Behind the secrets of silk lie high-tech opportunities

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Tougher than a bullet-proof vest yet synonymous with beauty and luxury, silks spun by worms and spiders are a masterpiece of nature whose properties have yet to be fully replicated in the laboratory. But Tufts University biomedical engineers report that success in unraveling the secrets of silk is taking silk from the world of textiles to technology. This silk card shows diffractive optics entirely constituted by pure silk obtained by pouring silk solution on nanopatterned molds and letting the solution dry and crystallize. The resulting film retains the pattern and is a free-standing optical component so flexible it can be rolled up. Credit: Fiorenzo Omenetto/Tufts University

Tougher than a bullet-proof vest yet synonymous with beauty and luxury, silk fibers are a masterpiece of nature whose remarkable properties have yet to be fully replicated in the laboratory.

Thanks to their amazing mechanical properties as well as their looks, silk fibers have been important materials in textiles, medical sutures, and even armor for 5,000 years.

Silk spun by spiders and silk worms combines high strength and extensibility. This one-two punch is unmatched by synthetics, even though silk is made from a relatively simple protein processed from water.

But in recent years scientists have begun to unravel the secrets of silk.

In the July 30, 2010, issue of the journal *Science*, Tufts biomedical engineering researchers Fiorenzo Omenetto, Ph.D., and David Kaplan, Ph.D., report that "Silk-based materials have been transformed in just the past decade from the commodity textile world to a growing web of applications in more high technology directions."

Fundamental discoveries into how silk fibers are made have shown that chemistry, molecular biology and biophysics all play a role in the process. These discoveries have provided the basis for a new generation of applications for silk materials, from medical devices and drug delivery to electronics.

Edible Optics, Implantable Electronics

The *Science* paper notes that the development of silk hydrogels, films, fibers and sponges is making possible advances in photonics and optics, nanotechnology, electronics, adhesives and microfluidics, as well as engineering of bone and ligaments. Because silk fiber formation does not rely on complex or toxic chemistries, such materials are biologically and environmentally friendly, even able to integrate with living systems.

Down the silk road of the future, Kaplan and Omenetto believe applications could include degradable and flexible electronic displays for sensors that are biologically and environmentally compatible and implantable optical systems for diagnosis and treatment. Progress in "edible optics" and implantable electronics has already been demonstrated by Kaplan and Omenetto, John Rogers at the University of Illinois at Urbana-Champaign, and others.

Many challenges remain. Kaplan and Omenetto say that key questions include how to fully replicate native silk assembly in the lab, how best to mimic silk protein sequences via genetic engineering to scale-up materials production, and how to use silk as a model polymer to spur new synthetic polymer designs that mimic natural silk's green chemistry.

Techniques for reprocessing natural silk protein in the lab continue to advance. Silks are also being cloned and expressed in a variety of hosts, including E. coli bacteria, fungi, plants and mammals, and through transgenic silkworms.

One day, efficient transgenic plants could be used to crop silk in much the same way that cotton is harvested today, the Tufts researchers note in their paper. In some regions, silk production might create a new microeconomy, as demand grows and production techniques improve.

"Based on the recent and rapid progression of silk materials from the ancient textile use into a host of new high-technology applications, we anticipate growth in the use of silks in a wide platform of applications will continue as answers to these remaining questions are obtained," say Omenetto and Kaplan.

Provided by Tufts University