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MODELLING THE FUTURE

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Development and test of a proof-of-concept microfluidic bacteria sample preparation circuit for magnetic detection

NANOTECHNOLOGIES
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ABSTRACT

Traditional magnetic labeling methods typically involve the use of multiple specialized laboratory instruments, resulting in prolonged times (in the timeframe of hours/days) from collection to analysis - a significant concern in situations involving e.g., biological threats such as anthrax, tuberculosis, and Legionnaire's disease. Our project addresses this challenge by introducing a microfluidic sample preparation circuit (MSPC) that is compact (footprint width_38650 × height_50 × length_50320 μm^3) and completes the labeling process in no more than 5 minutes, making it suitable for point-of-care applications.

METHODOLOGY

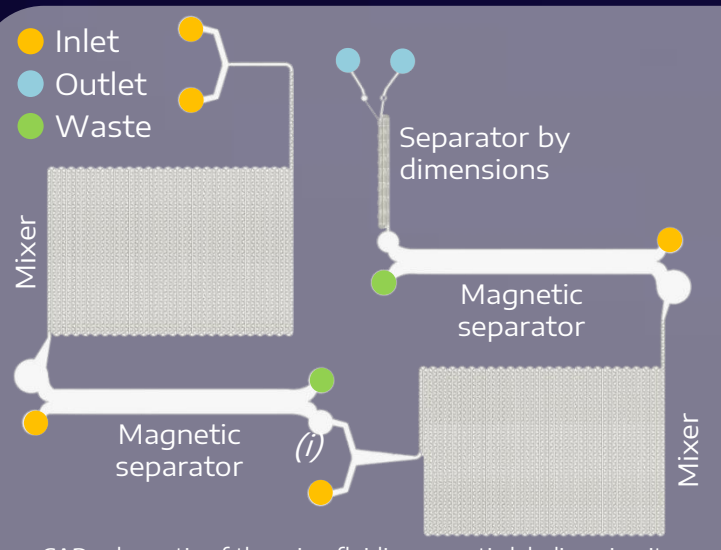
Our prototype, depicted below, makes use of 3 components, a mixer, a magnetic separator and a separator by dimensions, which magnetically label specific analytes in a sample and purify it. We made use of simulation to understand the functioning and the physics mechanisms behind each of the components. Finally, we tested the circuit to label polystyrene beads of 2 µm with magnetic nanoparticles (MNP) of 100 nm and analyzed the outputs of each component through scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS).

RESULTS

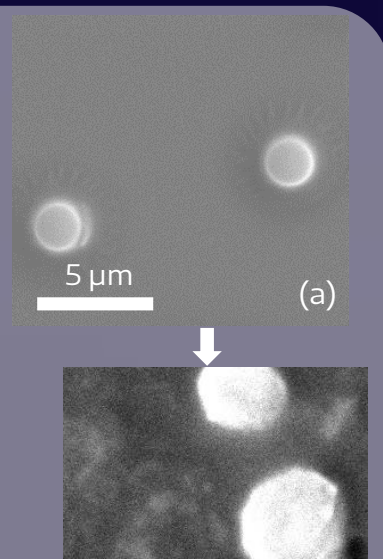
Mixer
→ *To label the beads with MNP*
The mixer, with obstacles, has a total length of 640 mm, for which we obtain a simulated mixing efficiency nearing 100 %

Magnetic separator
→ *To separate magnetic species from non-magnetic species*
Simulations show beads labeled with more than 440 MNP are deflected to continue in the flow circuit. EDS analysis confirms 5× more iron content in position *(i)* than at the outlet for waste

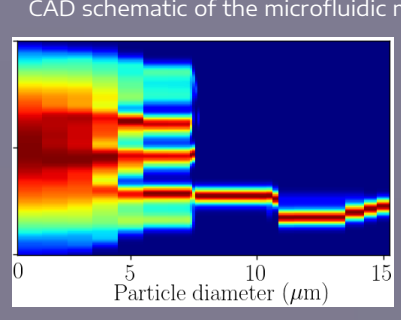
Separator by dimensions
→ *To separate labeled beads from free MNP*
Simulation shows particle separation for this design occurs for particles with diameter >7.5 µm



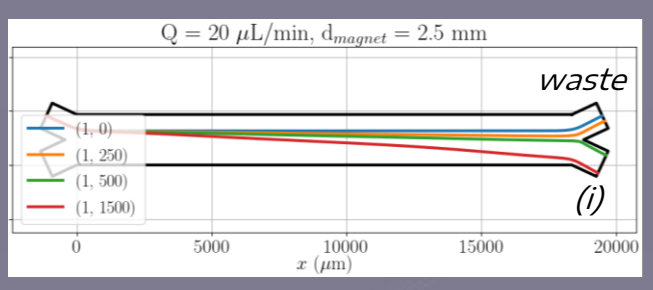
CAD schematic of the microfluidic magnetic labeling circuit



SEM images from bead suspension, before (a) and after (b) passing through the mixer



Distribution of particles at the outlet of the separator by dimensions as a function of their diameter



Simulated trajectories for one bead and n MNP (n_{beads}, n_{MNPs})

SUMMARY

Overall, we've shown the efficiency of the mixer (>99%) and of the magnetic separator (80%), both by simulation and experimental testing. In the future, we plan to implement a new design for the separator by dimensions optimized to separate 2 µm labeled beads and to test the whole circuit with biological samples.

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INL INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

fct Fundação para a Ciência e a Tecnologia

TEXAS The University of Texas at Austin