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SCIENCE

‘Diving suits’ enable cyborg roaches to survive up to three hours underwater

Such suits can enhance search-and-rescue efforts, be adapted to other cyborg insects

Zhaki Abdullah
Correspondent

Cyborg cockroaches manoeuvre through tiny spaces under rubble during search-and-rescue missions. Now, they may be used to search flooded or partially submerged spaces.

A flexible “diving suit”, developed by scientists from Nanyang Technological University (NTU) and Japan’s Waseda University, enables the insects to survive and move underwater, as well as in low-oxygen environments, for up to three hours.

Equipped with infrared cameras, sensors and electrodes, cyborg cockroaches can help to locate survivors in disaster-hit areas.

In March 2025, 10 such cockroaches were sent to assist with search-and-rescue efforts in Myanmar following a 7.7-magnitude earthquake that left more than 3,000 dead.

However, the use of these roaches is limited as the insects, which still rely on their natural respiratory system, are unable to take in oxygen when submerged.

To get around this, researchers developed a tiny suit comprising an oxygen-generation tank, a flexible shell and four silicone oxygen-supply tubes.

Diluted hydrogen peroxide is injected into the 3D-printed tank, which contains a sponge coated with manganese dioxide.

The resulting reaction between the hydrogen peroxide and the manganese dioxide releases oxygen, which is channelled through the flexible shell and silicone tubes to the cockroach’s spiracles – tiny openings on an insect’s body that connect to its respiratory system – allowing it to breathe underwater.

These tubes can be removed later without pain or harm, said the researchers, who noted that the insects were not harmed and were treated in line with research guidelines.

The suit was tested using the Madagascar hissing cockroach, which can grow to more than 7cm and live up to five years. The species is commonly used for cyborg insect research owing to its size, robustness and lack of wings.

The team’s findings were published in the peer-reviewed journal *Nature Communications* on June 29.

NTU’s Hirotaka Sato, who led the research, said: “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.”

This is important as heavy rain and flooding can block the roaches’ access to disaster areas, noted the professor at NTU’s School of Mechanical and Aerospace Engineering.

“By expanding the operating parameters of our cyborg insects to include underwater travel, we believe that they can enhance search-and-rescue efforts,” he said.

Another of the study’s authors, Shinjiro Umezaki, said: “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.”

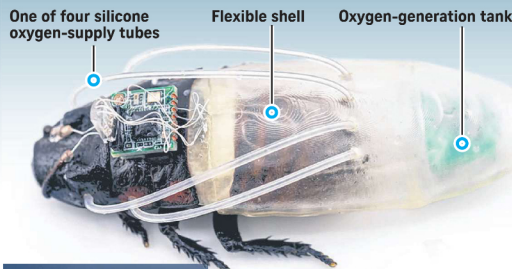
“Our approach combines a soft waterproof shell with a simple yet reliable chemical oxygen generator. This allows the insect to retain its natural mobility while being protected from an environment that it cannot normally survive in,” added the professor at Waseda University’s School of Creative Science and Engineering.

The researchers are testing the diving suit in simulated disaster environments.

Deep dive

A flexible “diving suit” for cyborg cockroaches that is developed by NTU and Japan’s Waseda University allows the insects to survive longer underwater during search-and-rescue operations.

KEY PARTS OF THE DIVING SUIT



HOW THE SUIT WORKS



1 Diluted hydrogen peroxide is added to a sponge coated with manganese dioxide in a 3D-printed tank, with the reaction producing oxygen.



2 A flexible shell covering part of the cockroach's body keeps water out and provides an enclosed cavity for oxygen supply.



3 Silicone tubes channel oxygen to the roach's spiracles – openings on an insect's thorax that connect to its respiratory system.



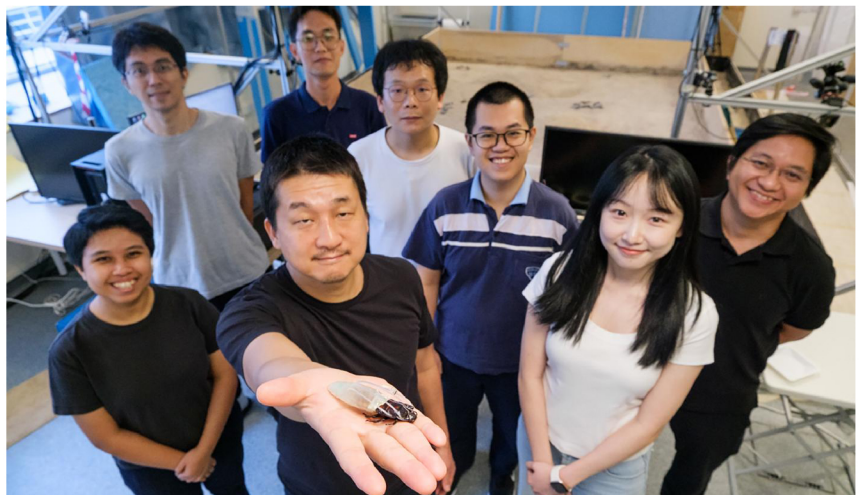
4 With oxygen supply, the cockroach is able to survive and move underwater as well as in low-oxygen environments.

3 hours

How long the diving suit allows cockroaches to survive underwater. Without it, the roaches would last only two minutes before becoming unresponsive.

(Below) Nanyang Technological University professor Hirotaka Sato (foreground, centre), who led the research to develop the flexible diving suit, holding a cyborg Madagascar hissing cockroach wearing the suit. PHOTO: NANYANG TECHNOLOGICAL UNIVERSITY

SOURCE AND PHOTOS: NANYANG TECHNOLOGICAL UNIVERSITY STRAITS TIMES GRAPHICS



They also hope to improve its durability and to integrate sensors and navigation systems.

Beyond search-and-rescue efforts, the suit could be used to allow the cyborg insects to inspect flooded pipes, tunnels and other

hard-to-reach places, they suggested. It could also potentially be adapted to other types of cyborg insects, the team added. These could include other cockroach species as well as locusts and beetles, which have similar body structures

and respiratory systems.

In March, it was reported that NTU was studying the use of cyborg cockroaches in checking utility pipes for corrosion and leakage.

azhaki@sph.com.sg