

NTU Singapore and Waseda University Develop Diving Suit for Cyborg Cockroaches

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Researchers at Nanyang Technological University (NTU) Singapore and Waseda University have developed a flexible diving suit that enables cyborg cockroaches to survive and move underwater and in low-oxygen environments for up to three hours, extending the operating range of insect-based robotic systems for potential search-and-rescue and infrastructure inspection applications.

The technology is described in a peer-reviewed study published in the journal *Nature Communications*. The researchers said the system could allow cyborg insects to operate in flooded rubble, drains, tunnels and other confined spaces that may be inaccessible to conventional robots following disasters.

Cyborg insects are living insects fitted with electronic controllers that guide their movement while relying on the insects’ own muscles for locomotion, reducing the power requirements associated with miniature robotic systems. However, the insects remain dependent on their natural respiratory systems and are unable to obtain oxygen when submerged because they breathe through spiracles connected to an internal tracheal network.

The newly developed diving suit addresses this limitation through a compact system consisting of an oxygen-generation tank, a flexible waterproof shell and four silicone tubes that deliver oxygen directly to the insect’s spiracles while preventing water from entering the respiratory system.

The oxygen-generation tank is produced using 3D-printed PMMA resin and contains a sponge coated with manganese dioxide, which acts as a catalyst. After diluted hydrogen peroxide is introduced and the tank is sealed, the chemical reaction generates oxygen that is channelled through the tubing to the insect’s breathing openings.

The researchers tested the system using Madagascar hissing cockroaches, a species commonly used in cyborg insect research because of its size, durability and lack of wings. In laboratory tests using plastic tubes designed to simulate flooded and low-oxygen environments, the insects remained active underwater for up to three hours while wearing the diving suit.

Professor Hirotaka Sato of NTU Singapore’s School of Mechanical and Aerospace Engineering, who led the research, said the system functions in a similar way to a scuba diver’s oxygen tank by supplying oxygen directly to the insect’s respiratory system, allowing operation in environments that would otherwise be inaccessible. He said expanding the insects’ capabilities to include underwater movement could improve their usefulness in search-and-rescue missions in flooded disaster areas.

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ool of Creative Science and Engineering said the engineering
mpact system capable of producing sufficient oxygen without
esign combines a soft waterproof shell with a chemical oxygen

a decade of cyborg insect research at NTU, where insect-based
nd air applications. According to the research team, the technology
operations and is also being developed for public infrastructure

mulated disaster environments, improving its durability and
deployment. The researchers also said the concept could
sects, including additional cockroach species, locusts and beetles,

The research was supported by Singapore’s Ministry of Education and Waseda University’s Top Global University
Project. The researchers said the insects were not harmed during the study and were handled in accordance with
research guidelines. A patent application related to the technology has been filed through NTUitive, NTU’s innovation
and enterprise company.

Photo credit NTU Singapore

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