Bioengineers develop world's first microfluidic device for rapid separation and detection of non-spherical bioparticles

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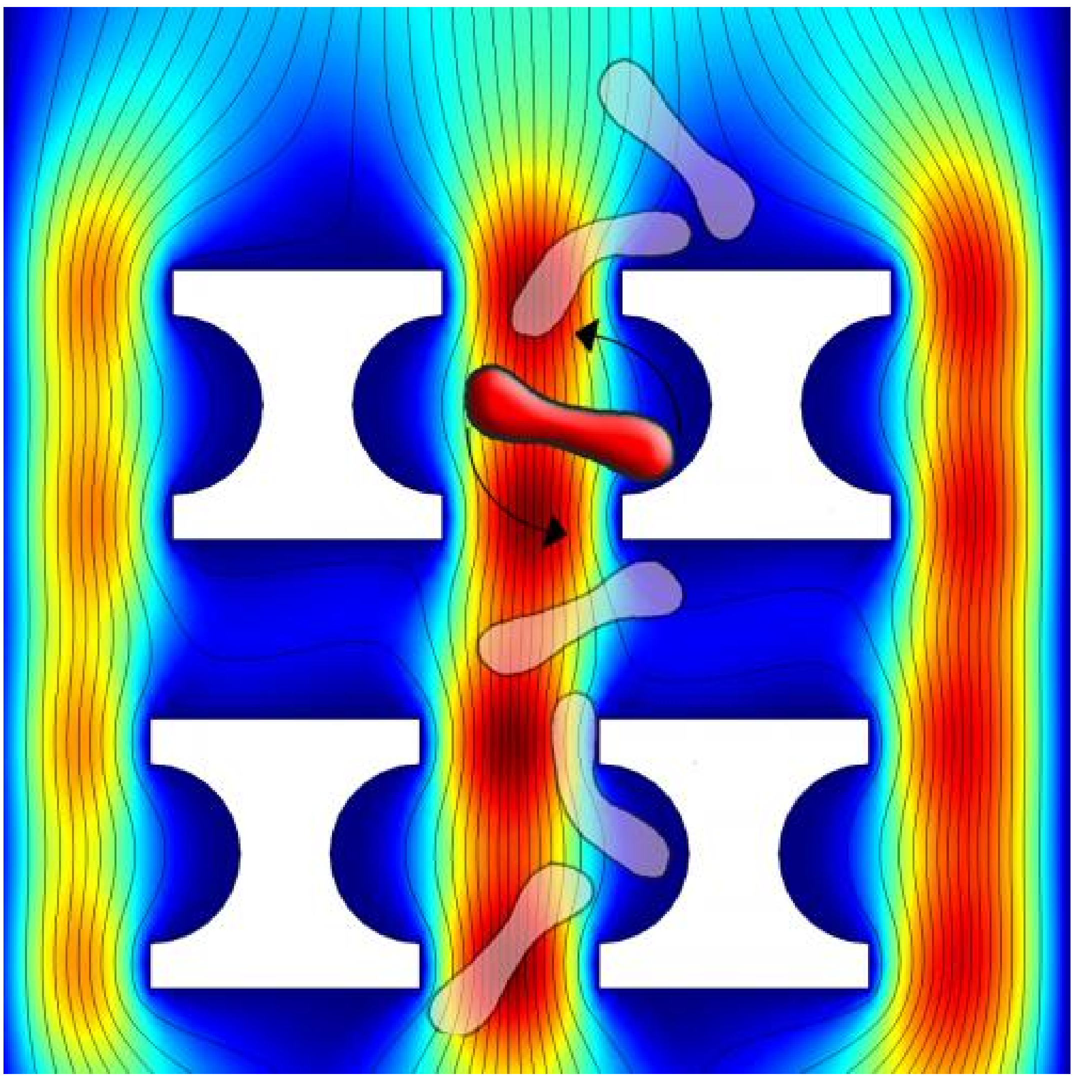


