Scientists Made Tiny Diving Suits for Cyborg Cockroaches. They Can Breathe Underwater for 3 Hours

The insects walked underwater for hours, a step toward search-and-rescue swarms.

by Tibi Puiu — June 30, 2026 in News, Robotics AA

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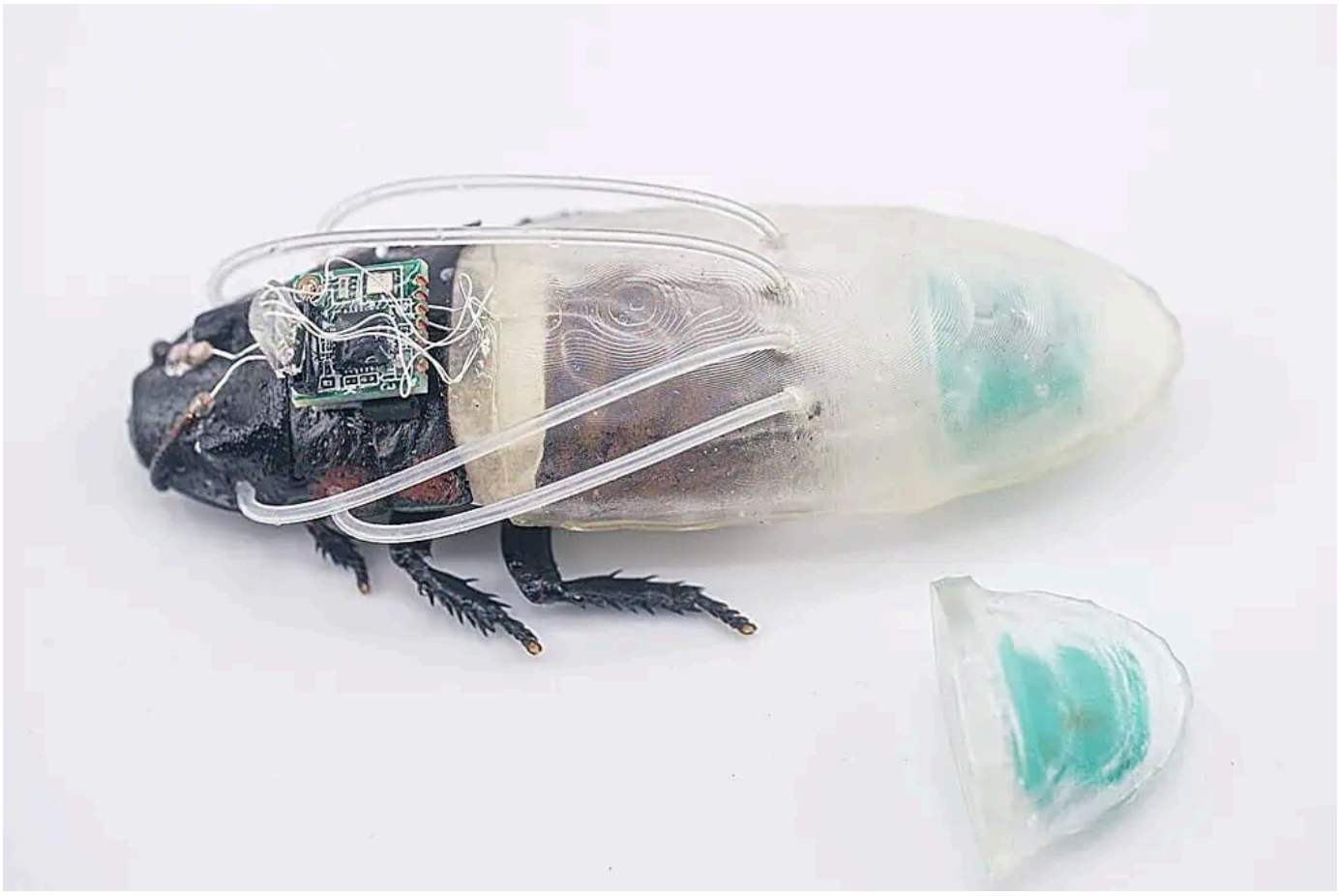

Close-up of the cyborg insect and the new diving suit, which has tubes that connect to the breathing holes of the insect and contains an oxygen generator at the back. Credit: Nanyang Technological University

A cyborg cockroach in a tiny diving suit sounds like a gag. In a Singapore lab, it just moved underwater for hours.

