# Experimental and Simulative Investigation of Deterministic Lateral Displacement and Dielectrophoresis Methods for Continuous Multi-Property Particle Sorting

**Jonathan Kottmeier [1,*], Maike Wullenweber [2,3,*], Ingo Kampen[2,3], Arno Kwade [2,3] and Andreas Dietzel [1,2]**

[1] TU Braunschweig, Institute of Microtechnology
[2] TU Braunschweig, Center of Pharmaceutical Engineering (PVZ)
[3] TU Braunschweig, Institute for Particle Technology
* Contributed equally, Correspondence: JK- j.kottmeier@tu-braunschweig.de; MW- m.wullenweber@tu-braunschweig.de

Supplementary data file #1

**Supplementary Material 1:**

**S1: Full list of volumetric flow rates used in the experiments**

The volumetric flow rates in the following tables are sorted by the particle property investigated. For the density and shape fractionation, only design 1 was used.

**Table S1.** Density fractionation.

| Re | $V_{total}$ [ml/min] | $V_{buffer1}$ [ml/min] | $V_{sample}$ [ml/min] | $V_{buffer2}$ [ml/min] |
|---|---|---|---|---|
| 5 μm particle diameter | | | | |
| 80 | 11.06 | 8.58 | 1.24 | 1.24 |
| 82 | 11.31 | 8.79 | 1.26 | 1.26 |
| 85 | 11.74 | 9.12 | 1.31 | 1.31 |
| 8 μm particle diameter | | | | |
| 50 | 6.91 | 5.35 | 0.77 | 0.77 |
| 52 | 7.19 | 5.58 | 0.80 | 0.80 |
| 55 | 7.58 | 5.90 | 0.84 | 0.84 |

**Table S2.** Shape fractionation.

| Re | $V_{total}$ [ml/min] | $V_{buffer1}$ [ml/min] | $V_{sample}$ [ml/min] | $V_{buffer2}$ [ml/min] |
|---|---|---|---|---|
| 10 | 1.38 | 1.08 | 0.15 | 0.15 |
| 20 | 2.76 | 2.14 | 0.31 | 0.31 |
| 30 | 4.14 | 3.22 | 0.46 | 0.46 |
| 40 | 5.51 | 4.29 | 0.61 | 0.61 |
| 50 | 6.89 | 5.35 | 0.77 | 0.77 |
| 60 | 8.27 | 6.43 | 0.92 | 0.92 |
| 70 | 9.65 | 7.51 | 1.07 | 1.07 |
| 80 | 11.06 | 8.58 | 1.24 | 1.24 |

## S2: Experimental setup for polydisperse solutions

To investigate the polydisperse solution fractionation using design 2, the following setup was used. Compared to design 1, only two syringes and valves were used, as illustrated in Figure S1.