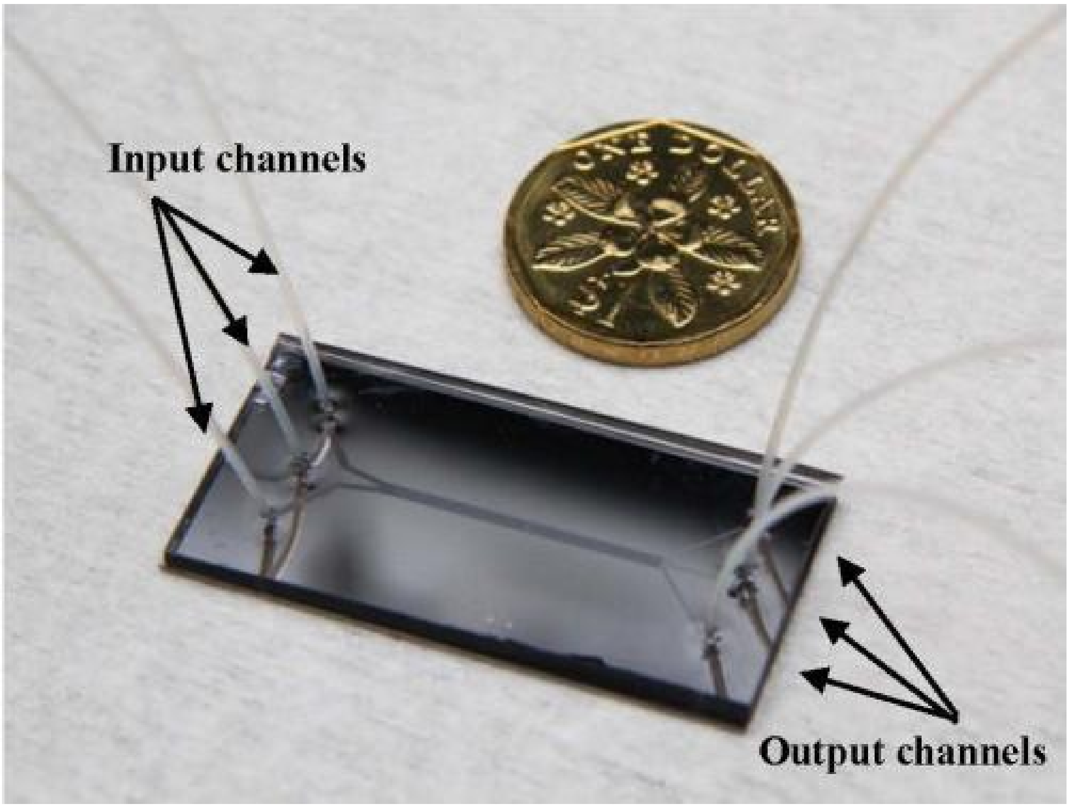
How the I-shape pillar array works. Non-spherical cells such as rod-shaped ones are rotated by I-shape pillar to increase their effective hydrodynamic size, isolating them from samples. Credit: National University of Singapore

A bioengineering research team from the National University of Singapore (NUS) team led by Associate Professor Zhang Yong has developed a novel microfluidic device for efficient, rapid separation and detection of non-spherical bioparticles. Microfluidic devices deal with the behavior, precise control and manipulation of fluids that are geometrically constrained to sub-millimeter scale. This new device, which separates and detects non-spherical bioparticles such as pathogenic bacteria and malaria infected red blood cells, can potentially be used for rapid medical diagnostics and treatment.

Bioparticles such as bacteria and red blood cells (RBC) are non-spherical. Many are also deformable – for example, our blood cells may change shape when affected by different pathogens in our body. Hence, the team's shape-sensitive technique is a significant discovery. Currently, separation techniques are mostly designed for spherical particles.

Though the team is focusing mainly on the rapid separation and detection of bacteria from pathological samples at the moment, their device has potential as a rapid diagnostic tool as well. Their new technique can potentially replace an age-old method of detection based on bacterial culture.

Explained Assoc Prof Zhang, "The old method was developed about 100 years ago, but it is still being used today as the mainstream technique because no new technique is available for effective separation of bacteria from pathological samples like blood. Many of the pathogenic bacteria are non-spherical but most of microfluidic devices today are for separating spherical cells. Our method uses a special I-shape pillar array which is capable of separating non-spherical or irregularly-shaped bioparticles."



Microfluidic chip which is only slightly bigger than a Singapore $1 coin. Credit: National University of Singapore

The method developed by the NUS team can complete the diagnosis process in less than an hour compared to 24-48 hours required for bacterial detection by using conventional methods. Their device is also efficient in separating red blood cells (RBCs) from blood samples as RBCs are non-spherical. This enables rapid detection of diagnostic biomarkers which reside in blood sample.

One of the most challenging aspects for the team was designing and fabricating a device that is capable of detecting even the smallest dimension of bioparticles and still provide reasonably good throughput (amount which can be processed through the system in a given time).

How it works and moving forward

Scientists have tried to address the problem of separating non-spherical bioparticles by using techniques such as restricting the flow of particles but these have not shown to be as effective. However, the NUS Bioengineering team's I-shape pillar array device has proven to be successful.

The I-shape pillar array induces rotational movements of the non-spherical particles which in turn increases the effective hydrodynamic size of the bioparticles flowing in the device, allowing for efficient separation. Their design is able to provide 100 percent separation of RBCs from blood samples, outperforming conventional cylindrical pillar array designs.

The device can also potentially separate bioparticles with diverse shapes and sizes. The team has tested their device successfully on rod-shaped bacteria such as Escherichia coli (common bacteria which can cause food poisoning). So far, this has been difficult to achieve using conventional microfluidic chips.

The team's findings were published in the reputed journal *Nature Communications* on 27 March 2013, in a manuscript titled "Rotational separation of non-spherical bioparticles using I-shaped pillar arrays in a microfluidic device".

Said Assoc Prof Zhang, "With our current findings, we hope to move on to separate other non-spherical bioparticles like fungi, with higher throughput and efficiency, circumventing the spherical size dependency of current techniques."

More information: "Rotational separation of non-spherical bioparticles using I-shaped pillar arrays in a microfluidic device" *Nature Communications*, 27 March 2013.

Provided by National University of Singapore