

Neutrophil-inspired propulsion

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Inspired by white blood cells rolling on endovascular walls before transmigrating to the disease site, scientists at ETH Zurich have succeeded in getting particles to move along the walls of microscopic, three-dimensional vessels. This method could be used in targeted cancer therapeutics.

When white [blood](#) cells are summoned to combat invasive bacteria, they move along blood vessels in a specific fashion, i.e., like a ball propelled by the wind, they roll along the vascular wall to reach their point of deployment. Since white blood cells can anchor themselves to the vasculature, they are capable of moving against the direction of the blood flow.

This type of behaviour of the white blood cells served as an inspiration for the postdoc, Daniel Ahmed, who was working in Professor Bradley Nelson's research group at ETH Zurich. In the lab, Ahmed and his co-workers developed a novel system that enables aggregates composed of magnetised particles to roll along a channel in a combined acoustic and magnetic field. In addition, researchers of Jürg Dual's group have developed numerical and theoretical studies of the project. Their work was published recently in the journal, *Nature Communications*.

The strategy of the devices' transport mechanism is both simple and ingenious, i.e., the scientists put commercially-available, biocompatible magnetic particles into an artificial vasculature. When a rotating magnetic field is applied, these particles self-assemble into aggregates and start to spin around their own axes. When the researchers apply

ultrasound at a specific frequency and pressure, the aggregates migrate towards the wall and start rolling along the boundaries. The rolling motion is initiated once the microparticles achieve a minimum size of six micrometres, which is 1/10 the diameter of a human hair. When researchers turn off the [magnetic field](#), the aggregates disassociate into their constituent parts and disperse in the fluid stream.

Feasible in living tissue

To date, Ahmed has only tested this system in artificial channels. However, he believes that the method is feasible for use in living organisms. He stated, "The ultimate goal is to use this kind of transport mechanism to deliver drugs in hard-to-reach sites within the body and integrate it with imaging modalities," he says. He is thinking about tumours that only can be reached via narrow capillaries but could be killed using rolling micro-therapeutics and their active substances.

In vivo imaging is an important challenge in the field of micro and nanorobotics. The ultrasound and magnetic imaging technique is well established in clinical practice. Currently, there are several in vivo imaging techniques, e.g., [magnetic resonance imaging](#) (MRI) and magnetic particle imaging (MPI). Both can be used to track the aggregates of the [superparamagnetic particles](#) used in the study. The MPI that uses clinically-approved, iron oxide-based MRI contrast agents is capable of 3-D, high-resolution imaging in real time. The researchers look forward to functionalizing nanodrugs with the iron oxide particles to allow mapping of the vasculature and the simultaneous transportation of nanodrugs.

Improve resolution of ultrasound imaging

The mechanism developed via ultrasound is another potential application. For example, superparamagnetic particles and

chemotherapeutic drugs can be incorporated in the polymeric shelled microbubbles. Bubbles are used as a contrast medium that could be distributed via a rolling motion into difficult-to-reach areas of the body. This could improve the resolution of [ultrasound imaging](#).

"In this study we demonstrated propulsion using self-assembling micro-aggregates, but that's only the beginning," Daniel Ahmed commented. The next step will be to examine how magnetic microrollers behave under flow conditions with auxiliary particles, such as red and [white blood cells](#), and whether it is possible to persuade the magnetic [particles](#) to move against the flow as well. He also wants to test his system in vivo in animal models.

More information: Daniel Ahmed et al. Neutrophil-inspired propulsion in a combined acoustic and magnetic field, *Nature Communications* (2017). [DOI: 10.1038/s41467-017-00845-5](https://doi.org/10.1038/s41467-017-00845-5)

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