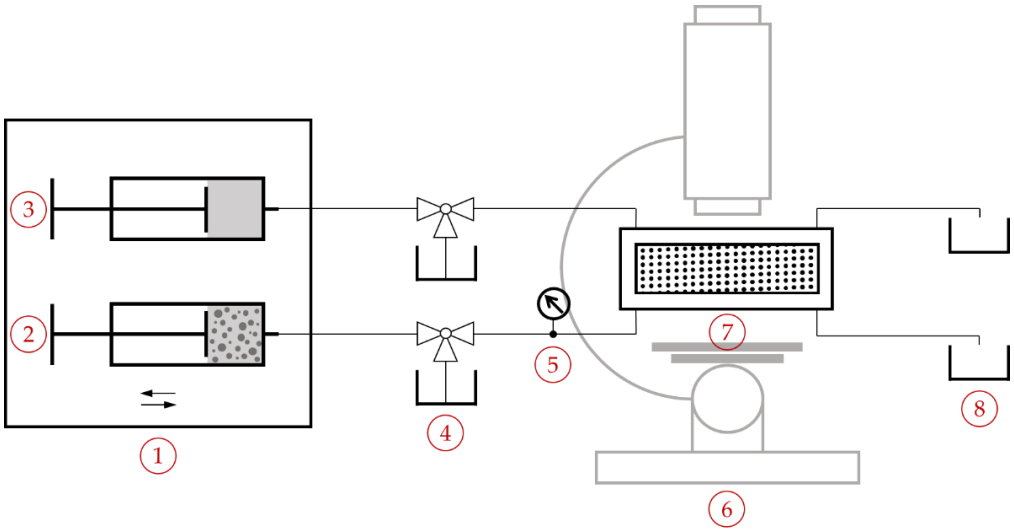



**Figure S1**: Experimental setup of design 2: (1) Cetoni Nemesys pump system (Cetoni GmbH, Korbussen, Germany) with two medium pressure modules, placed on a tumbling shaker plate (VWR, Pennsylvania, USA); (2) stainless steel syringe, containing feed particle suspension; (3) stainless steel syringe, containing buffer; (4) three-way ball valves to refill the syringe pumps from storage container; (5) pressure monitor; (6) Zeiss Axio Observer inverted microscope (Zeiss, Göttingen, Germany) with a 10x lens and a 1.6x photo adapter under darkfield illumination; (7) microsystem, fixed using a CNC-machined PEEK holder with sealing rings and an aluminum lid for fixation; (8) collection containers for the separated particle fraction suspensions.

## S3: Density fractionation of 5 µm particles at different Reynolds numbers

The results of the density-based fractionation at Re 85, which did not show any further displacement of 5 µm PS and melamine particles, are shown in Figure S2.

