Packaging insecticides in tiny capsules may make them more toxic

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Credit: Oregon State University

Encasing insecticides in microscopic plastic capsules – a common formulation for many pest sprays on the market – could lead to unintended consequences, according to a new study from Oregon State University.

Environmental toxicologist Stacey Harper and her team found that a common insecticide in its "capsule suspension" formulation – with molecules of the active ingredient encapsulated in tiny, inert plastic pellets – was more toxic than the same amount of active ingredient delivered straight up in water.

Their study is published in the journal *Nanomaterials*.

Harper, an associate professor in the College of Agricultural Sciences and the College of Engineering, and her doctoral student Matthew Slattery studied a commercial pyrethroid-type insecticide with an encapsulated active ingredient, gamma-cyhalothrin. The insecticide is primarily used in the home and garden for ants, bed bugs, ticks and other insects.

The capsules encasing the product's active ingredient range from micron-sized (a human hair is 40-75 microns thick), to nanometer-sized, a thousand times smaller.

"We want active ingredients to be relatively immobile, so they stay where they are applied," Slattery said. "This particular active ingredient is designed to be hydrophobic, so it won't be carried away with water. But if you encapsulate it, its hydrophobic nature is masked. The shell becomes a carrier device."

The researchers spun the off-the-shelf product in a centrifuge and sorted its capsules into two size classes. There was a wide range of sizes; most capsules were in the neighborhood of micron-sized, but some were nanometer-sized.

They exposed a species of water flea (Ceriodaphnia dubia) to five doses of the pesticide's active ingredient. One group got it in micron-sized capsules, and another group got the same dose in nanometer-sized capsules. As a control, a third group got the same dose of active ingredient, but it was not encapsulated.

The team found toxicity for the water fleas increased in the nanometer-sized capsules. The crustaceans were immobilized, leading to their death. The species lives in freshwater lakes, ponds and marshes and, due to its sensitivity to pollutants, is used in toxicity testing of waterways.

"These water fleas are filter feeders; they swim through the water and grab particles out of the water, normally bacteria and other food floating around," Slattery said. "In our study, it was the size of the particles that mattered. The nanometer-sized particles were in the 'Goldilocks zone' – large enough for the water flea to collect it but not so large so that it couldn't ingest it."

Chemical manufacturers have offered encapsulated formulations of pesticides for more than 50 years, Harper said, because encapsulation is thought to improve the product's dispersal and durability.

"We need to think about considering encapsulation as an ingredient because of how it alters how the active ingredient interacts with the environment," Harper said. "Currently, the only testing that's done after the final formulation are hazards like corrosivity and flammability. But not toxicity. What we've found is that encapsulation makes a difference in toxicity and that it is size-dependent."

Harper, also an environmental engineer, studies the environmental effects of human-made nanoparticles—microscopic bits of matter engineered to have commercially useful properties. Nanoparticles are widely used in pharmaceuticals, pesticides and personal care products, but little is known about their long-term environmental or health effects.

More information: Matthew Slattery et al. Pesticide Encapsulation at the Nanoscale Drives Changes to the Hydrophobic Partitioning and Toxicity of an Active Ingredient, *Nanomaterials* (2019). DOI: 10.3390/nano9010081

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