Non-Confidential

Technology Summary

Office of Society Academia Collaboration for Innovation
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KYOTO UNIVERSITY

Spider silk-based sustainable materials

Background

Spider silk, particularly dragline silk, has exceptional mechanical properties which make it an attractive source of natural fiber for different materials. Dragline silk is strong, tough, light, wettable, biodegradable and biocompatible. However, the adoption of spider dragline silk as a widely used natural material is hindered by its water sensitivity, i.e. embrittlement in dry environments, structure complexity, and unclear spinning mechanism of production. Attempts to produce synthetic spider silk are ongoing but large-scale manufacturing is still problematic. The present invention is a production method of artificial dragline silk using photosynthetic bacteria.

Technical Summary

➤ Desirable properties can be achieved

In order to produce spider silk-like fibers with desired characteristics, the inventors first performed a comprehensive analysis of spider silk genes and constructed a database of the physical, mechanical and biological properties of various spiders' silk, SILKome (Arakawa et al. 2022). Based on these data, they identified which sequences need to be altered/designed to produce more water resistant and biodegradable spider silk.

➤ More sustainable production method

Next, the inventors designed a system for sustainable synthesis of spider silk structural proteins using marine purple photosynthetic bacteria. To express the protein of interest, the researchers developed a method of high throughput bacteria transformation increasing the efficiency by 2 orders of magnitude (Miyamoto et al. 2022). This robust molecular tool of protein transduction can induce a unique cellular uptake mechanism for the efficient transport of bioactive proteins into bacteria.

Genetically modified yeast and bacteria fermentation is commonly used for producing spider silk. Unlike these processes, the use of photosynthetic bacterium doesn't require feeding therefore reducing the cost of spider silk protein synthesis. At Kyoto University a 4000L demo plant was built to streamline the process.

➤ Novel spinning method

The inventors also developed the first water-based spinning via LLPS process to draw spider silk fibers. By mimicking the native spinning process spiders use to make silk, the researchers managed to produce synthetic silk fibers structurally similar to the natural spider silk (Malay et al. 2020, Fig.1).

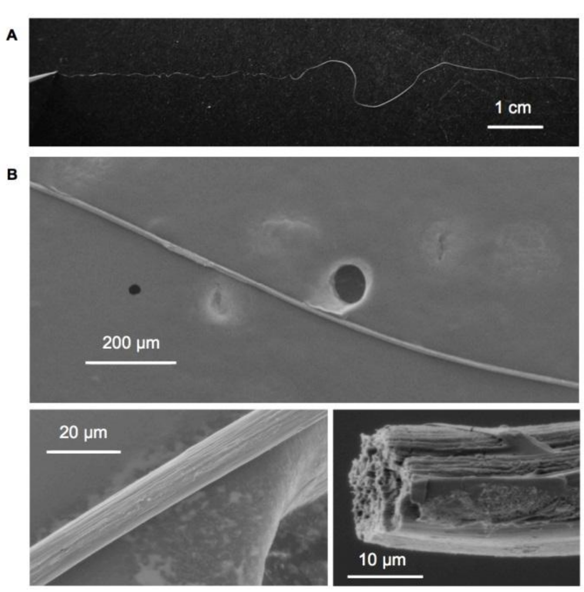

Figure 1. Morphology of biomimetic spider silk fibers. (A) A single fiber generated from 0.5 μl starting volume of MaSp2 protein, a primary component of spider silk. (B) SEM images showing morphology of fibers.

Technology Readiness Level
- 7

Potential Applications
- Clothing materials
- Plastic alternatives

Possible Collaboration Mode(s)
- R&D collaboration
- Licensing
- IP Acquisition
- Other

Patent No
WO2011006133

Publication(s)

Arakawa K, Kono N, Malay AD, Tateishi A, Ifuku N, Masunaga H *et al.* 1000 spider silkomes: Linking sequences to silk physical properties. *Sci Adv* 2022; **8**: eabo6043.

Miyamoto T, Toyooka K, Chuah J-A, Odahara M, Higchi-Takeuchi M, Goto Y *et al.* A Synthetic Multidomain Peptide That Drives a Macropinocytosis-Like Mechanism for Cytosolic Transport of Exogenous Proteins into Plants. *JACS Au* 2022; **2**: 223–233.

Malay AD, Suzuki T, Katashima T, Kono N, Arakawa K, Numata K. Spider silk self-assembly via modular liquid-liquid phase separation and nanofibrillation. *Sci Adv* 2020; **6**. doi:10.1126/sciadv.abb6030.

Symbiobe is a spin-off from Kyoto University which produces spider silk polymer and collaborates with Spiber, one of the leaders in spider silk production, as part of JST COI-Next program.

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