

# Native-like spider silk produced in metabolically engineered bacterium

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Researchers have long envied spiders' ability to manufacture silk that is light-weighted while as strong and tough as steel or Kevlar. Indeed, finer than human hair, five times stronger by weight than steel, and three times tougher than the top quality man-made fiber Kevlar, spider dragline silk is an ideal material for numerous applications. Suggested industrial applications have ranged from parachute cords and protective clothing to composite materials in aircrafts. Also, many biomedical applications are envisioned due to its biocompatibility and biodegradability.

Unfortunately, natural dragline silk cannot be conveniently obtained by farming spiders because they are highly territorial and aggressive. To develop a more sustainable process, can scientists mass-produce artificial silk while maintaining the amazing properties of native silk? That is something Sang Yup Lee at the Korea Advanced Institute of Science and Technology (KAIST) in Daejeon, the Republic of Korea, and his collaborators, Professor Young Hwan Park at Seoul National University and Professor David Kaplan at Tufts University, wanted to figure out. Their method is very similar to what spiders essentially do: first, expression of recombinant [silk proteins](#); second, making the soluble silk proteins into water-insoluble fibers through spinning.

For the successful expression of high molecular weight [spider silk](#) protein, Professor Lee and his colleagues pieced together the silk gene from chemically synthesized oligonucleotides, and then inserted it into the expression host (in this case, an industrially safe [bacterium](#)

[Escherichia coli](#) which is normally found in our gut). Initially, the bacterium refused to the challenging task of producing high molecular weight spider silk protein due to the unique characteristics of the protein, such as extremely large size, repetitive nature of the protein structure, and biased abundance of a particular amino acid glycine. "To make *E. coli* synthesize this ultra high molecular weight (as big as 285 kilodalton) spider silk protein having highly repetitive amino acid sequence, we helped *E. coli* overcome the difficulties by systems metabolic engineering," says Sang Yup Lee, Distinguished Professor of KAIST, who led this project. His team boosted the pool of glycyl-tRNA, the major building block of spider silk protein synthesis. "We could obtain appreciable expression of the 285 kilodalton spider silk protein, which is the largest recombinant silk protein ever produced in *E. coli*. That was really incredible." says Dr. Xia.

But this was only step one. The KAIST team performed high-cell-density cultures for mass production of the recombinant spider silk protein. Then, the team developed a simple, easy to scale-up purification process for the recombinant spider silk protein. The purified spider silk protein could be spun into beautiful silk fiber. To study the mechanical properties of the artificial spider silk, the researchers determined tenacity, elongation, and Young's modulus, the three critical mechanical parameters that represent a fiber's strength, extensibility, and stiffness. Importantly, the artificial fiber displayed the tenacity, elongation, and Young's modulus of 508 MPa, 15%, and 21 GPa, respectively, which are comparable to those of the native spider silk.

"We have offered an overall platform for mass production of native-like spider dragline silk. This platform would enable us to have broader industrial and biomedical applications for spider silk. Moreover, many other silk-like biomaterials such as elastin, collagen, byssus, resilin, and other repetitive proteins have similar features to spider silk protein. Thus, our platform should also be useful for their efficient bio-based

production and applications," concludes Professor Lee.

**More information:** This work is published on July 26 in the Proceedings of the National Academy of Sciences (PNAS) online.

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