‘Diving suits’ developed to assist Singapore’s cyborg cockroaches in underwater search-and-rescue efforts

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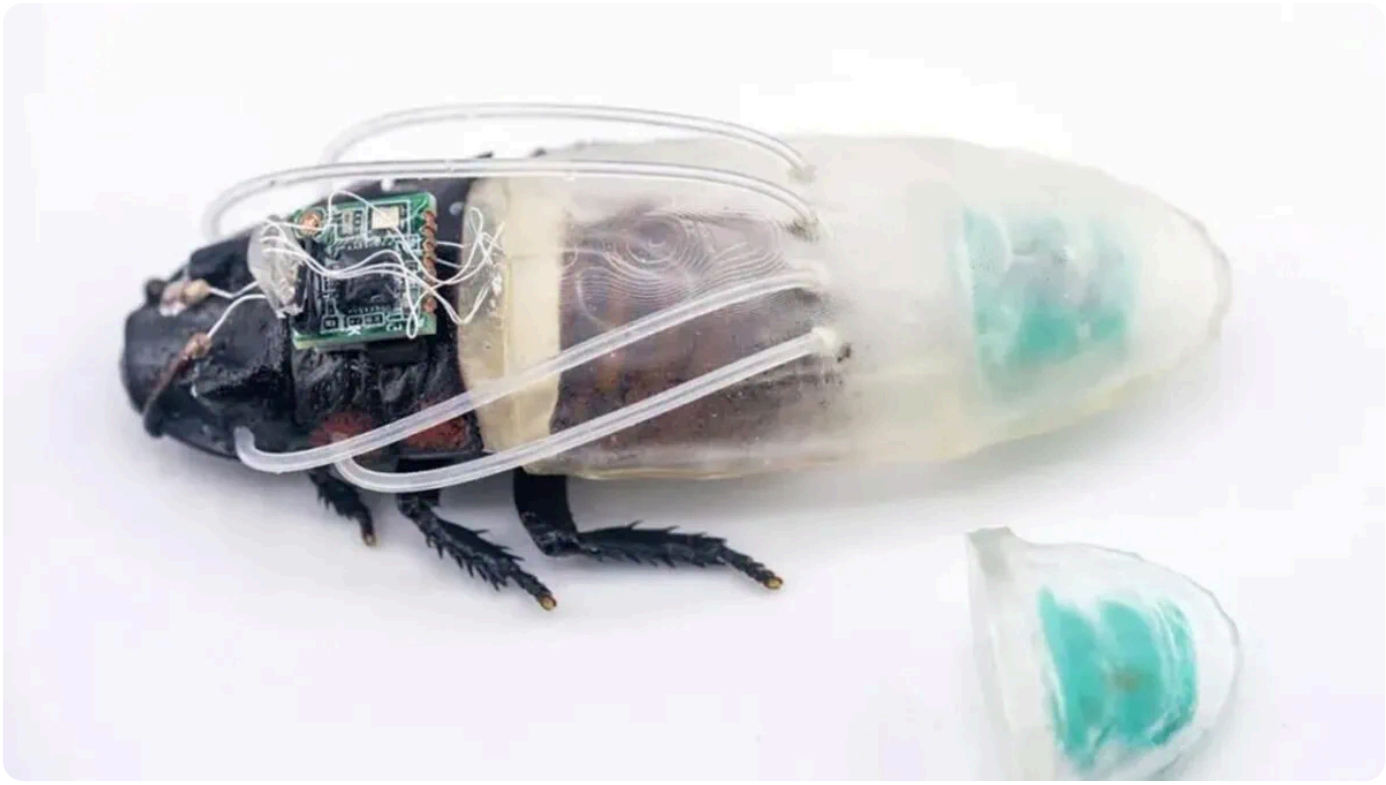

Equipped with infrared cameras, sensors and electrodes, cyborg cockroaches can help to locate survivors in disaster-hit areas. PHOTO: NANYANG TECHNOLOGICAL UNIVERSITY/THE STRAITS TIMES

SINGAPORE – 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 Wakeda 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 Umezu, 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.

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.