NEW ATLAS

MEDICAL INNOVATIONS

Grain-sized soft robot delivers multiple medications, guided by magnetic fields

By Bronwyn Thompson
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The NTU soft robot, which is the size of a grain of rice, is the first to demonstrate it can deliver multiple drugs to different regions, showing its huge potential for use in personalized therapeutics
NTU Singapore

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If you're ever faced with trying to pick up a grain of rice with a pair of chopsticks, spare a thought for the scientists behind this latest innovation, which has been called "a medical breakthrough on the verge of happening." They've painstakingly built a soft robot with the capacity to carry different types of drugs through the body. It's the size of a grain of rice, and can be driven to various internal targets via magnetic fields.

Researchers in the School of Mechanical and Aerospace Engineering (MAE) at Nanyang Technological University, Singapore (NTU Singapore), have built on earlier work to create a grain-sized soft robot that can enter the body and be controlled by magnetic fields to travel to a specific target. Once there, it can quickly or slowly release the medication it has stored in its tiny frame.

Delivering #medical drugs into the human body with a robot the size of a rice gr...

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While this kind of small-scale biotechnology is not novel, the fact it has four compartments that can carry and release different medications is.

"In this work, we have proposed a millimeter-scale soft robot, which can be actuated by alternating magnetic fields to dispense four types of drugs with reprogrammable drug-dispensing sequence and dosage," MAE lead investigator, Assistant Professor Lum Guo Zhan, told New Atlas. "This drug-dispensing functionality is unprecedented for small-scale robots because the majority of such existing robots can at most transport one type of drug. While there exist rare miniature robots that can carry multiple drugs, such robots are unable to change their drug-dispensing sequence and dosage. These robots can't transport more than three types of drugs, selectively dispense their drugs, maintain their mobility, or release their drugs at multiple sites.

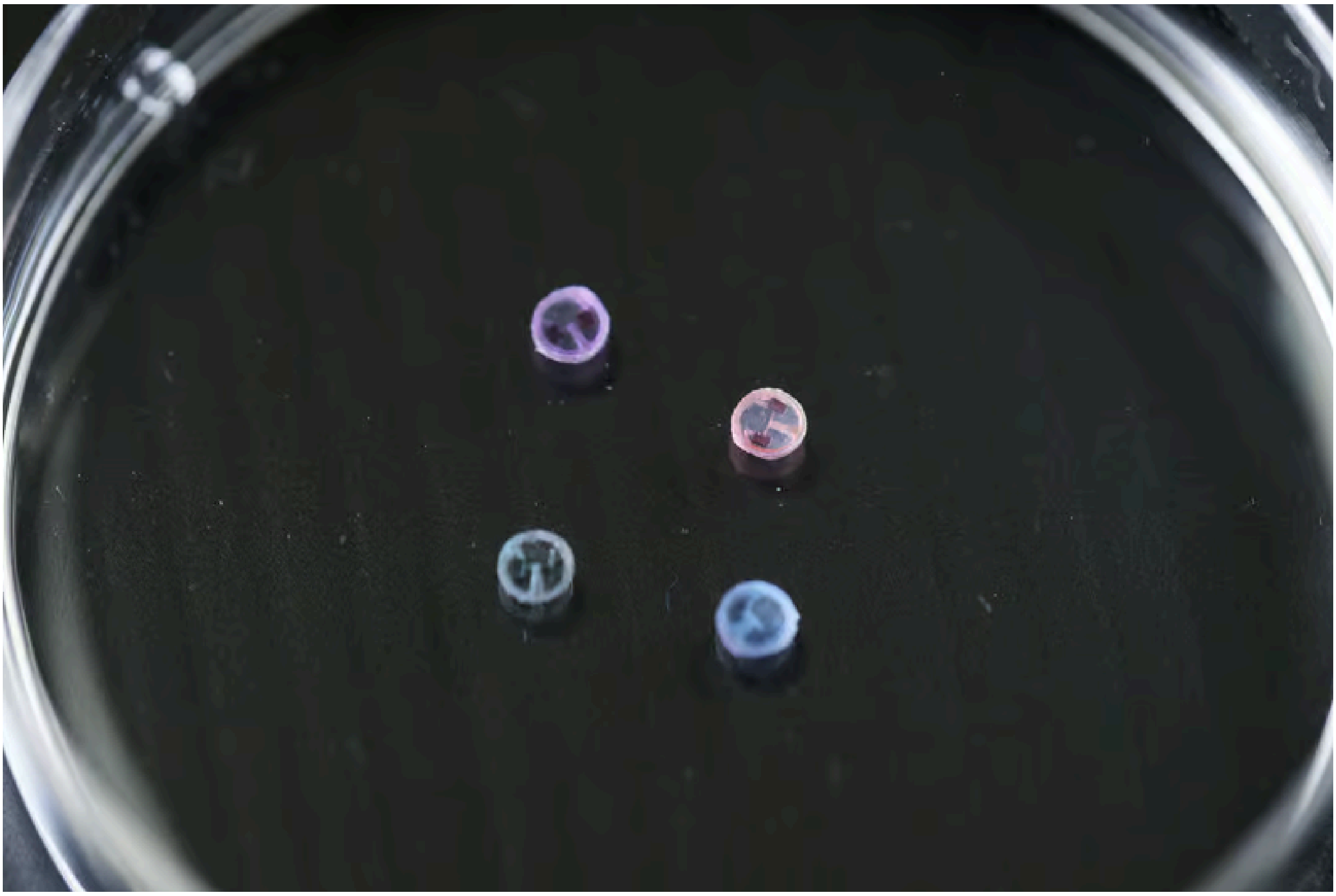
"In comparison, our soft robot has great potential to enable advanced targeted combination therapy, where four types of drugs must be delivered to various disease sites, each with a specific sequence and dosage of drugs."

