Sticky Tape Inspired by Insect Feet

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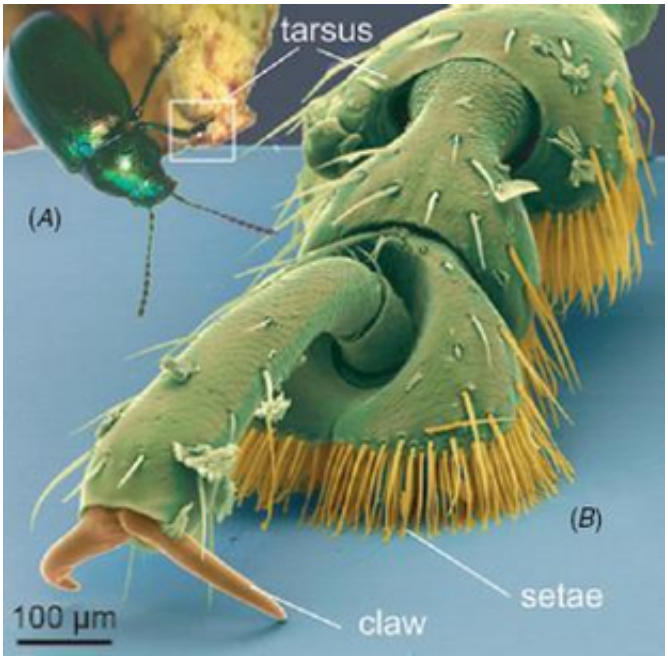

(A) Chrysomelid beetle with (B) a close-up of the tarsus with a hairy adhesive system (colored scanning electron microscope image). Credit: Stanislav Gorb, et al.

Scientists have designed an extremely sticky patterned adhesive, which is twice as sticky as flat tapes used for similar purposes. The new glue-free adhesive can also stick to dusty surfaces better, can be washed with soap and water, and can be reused multiple times.

The researchers call the material “insect tape” because its adhesive properties come from a pattern of microstructures that are inspired by

insect feet. The team, composed of evolutionary biomaterials researchers from the Max Planck Institute (MPI) in Stuttgart, Germany, and biologically inspired robotics researchers from Case Western Reserve in Cleveland, US, analyzed more than 300 different species of insects to determine the optimal properties for a man-made adhesive.

"This tape provides the highest stickiness among other tapes with reversible adhesion and remains sticky for the highest number of repetitions (several thousands of adhesion cycles)," co-author Stanislav Gorb of the MPI told *PhysOrg.com*. "After getting dirty, it can be washed with soapy water, and the initial stickiness will be recovered."

The way that insects walk on walls and ceilings has intrigued scientists since the 19th century (and likely well before). Today researchers know that many of the million known insect species have independently evolved two types of attachment structures: smooth pads (e.g. grasshoppers) and hairy surfaces (e.g. coleopterans, such as beetles).

The researchers focused on insects with hairy surfaces, which often consist of dense hairs and setae ranging in length from a few micrometers to several millimeters. The scientists found that a hierarchical design of hairs optimizes contact formation, and a high density of small structures can produce a larger contact area, resulting in better overall adhesion. The tape is resistant to dust contamination due to gaps in the microstructures where dust particles can sink, as well as the adaptability of the tape's contact surface. Further, mushroom-shaped tips, like those that appear on some insects' setae, enable the adhesive to adapt to uneven surfaces and irregularities, including cracks.

"The adhesive strength of insects, spiders, and geckos on smooth glass is in the range of 100 kPa [kilopascals, a measure of pressure]," Gorb said. "Our material demonstrates about 60 kPa. We are not that far from them."

Because of the fibers' flexibility, the tape can be used repeatedly. During pull-off, the elastic fibers elongate up to several micrometers to break the bond between the tape and substrate. After hundreds of cycles, the adhesion decreases; however, washing the tape with a soap solution and water enables the tape to completely recover its adhesive properties.

The researchers experimented with the insect tape on a glass-wall-climbing robot called Mini-Whegs™, which uses spokes with feet to climb over large obstacles. When the patterned surface of the insect tape was applied to its feet, the 120-gram (4.2-ounce), radio-controlled robot could successfully climb glass walls.

Besides robots, the tape could have applications in manipulating smooth surfaces such as optical lenses and CDs, as well as for adhering objects to or protecting sensitive glass surfaces. For further research, the scientists suggest that changing the shape of the surface contact features could optimize the tape for specific applications.

"It will be not as strong and as cheap as Scotch™ tape, but it will be reasonably cheap to use in everyday life," Gorb said. "We believe that the tape will not replace existing tapes but find its applications in certain technological niches. Right now, most of applications are coming from high-tech companies, such as robotics and optical technologies."

More information: Gorb, Stanislav N., Sinha, Mitali, Peressadko, Andrei, Daltorio, Kathryn A., and Quinn, Roger D. "Insects did it first: a micropatterned adhesive tape for robotic applications." *Bioinspiration & Biomimetics* 2, (2007) S117-S125.