IISER Mohali: Spider silk, a material for the future

Multifaceted: Spiders can make seven types of silk from different glands, each tuned to a special task | Photo Credit: K_R_DEEPAK

Spider silk is a biomaterial that has come to intrigue many in recent times. With five times the strength of steel of comparable weight, it offers immense possibilities for applications, however the difficulty in processing it and also welding it with other excellent materials were posing a challenge. Now, researchers at IISER Mohali have demonstrated how to overcome these challenges using a femtosecond laser pulse. They have succeeded in cutting and manipulating spider silk and making tiny objects of complex geometries such as braids and Mobius bands out of it. Their research is published in *Nature Materials.*

The early use of spider silk material was in microscopes, telescopes, guns and bomb-guiding systems as cross hairs in the optical elements. Since then, its extraordinary properties have been discovered. During spinning of the silk, amino acids arrange themselves as tiny nanocrystals embedded in a soft amorphous matrix of molecular nanosprings. While the amorphous regions provide elasticity, the nanocrystalline domains are optimized to provide great strength, explains Kamal P. Singh, School of Physical Sciences, IISER Mohali, who has carried out the research with Mehra S. Sidhu, a Post Doctoral Fellow at the department and first author of the paper.

“We collect spiders from gardens near Mohali and Chandigarh and grow them in large plastic boxes… to collect silk, we make the spider jump from a stick. It immediately suspends its body with a silk known as dragline silk. This is typically a few micrometer in diameter and is the strongest type of silk,” says Prof. Singh. Spiders can make seven types of silk from seven different glands. Each is tuned to perform a special task. For instance, capture silk is much more elastic with glue drops to trap the prey. The silk it makes to hold its babies can be softer, he explains in an email.

The researchers’ key innovation was that femtosecond (fs) laser pulses of duration about 10 fs can effectively process the silk fibre with minimal damage to its properties. They have also shown that these pulses can be used to weld the silk fibre with metals, glass and polymers to produce combinations that come in useful.

“The femtosecond pulses in our study were produced with commercial lasers. But we had to design our own experimental setup to target these pulses on the fine silk fibre precisely,” says Prof. Singh. A femto second is a millionth of a billionth of a second. “The mechanism of interaction of the silk with sub-10 femtosecond pulses was not known previously,” he adds.

The high strength and elasticity of the material makes many applications possible. They can be used, the researchers explain, in building radiation pressure meters. Radiation pressure can be felt when the momentum carried by photons is transferred to objects in its path. This is the operating principle of optical tweezers for instance. “With NASA trying to build tiny satellites and space vehicles that can be propelled in space by the pressure of sunlight (without burning fuel), it is important to develop sensors that can measure these tiny forces accurately,” says Prof. Singh.

A study of nearly 300 people living in different parts of India found that nine single-base variants (single-nucleotide polymorphisms or SNPs) account

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