A different approach to material-selective separation of small particles

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MAPEX Symposium 2018

Material-selective particle separation

Relevant for

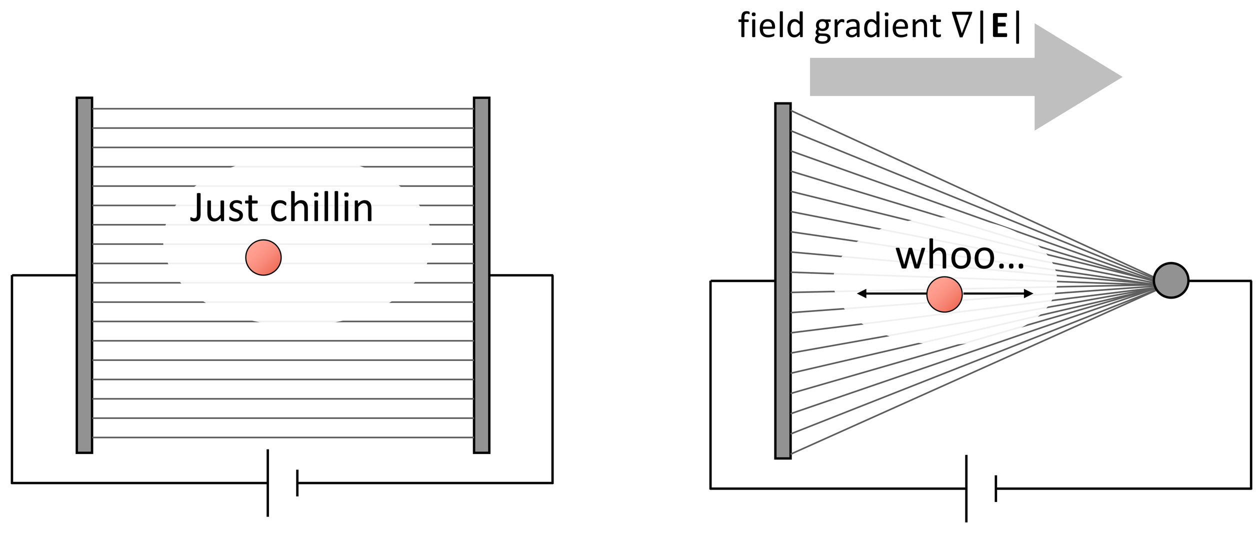
- Product quality enhancement (separation of conducting and non-conducting carbon nanotubes)
- Waste recycling (metal recovery from scrap)
- (Bio-)analytical chemistry
- …

Standard methods:

- (Density-gradient) centrifugation, Elutriation, Electrophoresis, Inertial Separation, Filtration, …
- Methods based on density differences fail when particles are very small or densities are close together (for example, different plastics …). Electrophoresis requires particle charge and filtration is usually not material selective.

Dielectrophoresis (DEP)

Movement of charged and **uncharged** matter in **inhomogeneous** electric fields.



Homogeneous field: No Effect.

Inhomogeneous field: DEP!

Movement velocity:

$$\mathbf{v}_{DEP} = \mu_{DEP} \nabla |\mathbf{E}|^2$$

Speed and direction of movement is given by the dielectrophoretic mobility:

$$\mu_{DEP} = \frac{\varepsilon_m R^2 \mathrm{Re}\left[\tilde{f}_{CM}\right]}{6\eta_F}$$

R – Particle size

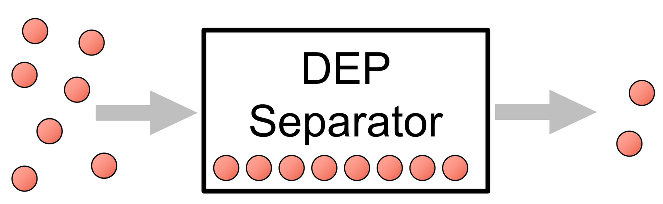
$\mathrm{Re}[f_{CM}]$ – Relative particle polarizability