Researchers at Nanyang Technological University in Singapore and Waseda University in Japan have built a soft, wearable oxygen system that lets cyborg cockroaches survive and move through water and low-oxygen spaces. The attempt turns a land insect into something closer to an amphibious robot, one that could someday crawl through flooded rubble, drains or collapsed tunnels after disasters.

Cyborg insects are living insects fitted with small electronics that guide their movement, often controlled by a human operator. Engineers like them because insects already solve many problems that plague tiny robots: they walk efficiently, avoid obstacles and squeeze through cluttered spaces without heavy motors or large batteries.

“Our new insect diving suit works like the oxygen tank used by human divers. It generates oxygen and delivers it directly to the insect’s breathing holes, allowing the cyborg cockroach to survive and move in underwater or low-oxygen environments,” said Professor Hirotaka Sato of NTU Singapore.

A Scuba System for Spiracles

The suit has three main parts: a flexible waterproof shell, an oxygen generator and four soft tubes that deliver oxygen to the cockroach’s thoracic spiracles.

The oxygen comes from a simple chemical reaction. The researchers placed manganese dioxide on a small sponge inside a 3D-printed tank, then added diluted hydrogen peroxide. The manganese dioxide acts as a catalyst, breaking the hydrogen peroxide into water and oxygen. A membrane lets gas pass through but keeps liquid inside.

A miniature pressurized oxygen tank would be awkward and heavy. The chemical generator avoids that problem and does not need extra electronics.

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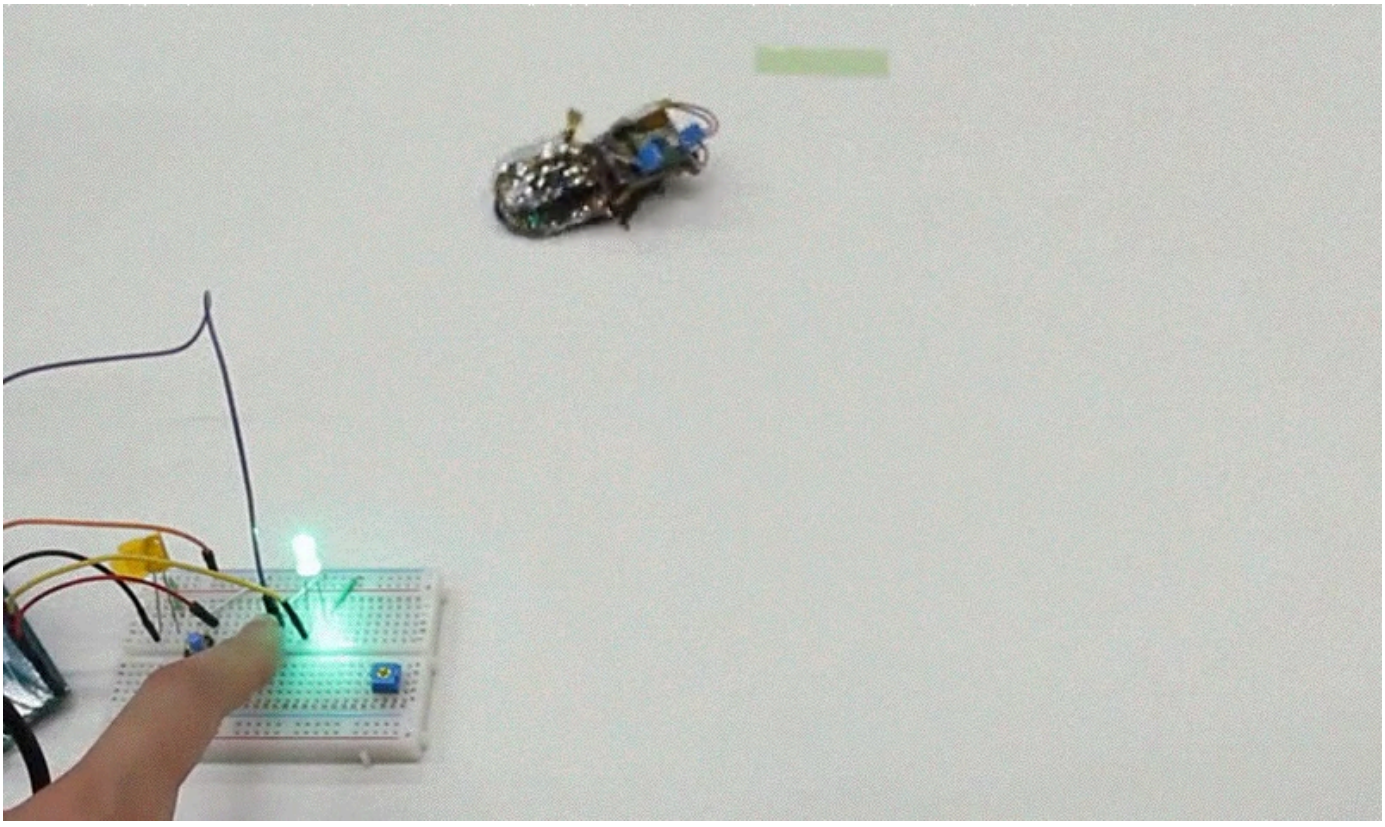

