of the fiber is significantly better than any man-made, silk-based material to our knowledge, and on the same level as what can be found in nature from spiders," says Daniel Söderberg, a researcher with the Wallenberg Wood Science Center at KTH.



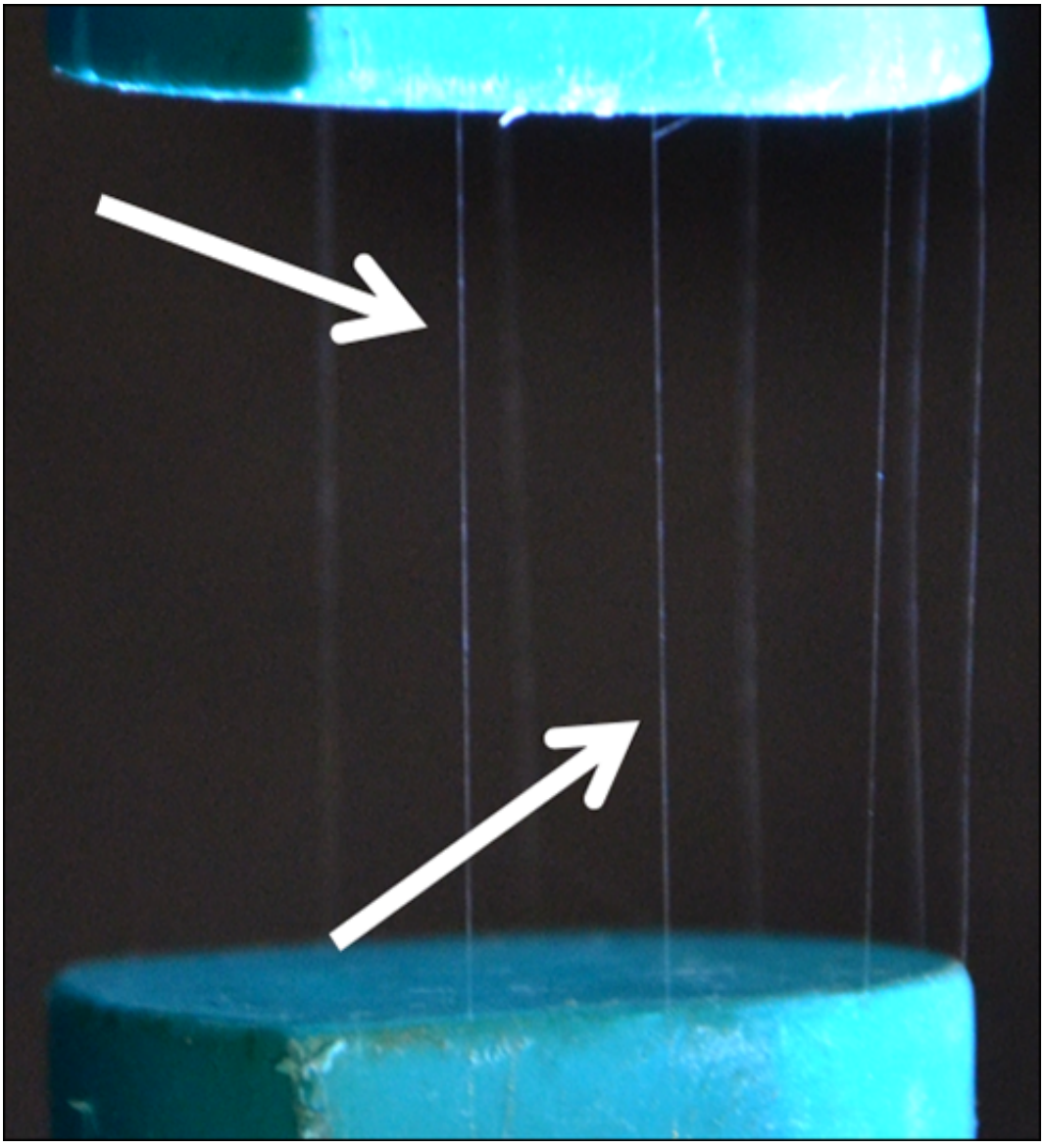
A close up of the fiber surface of the wood nanocellulose spider silk hybrid. Credit: KTH The Royal Institute of Technology

Today, cellulose nanofibrils obtained from trees receive scientific and commercial attention not only because they are renewable, biodegradable, virtually nontoxic and available in large volumes, but they also offer outstanding mechanical properties.

Söderberg says that the fabricated filament material could potentially be used as a building block for ligaments, for example.

To make the material, the researchers use what are known as recombinant silk proteins. Rather than using a spider as host, the researchers take the gene encoding the silk protein and combine it with a

gene encoding some desired function, such as cell-binding, Hedhammar says. "We transfer this fusion gene to a simple, easily-cultured lab bacteria, which then produces the functionalized silk proteins that can be purified in the lab," she says.



Filaments of hybrid spider silk with wood nanocellulose.

"Spider silk fusion proteins are then added to the dispersed cellulose nanofibrils, and thanks to the favorable interactions between the two components, a composite material can be produced."

Söderberg says the technique uses hydrodynamics to align the fibers' internal structure on the micro- and nano-scale. "When the nanocellulose is aligned in the macroscopic material, we can achieve high performance," he says.

More information: Nitesh Mittal et al. Ultrastrong and Bioactive Nanostructured Bio-Based Composites, *ACS Nano* (2017). DOI: 10.1021/acsnano.7b02305

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