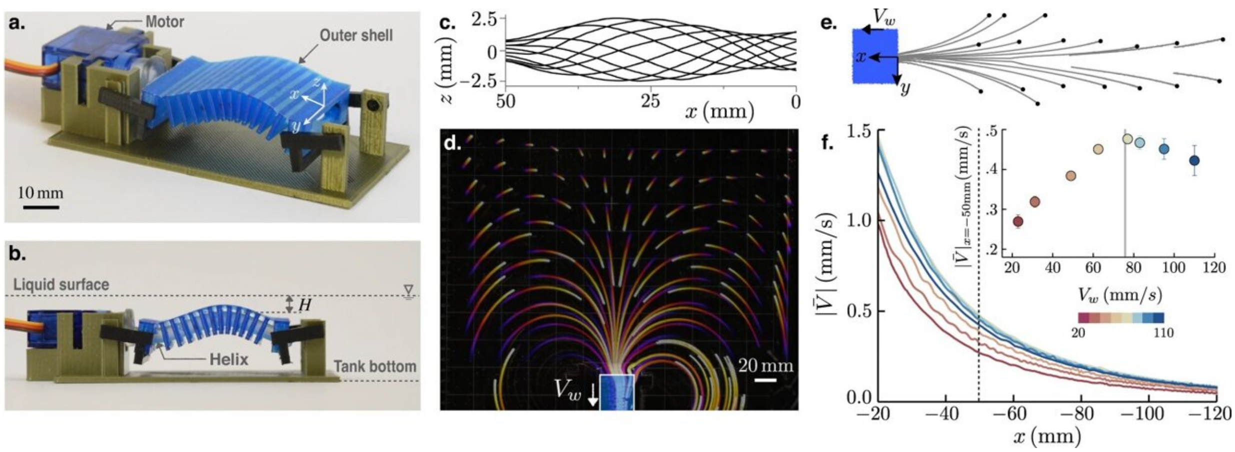
Snail-inspired robot could scoop ocean microplastics

December 4 2023, by Krishna Ramanujan



Large-scale transport of floaters by the undulating carpet. The actuator, shown in panels **a** and **b**, is comprised of a helix rotating inside a blue shell. Rotation of the helix causes an oscillatory motion of the shell forming a traveling wave on the surface. It is placed at a mean depth *H* below the liquid surface. **c** Shape of the undulations over a period of oscillation. These shapes are captured by a traveling sine wave of $\delta\sin[2\pi(x-V_w t)/\lambda]$\delta \sin [2\pi(x-{V}_{w}t)/\lambda]. **d** Trajectories representing motion of styrofoam particles at the interface due to 30 min of continuous oscillation of the undulator in silicone oil (viscosity 0.97 Pa · s) at a constant V_w. This panel is a top-view image with the actuator position marked at the bottom of the frame. The color coding of dark to light indicates the arrow of time. **e** Magnified trajectories of particles located straight ahead of the actuator. The filled circles represent the initial positions of the styrofoam particles. **f** Particle velocity as a function of distance for increasing wave speeds (V_w). Different wave speeds are marked by the color coding. Distances are measured from the edge of the actuator, as shown in panel **e**. Each of the curves is an average of over 20 trajectories. Particle velocity exhibits a non-monotonic behavior with V_w with maximum velocities measured at intermediate wave speeds. The inset confirms this behavior by showing particle velocity at a fixed location, $x = 50$ mm for different V_w. Error bars in this plot represent standard deviation in velocity magnitude. The gray line is the prediction from eq. (8). Credit: Cornell University

Inspired by a small and slow snail, scientists have developed a robot protype that may one day scoop up microplastics from the surfaces of oceans, seas and lakes.

The robot's design is based on the Hawaiian apple snail (Pomacea canaliculate), a common aquarium snail that uses the undulating motion of its foot to drive water surface flow and suck in floating food particles.

Currently, plastic collection devices mostly rely on drag nets or conveyor belts to gather and remove larger plastic debris from water, but they lack the fine scale required for retrieving microplastics. These tiny particles of plastic can be ingested and end up in the tissues of marine animals, thereby entering the food chain where they become a health issue and potentially carcinogenic to humans. Plastic waste makes up 80% of all marine pollution, with 8 to 10 million metric tons of plastic ending up in the ocean each year, according to the United Nations Economic and Social Council.

"We were inspired by how this snail collects food particles at the [water and air] interface to engineer a device that could possibly collect microplastics in the ocean or at a water body's surface, " said Sunghwan "Sunny" Jung, professor and director of graduate studies in the Department of Biological and Environmental Engineering in the College of Agriculture and Life Sciences (CALS). Jung is senior author of a study, "Optimal free-surface pumping by an undulating carpet," which was published online in *Nature Communications*.

The prototype, modified from an existing design, would need to be scaled up to be practical in a real-world setting. The researchers used a 3D printer to make a flexible carpet-like sheet capable of undulating. A helical structure on the underside of the sheet rotates like a corkscrew to cause the carpet to undulate and create a traveling wave on the water.

Analyzing the motion of the fluid was key to this research.

"We needed to understand the fluid flow to characterize the pumping behavior," Jung said. The fluid-pumping system based on the snail's technique is open to the air. The researchers calculated that a similar closed system, where the pump is enclosed and uses a tube to suck in water and particles, would require high energy inputs to operate. On the other hand, the snail-like open system is far more efficient. For example, the prototype, though small, runs on only 5 volts of electricity while still effectively sucking in water, Jung said.

Due to the weight of a battery and motor, the researchers may need to attach a floatation device to the robot to keep it from sinking, Jung said.

Anupam Pandey, a former postdoctoral researcher in Jung's lab, currently an assistant professor of mechanical engineering at Syracuse University, is the paper's first author.

More information: Anupam Pandey et al, Optimal free-surface pumping by an undulating carpet, *Nature Communications* (2023). [DOI: 10.1038/s41467-023-43059-8](https://dx.doi.org/10.1038/s41467-023-43059-8)

Provided by Cornell University