New artificial spider silk: stronger than steel and 98 percent water

By Emily Matchar, Smithsonian.com, adapted by Newsela staff on 08.09.17

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A spider works on its web as an early morning dew highlights the thin strands of silk. Photo from: Getty

The silk of the humble spider has some pretty impressive properties. It's one of the sturdiest materials found in nature, stronger than steel and tougher than Kevlar. It can be stretched several times its length before it breaks. For these reasons, replicating spider silk in the lab has been a bit of an obsession among materials scientists for decades.

Now, researchers at the University of Cambridge have created a new material that mimics spider silk's strength, stretchiness and energy-absorbing capacity. This material offers the possibility of improving on products from bike helmets to parachutes to bulletproof jackets to airplane wings. Perhaps its most impressive property? It's 98 percent water.

Copying Spider Silk

Darshil Shah is one of the researchers. He is an engineer at Cambridge's Centre for Natural Material Innovation. "Spiders are interesting models because they are able to produce these superb silk fibers at room temperature using water as a solvent," says Shah. Spiders evolved this process over hundreds of millions of years, Shah said. So far, humans have not been able to copy it.

The lab-made fibers are created from a material called a hydrogel. It is 98 percent water and 2 percent silica and cellulose. The latter two parts are held together by molecules called cucurbiturils that serve as "handcuffs." The silica and cellulose fibers can be pulled from the hydrogel. After 30 seconds or so, the water evaporates. Only the strong, stretchy thread is left behind.

The fibers are extremely strong — though not quite as strong as the strongest spider silks. Significantly, they can be made at room temperature without chemical solvents. This means that if they can be produced at scale, they have an advantage over other synthetic fibers, such as nylon. Synthetic fibers require extremely high temperatures for spinning. This makes textile

production one of the world's dirtiest industries. The artificial spider silk is also completely biodegradable. And since it's made from common, easily accessible materials — water, silica and cellulose — it has the potential to be affordable.

Future For Protective Fabrics

The material can absorb great amounts of energy. Researchers think it could potentially be used as a protective fabric.

"Spiders need that absorption capacity, because when a bird or a fly hits their web, it needs to be able to absorb that," Shah explains. If not, the web would break.

Thanks to this quality, the new material may eventually be used in bulletproof vests or other protective military clothing. "That would be an exciting application," Shah says.

Other potential applications include sail cloth, parachute fabric, hot air balloon material, and bike or skateboard helmets. The material is also biocompatible. This means it could be used inside the human body for things like stitches.

The fibers could also be modified in a number of interesting ways, Shah says. Replacing the cellulose with various polymers could turn the silk into an entirely different material. The basic method could be replicated to produce low-heat, no-chemical-solvents-needed versions of many fabrics. This could make the production of artificial fibers more environmentally friendly, Shah says.

Shah and his team are far from the only scientists to work on artificial spider silk. Silkworms can be farmed for their silk, but spiders cannot. They are cannibals who wouldn't tolerate the close quarters necessary for farming. So turning to the lab is the only way to get significant quantities of the material.

Scaling Up

Every few years brings headlines about new inroads in the process. A German team has modified E-coli bacteria to produce spider silk molecules. Scientists at Utah State University bred genetically modified "spider goats" to produce silk proteins in their milk. The U.S. Army is testing "dragon silk" produced via modified silkworms for use in bulletproof vests. Earlier this year, researchers at the Karolinska Institute in Sweden published a paper on a new method for using bacteria to produce spider silk proteins in a potentially sustainable, scalable way. And this spring, California-based startup Bolt Threads debuted bioengineered spider silk neckties at the SXSW festival. Their product is promising enough to have generated a partnership with the outdoor manufacturer Patagonia.

But mass-producing synthetic spider silk has proven difficult. An article published in Wired magazine in 2015 pointed this out. "So far, every group that's attempted to produce enough of the stuff to bring it to the mass market, from researchers to giant corporations, has pretty much failed," the article reports.

This is the challenge Shah and his team are facing right now.

"Currently we make around a few tens of milligrams of these materials and then pull fibers from them," he says. "But we want to try and do this at a much larger scale."

To do so, the team is working on a robotic device to pull and spin fibers more quickly and at a larger scale than previously. They've had some success, Shah says. The team will continue to explore the process.

"We're still in the early stages of research," he says.