Genetic Engineering Fuses Spider Silk and Silica

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Bioengineers at Tufts University have created a new fusion protein that for the first time combines the toughness of spider silk with the intricate structure of silica. The resulting nanocomposite could be used in medical and industrial applications, such as growing bone tissue.

“This is a novel genetic engineering strategy to design and develop new ‘chimeric’ materials by combining two of nature’s most remarkable materials -- spider silk and diatom glassy skeletons – that normally are not found together,” said David L. Kaplan, professor and chair of biomedical engineering and director of Tufts’ Bioengineering and Biotechnology Center.

Kaplan, along with his Tufts graduate students and collaborators Carol C. Perry from Nottingham Trent University in England and Rajesh Naik from the Air Force Research Laboratory, released their findings in the paper “Novel Nanocomposites from Spider Silk-Silica Fusion (Chimeric) Proteins” published in the *Proceedings of the National Academy of Sciences*.

Silica provides structural support to diatoms (single-celled organisms known for their remarkable nanostructural details) while silk proteins from spiders and silkworms are more flexible, stronger and able to self-assemble into readily defined structures. The Tufts researchers were able to design and clone genetic fusions of the encoding genes for these two proteins, and then generate these genetically engineered proteins into nanocomposites at ambient temperatures using only water. In contrast, high temperatures and harsh conditions are typically required by geochemical and industrial synthesis of silica in the laboratory.

Another remarkable detail about the spider silk-silica composite is its size. While past tests using silica have formed silica particles with a diameter between 0.5 and 10 nanometers, the silk-glass composite has a diameter size distribution between 0.5 and 2 nanometers. The smaller, more uniform size will provide better control and more options for processing, which would be "important benefits for biomedical and specialty materials," according to the research.

Kaplan says this new chimeric protein could lead to a variety of biomedical materials that restore tissue structure and function, including bone repair and regeneration. Other likely applications involve more basic areas of materials science and engineering, including "green chemistry," which will prevent or reduce pollution.

The research was funded by the National Institutes of Health, the U.S. Air Force Office of Scientific Research and the European Commission.

Silk research spans a decade

Kaplan and his fellow researchers have been working on silks for more than a decade and have focused on these specific spider silk-silica chimeric proteins for about a year.

"We have worked on silks for a long time and we were designing new versions of silks using genetic engineering," said Kaplan. "Since the diatom and other mineral forming domains had recently been identified in the literature, the silk-silica combination seemed potentially important from a materials perspective."

In 2002, Kaplan and his team of researchers from Tufts' School of

Engineering and School of Medicine developed a tissue engineering strategy to repair one of the world's most common knee injuries -- ruptured anterior cruciate ligaments (ACL) -- by mechanically and biologically engineering new ones using silk scaffolding for cell growth. A year later, Kaplan and a postdoctoral fellow at Tufts discovered how spiders and silkworms are able to spin webs and cocoons made of silk and aspects of the spinning process to replicate it artificially.

Source: Tufts University