- $\mathrm{Re}[f_{CM}] > 0$ Positive DEP
- $\mathrm{Re}[f_{CM}] < 0$ Negative DEP

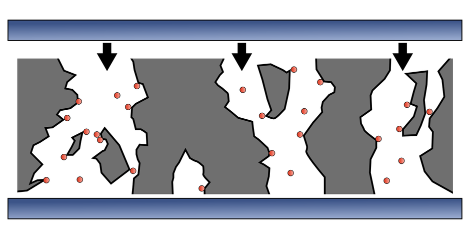
Depends on material!

DEP Filtration – Concept

- DEP Trapping: Immobilization of particles in field traps (currently only *non-selective*)!



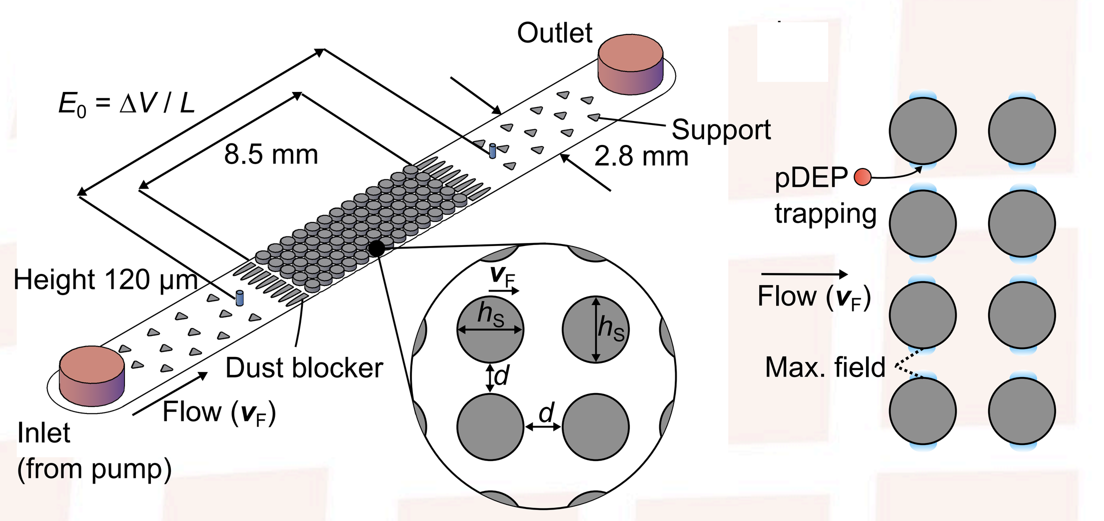
- Field trap: local **maximum** of the electric field
- Aim: Find a configuration that generates a lot of field maxima for trapping!

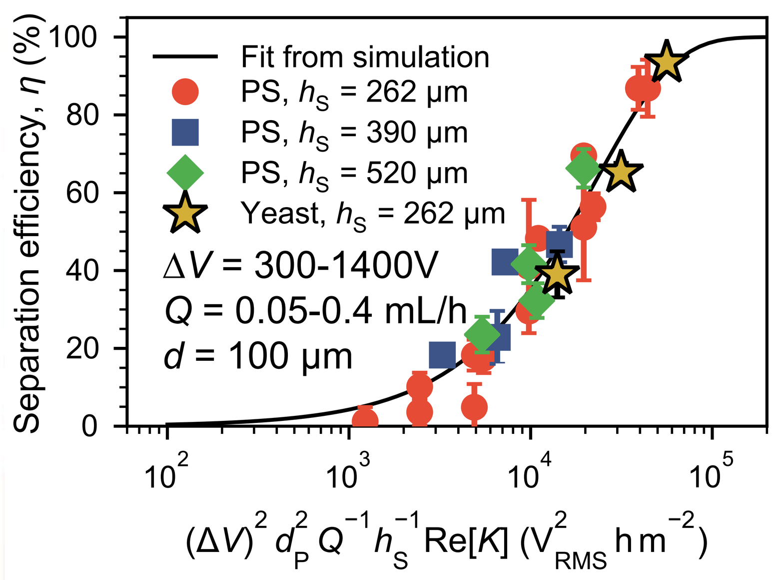


Scattering of electric field at material boundary generates field traps!

