SCIENCE & TECHNOLOGY

Tiny swimming robots can restructure materials on a microscopic level

Penn Engineers are working to make controlling microscopic processes, such as transporting drugs to tumors for precise therapies, faster, safer, and more reliable through the use of microrobots.

Controlling microscopic processes is inherently challenging. The everyday tools used to manipulate matter on the macroscale can't simply be shrunk down to the size of cell, and even if they could, the physical forces they rely on work differently when their targets are measured in nanometers. But while it's no easy feat, attaining this type of control would pay enormous dividends, whether it's transporting drugs to tumors for precise therapies, or making functional materials out of the liquid-suspended building blocks known as colloids. Penn Engineers are working to make these processes faster, safer and more reliable through the use of microrobots.

Ten slides showing the rotation of a microscopic robot.

The researchers' microrobots use "physical intelligence" to exert control over nearby objects. By spinning and disrupting the alignment of the liquid crystal surrounding them, the robots can attract smaller particles to their edges, then precisely deposit them. (Image: Penn Engineering Today)

Since they're too small for their own onboard computers, microrobots move about by means of an external magnetic force. And to manipulate equally small cargo, they need to take advantage of the different physical and chemical laws that rule the microscale.

At those sizes, every object is greatly influenced by the molecules surrounding it. Whether they are surrounded by gas, like the ambient atmosphere, or immersed in a liquid, microrobots must be designed to exploit this influence through a concept known as "physical intelligence."

Kathleen Stebe (https://directory.seas.upenn.edu/kathleen-j-stebe/), Richer & Elizabeth Goodwin Professor in Chemical and Biomolecular Engineering and Mechanical Engineering and Applied Mechanics, Tianyi Yao, a former Ph.D. student in her lab, Qi Xing Zhang, a current Ph.D. student, and collaborators in the group of Professor Miha Ravnik at the University of Ljubljana are conducting fundamental research that will lay the groundwork for understanding these small-scale interactions in a colloidal fluid of nematic liquid crystals (NLCs), the fluid that makes up each pixel in a liquid crystal display (LCD) screen.

In a study (https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202205546) published in *Advanced Functional Materials* the research team describes a four-armed, magnetically controlled microrobot that can swim, carry cargo and actively restructure particles in this complex fluid.

Being able to manipulate processes on this level is groundbreaking, and understanding how robotic systems are able to perform tasks in an indirect way, considering the fluid dynamics and physical interactions of the media as a part of the microrobot's design, is key.

Stebe and her team are now able to imagine real-world applications for this technology in the optical device industry as well as many other fields. Smart materials, aware of their environment, may be designed using temperature and light as controls for microrobotic tasks.

This story is by Melissa Pappas. Read more at Penn Engineering Today. (https://blog.seas.upenn.edu/tiny-swimming-robots-can-restructure-materials-on-a-microscopic-level/)

CREDITS — **From Penn Engineering Today**
Writer

DATE — **November 30, 2022**

SUBTOPICS — **Robotics, Nanotechnology**

SCHOOLS

School of Engineering & Applied Science