NTU Assistant Professor Lum Guo Zhan and co-author Yang Zilin controlling the miniature robots using magnetic fields NTU Singapore

If this sounds somewhat like a sci-fi plot, you'd be right – the team was initially inspired by the 1966 film *Fantastic Voyage*, and we highly recommend watching the trailer here.

“What was a scenario in a sci-fi movie is now becoming closer to reality with our lab’s innovation," said Lum. "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."

Previously, the team had created a small robot that could 'swim' through openings and hold onto small objects, also controlled by magnets. But the new development, featuring a tiny bot made out of magnetic microparticles and polymer, is a huge step forward in biocompatible personalized and targeted drug delivery.



The grain-sized robot was created using smart magnetic composite materials that are non-toxic to humans and can transport up to four different drugs NTU Singapore

This tiny robot is the first of its kind to show both biocompatibility and efficacy in the controlled release of various medications at different sites. This has the potential to be a game-changing way to deliver therapeutics.

“As a doctor who performs minimally invasive procedures, we currently use a catheter and a wire to move through blood vessels to treat problems," said Dr. Yeo Leong Litt Leonard, a surgeon at the Division of Neurology, Department of Medicine, at the National University Hospital and Ng Teng Fong General Hospital, who was not involved in the research. "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."

Lum, who has been working on small-scale robots for 11 years, also believes that this new technology has the potential to change the face of invasive medical procedures and provide more targeted and effective treatment.

The robot, yet to undergo clinical testing, has so far demonstrated it can navigate through various liquid viscosity that mimics the environment it would face in a human body. In lab tests, it was able to navigate to four different regions, at a speed of between 0.30 mm and 16.5 mm per second, to release a specific drug at each spot. What's more, the engineers were able to manipulate the device to slowly release a drug over eight hours, and they believe the robot has the potential to offer both immediate and sustained medication delivery, tailored to the patient's needs.

"The roadmap towards realizing this goal is to first evaluate the performance of robots further with organ-on-chip devices and eventually conduct animal trials," Lum added. "We can perhaps complete this stage of research within the next two to five years' time."

The NTU research team is now looking at developing even smaller soft robots, which could be used to cross the blood-brain barrier for tumors and also treat bladder and colorectal cancers. And once the device has done its job, it can be safely removed from the body – by simply steering it back the way it entered.

"We aim to let our robot reverse its trajectory and exit through its entry point after it has performed the required treatments," Lum explained. "Since our small-scale robot can exploit its size to non-invasively access the human body via natural openings or via pinholes, they will be able to exit via these openings too."

"In these experiments, we showed that 98.791-99.633% of the anonymous human dermal fibroblast cells (ATCC) remained viable after they have interacted with the smart magnetic composites of our robot," he added. "Since these viability rates are higher than 98% and they are similar to the viability rate of a control group which is evaluated to be 99.688%, such results suggest that our smart magnetic composites do not cause observable cell damage or death, and they are indeed very biocompatible."

And, we had to ask: Does working on this sort of scientific research require both patience and steady hands? As expected, the answer is a resounding yes.

"Indeed, we require very steady hands when we construct and test these robots," Lum said. "As these robots are very small, we also use microscopes and high-resolution cameras to observe them during the experiments. Nonetheless, the thought that these robots have the potential to eventually transform a wide range of treatments in the future, strongly motivates me and my team to push the boundary of this technology."

The study was published in the journal *Advanced Materials*.

Source: Nanyang Technological University, Singapore

Bronwyn Thompson

Bronwyn has always loved words and animals, and she has the journalism and zoology degrees to prove it. After more than 20 years as a writer and editor, the former music journalist went back to university to build on her passion for wildlife and conservation with a Bachelor of Zoology, which unlocked two new loves: sharing animal facts at any opportunity and getting others excited about science. Particularly interested in neuroscience, genetics, animal behavior and evolutionary biology, Bronwyn has found a happy home at New Atlas, coming on board in February 2023.