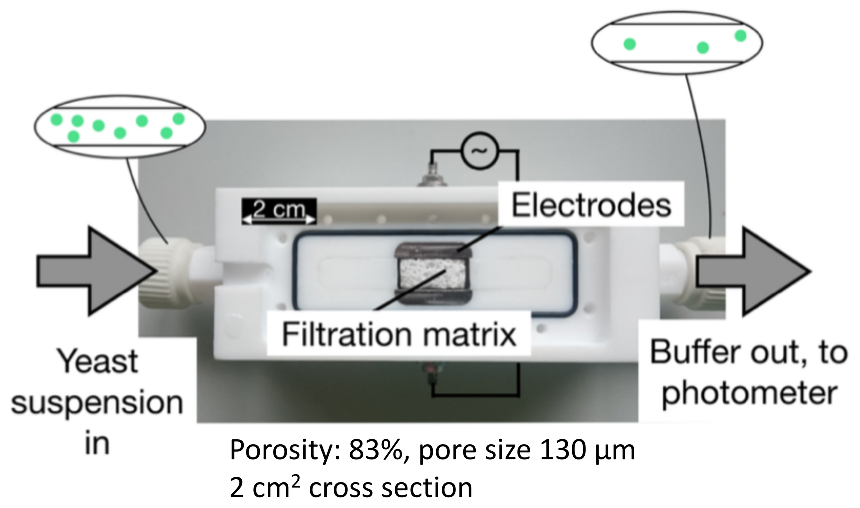
DEP Filtration – Modeling

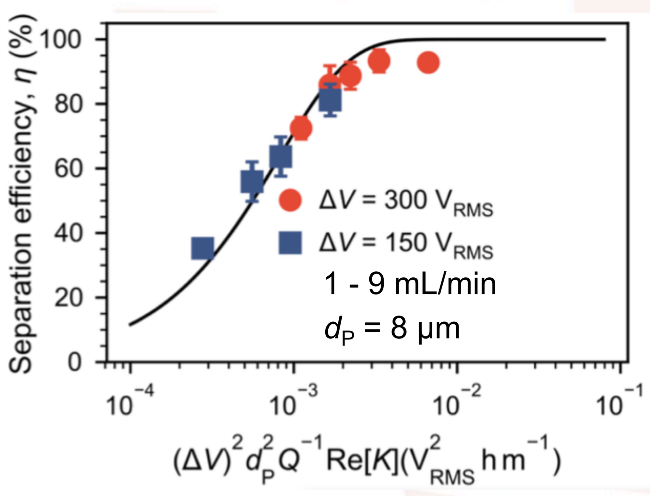
- Simplififcation of filter with microchannel model structure
- Simulation with COMSOL and experiments with 1 µm polystyrene particles and yeast cells (8 µm) in polydimethylsiloxane channels





DEP Filtration – High throughput





Conclusion and Outlook

- Two setups: Microfluidic setup for **understanding** and **observing** (microscope!); macroscopic filter setup for high-throughput separation
- Next steps: *Selective* separation (e.g., trap metal in a metal-plastic mixture)
- Decrease particle size (nanoparticles)

References

Pesch et al. (2016), Electrophoresis 37(2); Pesch et al. (2017), J. Chrom. A. 1483, 127–137; Pesch et al. (2018), Sci. Rep., Under Review

Acknowledgement

DFG Graduiertenkolleg 1860 „MIMENIMA"

Malte Lorenz (Filtration experiments), Michael Baune, Fei Du, Jorg Thöming (all UFT), Shaurya Sachdev (Microfluidic experiments), Pouyan Boukany (both TU Delft)

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