# 'Shrilk': Inspired by insect cuticle, researchers develop low-cost material with exceptional strength and toughness

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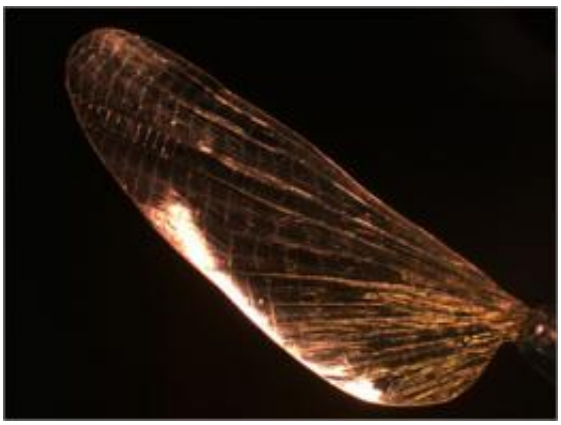

Shrilk is similar in strength and toughness to an aluminum alloy, but it is only half the weight. Shown here is a replica of a grasshopper wing, which was made with the new material.

(PhysOrg.com) -- Researchers at the Wyss Institute for Biologically Inspired Engineering at Harvard University have developed a new material that replicates the exceptional strength, toughness, and versatility of one of nature's more extraordinary substances—insect cuticle. Also low-cost, biodegradable, and biocompatible, the new material, called "Shrilk," could one day replace plastics in consumer products and be used safely in a variety of medical applications.

The research findings appear in the December 13 online edition of

*Advanced* Materials. The work was conducted by Wyss Institute postdoctoral fellow, Javier G. Fernandez, Ph.D., with Wyss Institute Founding Director Donald Ingber, M.D., Ph.D. Ingber is also the Judah Folkman Professor of Vascular Biology at Harvard Medical School and Children's Hospital Boston and is a Professor of Bioengineering at the Harvard School of Engineering and Applied Sciences.

Natural insect cuticle, such as that found in the rigid exoskeleton of a housefly or grasshopper, is uniquely suited to the challenge of providing protection without adding weight or bulk. As such, it can deflect external chemical and physical strains without damaging the insect's internal components, while providing structure for the insect's muscles and wings. It is so light that it doesn't inhibit flight and so thin that it allows flexibility. Also remarkable is its ability to vary its properties, from rigid along the insect's body segments and wings to elastic along its limb joints.

Insect cuticle is a composite material consisting of layers of chitin, a polysaccharide polymer, and protein organized in a laminar, plywood-like structure. Mechanical and chemical interactions between these materials provide the cuticle with its unique mechanical and chemical properties. By studying these complex interactions and recreating this unique chemistry and laminar design in the lab, Fernandez and Ingber were able to engineer a thin, clear film that has the same composition and structure as insect cuticle. The material is called Shrilk because it is composed of fibroin protein from silk and from chitin, which is commonly extracted from discarded shrimp shells.

Shrilk is similar in strength and toughness to an aluminum alloy, but it is only half the weight. It is biodegradable and can be produced at a very lost cost, since chitin is readily available as a shrimp waste product. It is also easily molded into complex shapes, such as tubes. By controlling the water content in the fabrication process, the researchers were even able

to reproduce the wide variations in stiffness, from elasticity to rigidity.

These attributes could have multiple applications. As a cheap, environmentally safe alternative to plastic, Shrilk could be used to make trash bags, packaging, and diapers that degrade quickly. As an exceptionally strong, biocompatible material, it could be used to suture wounds that bear high loads, such as in hernia repair, or as a scaffold for tissue regeneration.

"When we talk about the Wyss Institute's mission to create bioinspired materials and products, Shrilk is an example of what we have in mind," said Ingber. "It has the potential to be both a solution to some of today's most critical environmental problems and a stepping stone toward significant medical advances."

Provided by Harvard University