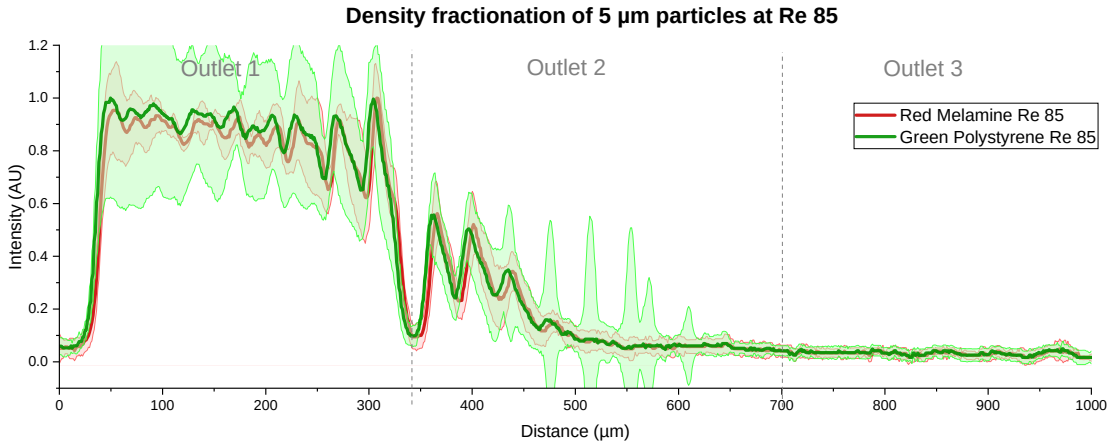
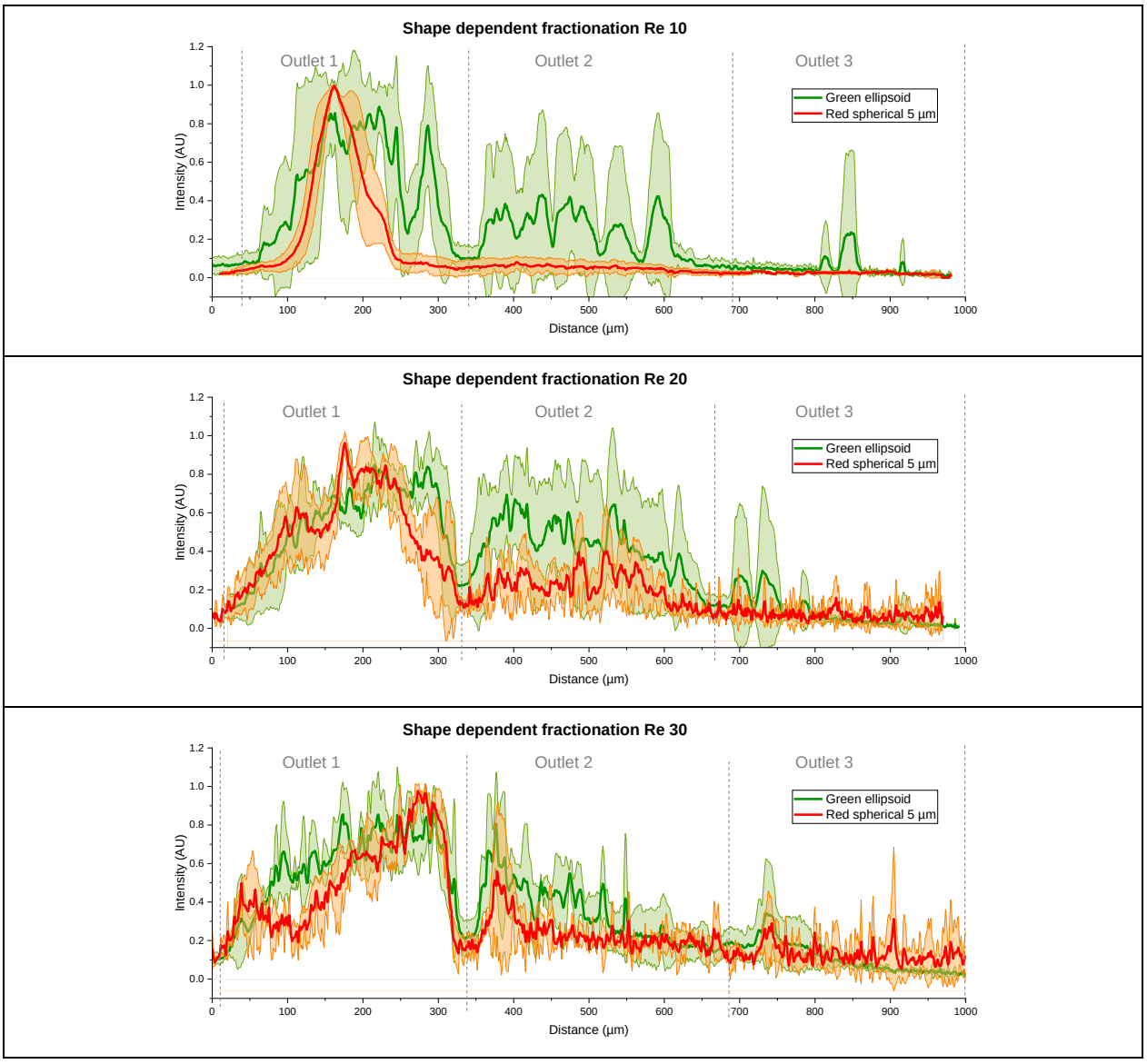
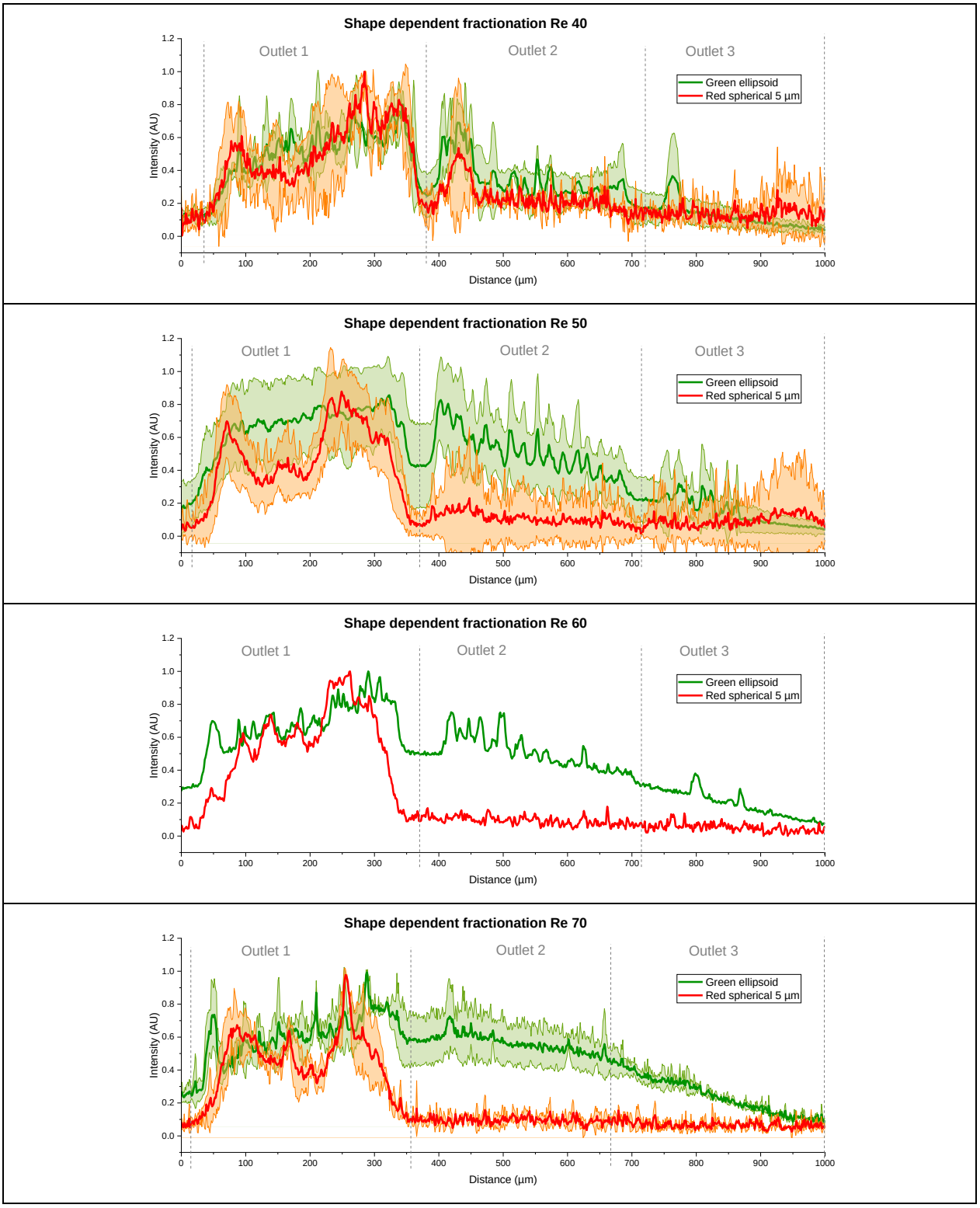



