Cyborg cockroaches in diving suits: Emergency services for flooded rubble

When rescue workers reach inaccessible locations, unconventional tools come into play. A new development from Asia now equips tiny helpers for extreme conditions, overcoming physical limitations in the process.

By **Dieter Petereit**

July 1, 2026, 7:39 PM • 3 min.

The Madagascar hissing cockroach used in the experiment reaches a considerable size. (Photo: Barbara Ash/Shutterstock)

A team of researchers from Nanyang Technological University in Singapore and Waseda University in Tokyo, Japan, has developed a flexible diving suit for cyborg insects. This technology allows Madagascan hissing cockroaches to survive underwater or in oxygen-depleted environments for up to three hours and to move around autonomously. As reported in a study published in the British scientific journal Nature Communications , the development is aimed at use in disaster areas.

In such scenarios, flooded debris, deep puddles, or narrow, partially submerged cavities often block access for conventional rescue robots. Cyborg insects—living animals with attached electronic controllers for movement control—offer a crucial advantage here because they use their own muscles for locomotion. This means they require far less power than purely artificial miniature robots, whose drive motors typically drain their integrated batteries completely after a short time.

Chemical oxygen tank instead of heavy electronics

The main problem with existing cyborg insects is their complete dependence on the natural respiratory system, which simply doesn't function underwater. Cockroaches breathe through tiny openings on their thorax and abdomen, called spiracles, which ensure oxygen exchange with the air. As soon as the animals submerge, they can no longer absorb oxygen from the water and suffocate within minutes.

To overcome this hurdle, the scientists constructed a compact, self-contained system that generates oxygen through a controlled chemical reaction. The diving suit consists of a 3D-printed oxygen generator, a waterproof casing, and flexible silicone tubes that deliver the gas directly to the spiracles. Additional electronic components for oxygen production were deliberately omitted to keep the weight down and avoid putting a strain on the already small batteries of the control unit.

Successful tests in the simulated disaster area

Inside the tank, printed from transparent plastic, is a sponge coated with manganese dioxide as a catalyst. The addition of a small amount of diluted hydrogen peroxide triggers a chemical reaction in which the peroxide slowly decomposes, releasing oxygen and a small amount of water. As EurekAlert reports in an accompanying article, the soft outer shell reliably protects the insects from the surrounding liquid. Lead researcher Hirotaka Sato explains that this innovation functions essentially like an oxygen tank for human divers, ensuring a direct supply of oxygen.

To demonstrate its effectiveness in practice, the research team sent the modified cockroaches through a 1.7-meter-long test tunnel that simulated various danger zones. First, the insects had to cross a section filled with carbon dioxide, followed immediately by a tube completely flooded with water. Cockroaches without the suit instantly lost their bearings in the gas mixture and suffocated in the water section within seconds. The cyborg insects equipped with the oxygen generator, however, mastered both sections with a steady gait.

Real limits when used in wet environments

Despite these obvious technological advancements, the underwater trials also reveal significant physical limitations that must be taken into account in real-world applications. Underwater, the forward speed of the modified cockroaches decreases by approximately ten percent compared to locomotion on land. The losses are considerably more pronounced when changing direction, as the new technical setups cause the animals to react and turn up to 51 percent more slowly to steering commands.

This slowdown is primarily due to the increased water resistance and the additional mass of the diving suit. Furthermore, the natural buoyancy forces the insects to constantly cling to the substrate with their tiny claws to avoid losing their balance or being swept away by currents. The mechanical effort required for this continuous grip contributes significantly to the animals' physiological fatigue and noticeably reduces their agility in the water over the course of the dive.

Another critical point in practice is the system's inherent time limitation, as the chemical reaction is completely exhausted after a maximum of three hours. Once the hydrogen peroxide is used up, the cockroach's oxygen supply inevitably cuts off. For lengthy search operations in extensive, confusing rubble fields or complex sewer systems, this absolute time limit must be factored into the planning to prevent the complete failure of these insect helpers.

In future development phases, the system will be equipped with additional sensors and miniature cameras to provide actual reconnaissance data from disaster areas. Furthermore, work is underway on structural adaptations for other terrestrial insect species with comparable respiratory systems. However, before cyborg cockroaches can routinely search for survivors during massive floods, significant technical hurdles regarding spatial navigation and the reliability of wireless data transmission from underwater must be overcome.