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From protein to planes and pigskin

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Scientists may soon be able to make pest insects buzz off for good or even turn them into models for new technologies, all thanks to a tiny finding with enormous potential.

Sujata Chaudhari, a Kansas State University doctoral candidate in biochemistry, Pune, India, is the senior author of a study that was published this week in the Proceedings of the National Academy of Sciences. Her work includes a discovery that could expand the possibilities for selective pest control and new biomaterials like football padding or lightweight aircraft components -- and all by debunking a more than 50-year-old belief about the protective shell of insects.

The study looks at the red flour beetle and examines the dynamic biochemical processes the insect uses to replace the protective coating on its skin while shedding its old skin. This coating is called the cuticle and is the main structural and protective part of an insect's exoskeleton, creating a stiff but lightweight outer shell or flexible wings and joints.

"As an insect develops, it outgrows its rigid skin and must periodically get rid of its old cuticle and synthesize a new, larger one," Chaudhari said. "This process of shedding the old cuticle is called molting."

In order to molt, the insect's body secretes a fluid loaded with an enzyme called chitinase, which is pronounced ky-tin-ayes. Chitinase breaks down chitin, the main component of the cuticle, and consequently aids in dissolving the insect's old cuticle. For decades it has been assumed that chitinase does not come into contact with and dissolve the insect's newly formed cuticle because of an impenetrable envelope between the old and new cuticles, Chaudhari said.

But Chaudhari and her colleagues found that's not actually the case.

Instead, their research shows that chitinase is present in the new cuticle as well as in the old cuticle. Moreover, they found that the enveloping layer that separates the two cuticles is not responsible for protecting the new cuticle from being dissolved by chitinase. Rather it is the protein called Knickkopf -- pronounced kuh-NICK-kaw-pff.

"Think of Knickkopf as a fire retardant, chitinase as a fire, and the insect's cuticle as the wall of a house," said Subbaratnam Muthukrishnan, a university distinguished professor of biochemistry at Kansas State University, Chaudhari's adviser and a collaborator on the study. "During molting, it's like the house is on fire, but the fire is only burning things on the outside. Everything inside is safe because there's a fire retardant wall."

Although this discovery that chitinase is stopped by a protein and not a physical barrier was made in the red flour beetle, Tribolium castaneum, the same protein is found in all other insect species examined, and probably has the same chitin-protective function, Chaudhari said. Most likely the same holds true for all arthropods: insects, arachnids, crustaceans, nematodes and other organisms. That's a game-changer for scientists and inventors.

In the future, agricultural crop pests like the red flour beetle could find themselves the targets of insecticides or interfering RNAs that shut down the Knickkopf protein, leaving the insect's body open to disease or to molting defects, said Richard Beeman, a Kansas State University entomology adjunct professor, researcher with the U.S. Department of Agriculture and collaborator on the project. Additionally, the beetle's cuticle could be replicated into new lightweight body armor, prosthetics or materials for flight.

"The cuticle is a gigantic puzzle, and we're slowly finding what the pieces are in the puzzle and how they interact to make the cuticle, organize it and digest it," said Karl Kramer, a Kansas State University emeritus biochemistry adjunct professor and collaborator with the USDA, who also worked on the project. "In solving the puzzle, we could target these composition materials for improved insect control. We could also develop biomaterial that could be used in agriculture or medicine -- or even make K-State football coach Bill Snyder some new protective padding for the Wildcats."

More information: "Knickkopf protein protects and organizes chitin in the newly synthesized insect exoskeleton," *Proceedings of the National Academy of Sciences*.

Provided by Kansas State University