An acoustically actuated microscopic device

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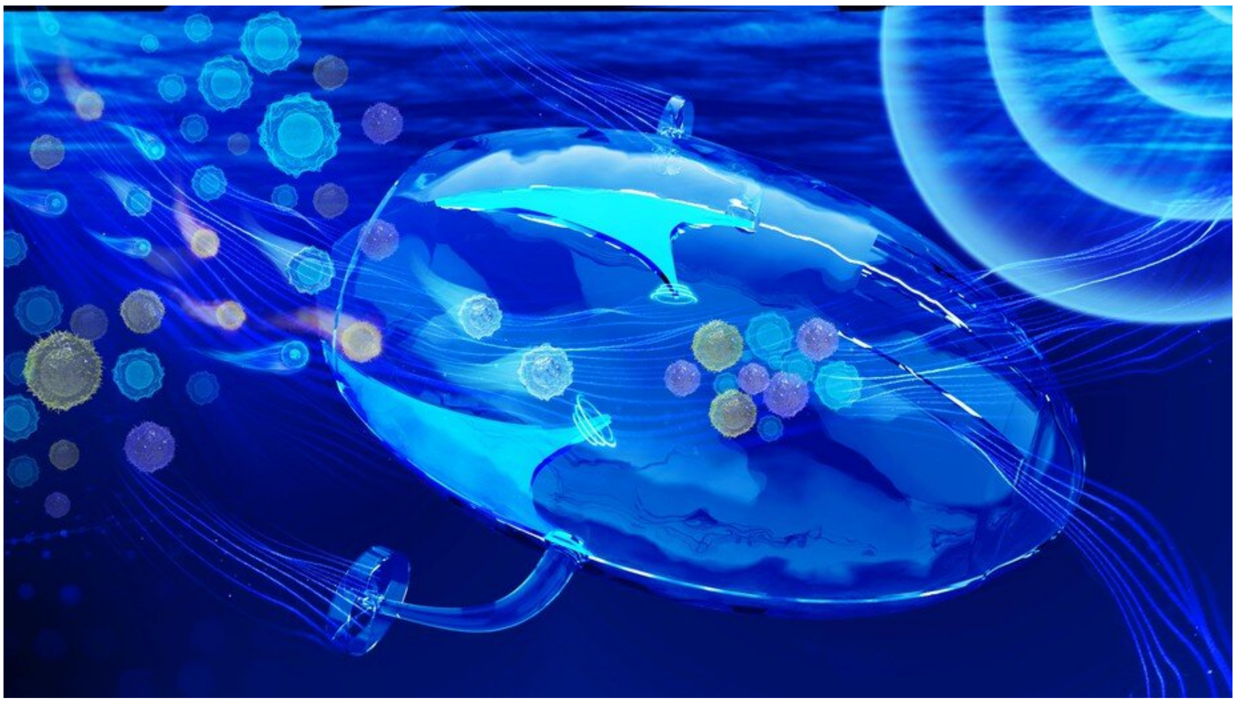

Credit: Ecole Polytechnique Federale de Lausanne

Researchers at EPFL have developed remote-controlled, mechanical microdevices that, when inserted into human tissue, can manipulate the fluid that surrounds them, collect cells or release drugs. This breakthrough offers numerous potential applications in the biomedical field, from diagnostics to therapy.

Does the idea of a soft, cell-sized capsule that can be injected into your body in order to collect samples for biopsy, release medication or carry out targeted interventions seem unimaginable? It wasn't for the scientists in EPFL's MicroBioRobotic Systems Laboratory (MICROBS), who have come up with technology that does all of these things. "The core component of our device is an acoustic microengine, which we manufactured using 3-D nanoprinting," says Selman Sakar, a professor at the Institute of Mechanical Engineering. "The parts are made out of hydrogel, a biocompatible material that is about as stiff as human tissue. We then drew on computational simulations to invent a complex microdevice consisting of several engines."

Remote actuation

"After the device enters the body, it has to be actuated remotely," says Sakar. "It would be too invasive to use tethers such as cables or tubes." The researchers use ultrasound to actuate the specific microengines and manipulate the surrounding fluid. "The device works precisely because of its structural design. Using mechanical resonance, we can carefully control which part of the device is actuated by modulating the frequency of acoustic excitation."

Sakar's team has also developed an array of engines and mechanisms. By combining various parts—pumps, a collection chamber and filters of various sizes—they designed a biopsy device. The researchers have also built mobile devices that are propelled by the fluid flow generated by acoustic microengines.

Programmable in vivo pharmacology and targeted therapy

Combining this technology with medical imaging means patients will be able to undergo long-term monitoring without any outside intervention.

"We have freed microfluidics technology from its electronic and external constraints," says Murat Kaynak, lead author of the study. "Microfluidic devices can now be injected into human tissue and used to greatly enhance biochemical analysis thanks to the tunability of hydrogels."

The devices could also be used for therapeutic purposes. "Doctors will be able to program the device to release a specific drug dosage when actuated by ultrasound," adds Kaynak. "This will allow them to treat a specific part of the body and minimize the side effects."

Controlled lifespan

While injecting the microscopic devices is minimally invasive, removing the devices has proven more of a challenge. The solution can be found in the materials used to construct the device. "How long a device lasts depends on the materials it's made of," says Kaynak. "Some hydrogels biodegrade quickly while others stick around longer. The actuation concept works well with various types of polymers."

Only in vitro experiments have been conducted so far. The next step will be to test these devices in vivo.

More information: Murat Kaynak et al. Addressable Acoustic Actuation of 3D Printed Soft Robotic Microsystems, *Advanced Science* (2020). DOI: 10.1002/advs.202001120

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