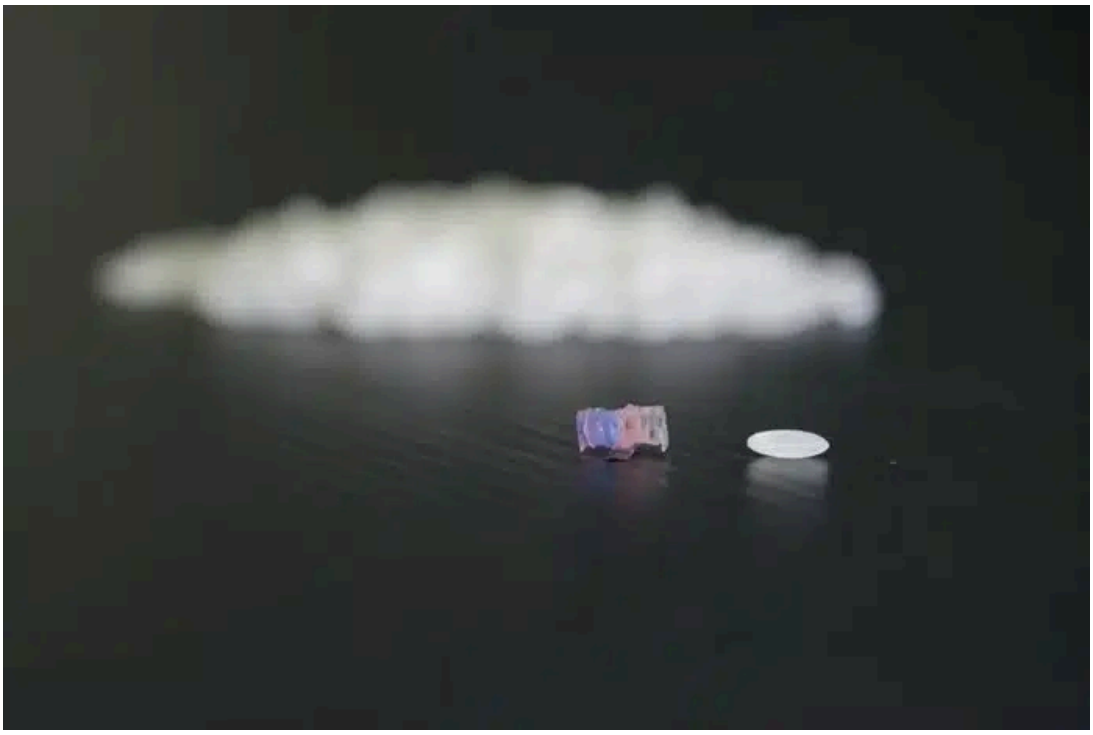
ROBOTICS

Grain-sized soft robots deliver drugs to the human body

By **Ashwini Sakharkar** 25 Oct, 2024



Robots as small as a grain deliver drugs. Credit: NTU Singapore

Researchers at Nanyang Technological University, Singapore (NTU Singapore) have made a groundbreaking advancement by creating grain-sized soft robots, controllable through magnetic fields for precision drug delivery. This innovative technology has the potential to revolutionize therapies in the future.

The soft robot, developed by engineers from NTU's School of Mechanical and Aerospace Engineering (MAE), was highlighted in a recent paper published in the esteemed journal Advanced Materials.

This study represents a pioneering achievement, showcasing miniature robots capable of transporting up to four distinct drugs, releasing them in customizable sequences and dosages.

The newly developed miniature robots represent a groundbreaking advancement compared to earlier small-scale counterparts, which could only carry a limited selection of three drugs and lacked programmable release orders.

This innovative design promises unparalleled precision functions that can dramatically enhance therapeutic outcomes while significantly reducing side effects, according to the research team.

Building on their earlier success, the NTU team had already created magnetically controlled miniature robots adept at intricate maneuvers, enabling them to 'swim' through confined spaces and grasp minute objects.

Inspired by the iconic 1960s film 'Fantastic Voyage,' in which a crew is miniaturized to repair damage within a scientist's brain, lead investigator Assistant Professor Lum Guo Zhan from the School of Mechanical and Aerospace Engineering (MAE) has propelled this remarkable work forward.

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

The grain-sized robot was designed with advanced smart magnetic composite materials—comprising non-toxic magnetic microparticles and polymers safe for human use. Unlike current miniature robots, which struggle to maintain precise orientations, this innovative

soft robot showcases exceptional dexterity and is capable of swiftly rolling and crawling over obstacles.

Such agility opens exciting possibilities for navigating the intricate, unstructured environments within the human body. In laboratory tests, this remarkable robot successfully performed tasks in water, closely simulating the conditions it would encounter inside our bodies.

The innovative robot demonstrated remarkable versatility when placed on a surface divided into four sections. It effectively navigated each section at impressive speeds ranging from 0.30 mm to 16.5 mm per second, accurately releasing different drugs in each area. This capability highlights its potential for carrying multiple medications and its programmability for precise, controlled release.

In a subsequent experiment, researchers challenged the robot in tougher conditions using a thicker liquid. Remarkably, the robot maintained its navigational skills, successfully delivering adequate amounts of medication over an extended eight-hour period.

Furthermore, following continuous movement for eight hours, the robot displayed minimal drug leakage. This exceptional ability to manage drug release with precision and minimal waste positions the soft robot as a leading candidate for advanced treatments that demand careful timing and location for multiple drug deliveries.

"*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,*" Research Fellow Yang Zilin said.

"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, Senior Consultant and surgeon at the Division of Neurology, Department of Medicine, National University Hospital and Ng Teng Fong General Hospital. *"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 on a pioneering mission to shrink their robots, aiming to revolutionize treatments for challenging conditions such as brain tumors, bladder cancer, and colorectal cancer.

Before deploying these innovative miniature robots in medical settings, the researchers are dedicated to rigorously evaluating their performance using advanced organ-on-chip devices and animal models.

This thorough assessment is crucial to ensuring safe and effective therapies for patients in need.

Journal reference:

1. Zilin Yang, Changyu Xu, Jia Xin Lee, Guo Zhan Lum. Magnetic Miniature Soft Robot with Reprogrammable Drug-Dispensing Functionalities: Toward Advanced Targeted Combination Therapy. Advanced Material, 2024; DOI: 10.1002/adma.202408750