CFD-DEM Simulations of DLD Microarrays for Particle Fractionation at Re > 1

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ABSTRACT

For the production of, for instance, pharmaceutical ingredients or particle-based printer inks, particles in narrow size ranges are required. In contrast, grinding or dispersion processes generate technical suspensions with comparatively broad size ranges. These technical suspensions could be fractionated in a later step in fluidic microsystems. So called deterministic lateral displacement (DLD) devices are capable of separating particles on the basis of size with a resolution of down to 10 nm. This technology consists of a channel that contains a pattern of periodically disposed rows of microposts, forming separate flow laminae. Different factors, like row shift, post diameter, height and distance, post shape and Reynolds number are affecting the separation [1].

Despite their accuracy, DLD microsystems still bear some drawbacks and need to be improved, especially with the aim of using them for industrial applications. The first problem is that they tend to clog and often need to be cleaned or replaced. The second challenge is increasing the throughput to industrial relevant extent. The small cross-section of the channel, comparable to a human hair, leads to high flow resistance and therefore high pressure during use. The aim in our project, which is part of the DFG-SPP 2045 "MehrDimPart", is to enhance the design of a DLD microsystem regarding higher throughput (but still laminar Reynolds numbers) and higher particle concentrations. To achieve this aim, the effect of microsystem height and different (asymmetrical) post shapes are investigated. Changes in the post shape and also inertial flow have the ability to alter flow laminae in such a way, that the critical separation diameter decreases. This effect allows to increase the size of the gap between posts for a given critical particle size, which reduces clogging and allows for a higher flow rate for a given pressure gradient [1, 2].

Different DLD configurations are tested using the CFD-DEM coupling simulation software CFDEM®coupling. For this, the DLD microsystem is broken down to a representative fragment comprising a small number of microposts and using periodic boundary conditions. The post arrangement can easily be changed parametrically. To resolve flow around particles and posts, a four-way coupled immersed boundary simulation is employed. Micro particle image velocimetry (µPIV) experiments are carried out to verify and calibrate the simulation results.

In the presentation we will show the simulation setup and the results of the simulations with higher Reynolds numbers. These results are compared with µPIV measurements, also taking into account the velocity profile over the channel height. Furthermore, we will present different post shapes and their effect on particle separation at higher throughput.

REFERENCES

[1] McGrath, J., M. Jimenez, and H. Bridle. "Deterministic lateral displacement for particle separation: a review." Lab on a Chip 14.21 (2014): 4139-4158.

[2] Dincau, Brian M., et al. "Deterministic lateral displacement (DLD) in the high Reynolds number regime: high-throughput and dynamic separation characteristics." Microfluidics and Nanofluidics 22.6 (2018): 59.