The direction of a cyborg cockroach can be controlled at the touch of a button. Credit: Y. Kakei

“The key engineering challenge was to build a system that was small, light and flexible enough for the insect to wear while still producing enough oxygen for long-duration underwater movement,” said Professor Shinjiro Umezu of Waseda University.

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The team tested their prototype on Madagascar hissing cockroaches, a favorite in cyborg-insect research because they are large, hardy and wingless. With the suit, the insects stayed active underwater for up to three hours. Without it, a control cockroach suffocated within minutes during experiments.

The insects proved resilient and even faster than in their natural habitat. Suit-wearing cyborg cockroaches moved at an average of 87.5 millimeters per second on land and 78.4 millimeters per second underwater. However, they were slower when turning, where water resistance punished the bulky suit.

Why Would Anyone Build This?

The most immediate practical application is for enhancing search-and-rescue robots. But small robots face an energy tradeoff. A robot small enough to enter rubble and slip through the cracks often cannot carry enough battery to work for long.

“There have been attempts to build very small robots, but the problem is batteries. With a very small robot, you typically don’t get very much battery life,” Alan Winfield of the University of the West of England told *New Scientist*. “People often used to say to me, what are the three big problems in mobile robots? And I’d say: energy, energy and energy.”

Using live cockroaches solves a lot of problems because you can use their own muscles and metabolism, which biology perfected for efficient energy use over millions of years of evolution. The electronics only steer them. Now imagine a swarm of hundreds or even thousands of these roaches dispersing in all directions across a disaster zone.

In one test, the researchers built a 1.7-meter tunnel with a carbon dioxide-filled section followed by a water-filled section. Unsuitable conditions quickly disabled cyborg cockroaches without the suit. Suit-wearing insects crossed both zones in three out of three trials.

The team also tested a 2-centimeter-high underwater crevice. To get through, the researchers used a more extreme configuration: they implanted the electronics and battery inside the insect’s body rather than mounting them as a backpack. That prevented snagging in tight gaps.

Still In Progress

Despite the promising results, the work remains far from real rescue deployment. Lab tunnels do not match unstable debris, toxic liquids, mud, sharp edges or chaotic water flow. Still, the study fits a broader trend in robotics: instead of copying biology from scratch, engineers increasingly borrow living systems and add machine control.

Sato is already looking beyond flooded rubble. “The ultimate goal is to [take this technology to] space,” he told *New Scientist*. “It’s kind of one step, one big step, towards space suits for cyborg insects. Exploration over the Mars surface, for example.”

That would cause its own problem: biological contamination. Space agencies work hard to avoid carrying Earth microbes to Mars. Sending cockroaches there would make that concern hard to ignore.

For now, the more immediate destination is closer to home and more practical: the dark, wet spaces where human rescuers and wheeled robots cannot go.

The findings were published in the journal *Nature Communications*.

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