**Figure S2.** Density-dependent fractionation of 5 µm particles made from polystyrene and melamine. At this condition, no further displacement of any particle is visible.

## S4: Shape-dependent fractionation

The graphs of all investigated Reynolds numbers for the binary suspensions containing elliptical PS and spherical melamine particles are shown in Figure S3. Due to clogging around the outlet section, the "AVG" function of the ImageJ stacking algorithm did not show any results; thus, the "MAX" stacking algorithm had to be used instead. However, with this function, an offset in the green channel was induced that could not be counteracted without altering the image information.




Shape dependent fractionation Re 40
Outlet 1
Outlet 2
Outlet 3
Green ellipsoid
Red spherical 5 µm
Intensity (AU)
Distance (µm)
Shape dependent fractionation Re 50
Outlet 1
Outlet 2
Outlet 3
Green ellipsoid
Red spherical 5 µm
Intensity (AU)
Distance (µm)
Shape dependent fractionation Re 60
Outlet 1
Outlet 2
Outlet 3
Green ellipsoid
Red spherical 5 µm
Intensity (AU)
Distance (µm)
Shape dependent fractionation Re 70
Outlet 1
Outlet 2
Outlet 3
Green ellipsoid
Red spherical 5 µm
Intensity (AU)
Distance (µm)

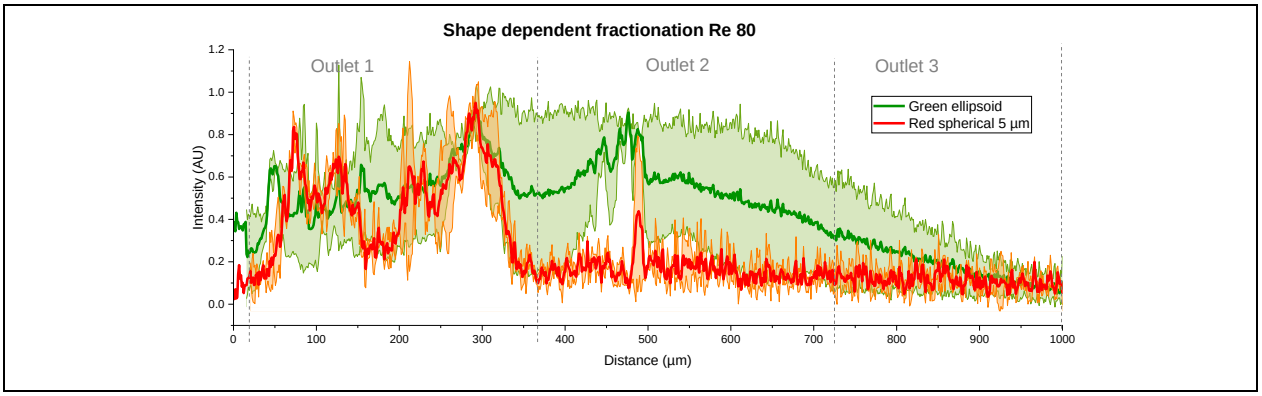



**Figure S3.** Overview of all measurements of shape-dependent fractionation. Due to the "MAX" stacking algorithm, an offset was induced in the green channel. For *Re* = 60, only one dataset was taken, therefore on this graph there are no error bars.