Singapore Scientists Develop Tiny Robots for Targeted Drug Delivery

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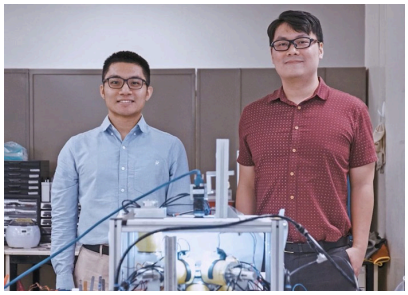
ROBOTICS, SECURITY, TECHNOLOGY



Scientists from Singapore's Nanyang Technological University (NTU) have developed grain-sized soft robots controlled by magnetic fields for targeted drug delivery, paving the way to possible improved therapies in future.

The new soft robot developed by engineers at NTU's School of Mechanical and Aerospace Engineering (MAE) was reported in a paper published in the scientific journal Advanced Materials. The study is believed to be the first reported instance of miniature robots that can transport up to four different drugs and release them in reprogrammable orders and doses.

Compared to earlier small-scale robots, which can only carry up to three types of drugs and cannot be programmed for release in order, the newly developed miniature robots offer precision functions that have the potential to significantly improve therapeutic outcomes while minimising side effects.

The NTU team had previously developed magnetically controlled miniature robots capable of complex manoeuvres such as swimming through tight spaces and gripping tiny objects. Building on their earlier work, MAE Lead Investigator Assistant Professor Lum Guo Zhan said the team was inspired by the 1960s film Fantastic Voyage, in which a submarine crew was shrunk to the size of a cell to repair damage in an injured scientist's brain.

"What was a scenario in a sci-fi movie is now becoming closer to reality with our lab's innovation," he said. "Traditional methods of drug delivery like oral administration and injections will seem comparatively inefficient when stacked up against sending a tiny robot through the body to deliver the drug exactly where it is needed."

The grain-sized robot was created using smart magnetic composite materials (magnetic microparticles and polymer) that are non-toxic to humans. Unlike existing miniature robots that cannot precisely control their orientations, the newly developed soft robot is highly dexterous – quickly rolling and crawling to negotiate obstacles. Its dexterity offers great potential for navigating complex, unstructured environments inside the human body.

In lab experiments, the robot accomplished tasks in water that mimicked conditions in the human body. The robot was first placed on a surface divided into four sections, and it succeeded in moving to each section at speeds of between 0.30 mm and 16.5 mm per second and releasing a different drug in each section, proving its ability to carry multiple drugs and to be programmable for their release in a controlled manner.

In another experiment, researchers tested the robot's ability to deliver drugs in more challenging environments by using a thicker liquid, and results showed that the robot could navigate the environment and release sufficient drugs over eight hours. Furthermore, after eight hours of continuous movement, the robot exhibited minimal drug leakage. This ability to control drug release without excessive leakage makes the soft robot a good candidate for treatments requiring the precise delivery of multiple drugs at different times and locations.

Co-authors of the study included Research Fellow Yang Zilin and PhD Graduate Xu Changyu. "These findings show that our soft robot could potentially play a key role in the future of targeted drug delivery, especially in those treatments such as cancer therapies that need precise control over multiple drugs," said Yang.

Dr Yeo Leong Litt Leonard, Senior Consultant and surgeon at the National University Hospital and Ng Teng Fong General Hospital, provided an independent view.

“As a doctor who performs minimally invasive procedures, we currently use a catheter and a wire to move through blood vessels to treat problems,” he said. “But I can foresee it will not be long before this is superseded by tiny robots that can autonomously swim through the body to reach places we can’t get to with our tools. These robots could stay in place and release medication over time, which would be much safer than leaving a catheter or stent inside the body for a long time. This is a medical breakthrough on the verge of happening.”

The NTU research team is now looking to make their robots even smaller so that they could eventually be used to provide revolutionary treatments for conditions such as brain tumours, bladder cancer, and colorectal cancer. Before these tiny robots are deployed for such medical treatments, the NTU researchers aim to further evaluate their performance with organ-on-chip devices and animal models.