Karlsruhe Institute of Technology

Institute for Technical Chemistry

Numerical Simulation of Fiber Deposition Behavior in an Air-Liquid Interface Exposure System

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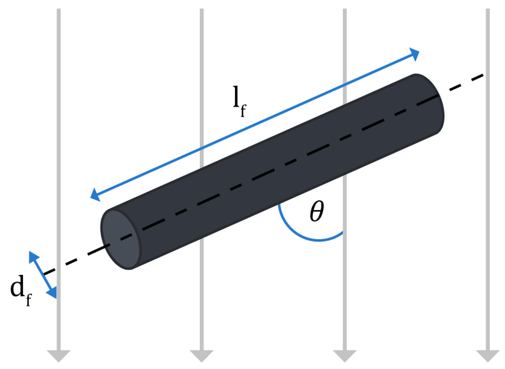
Fiber geometries and their description

Fiber diameter $\mathbf{d_f}$ Fiber length $\mathbf{l_f}$

Aspect ratio $\boldsymbol{\beta} = \frac{l_f}{d_f}$ Angle of fiber orientation $\boldsymbol{\theta}$



Determining the shape factor (χ) using the **elongated ellipsoid** of revolution method[1]:

Shape factor and drag force

For motion **parallel** to the streamlines:

$$\chi^{\parallel} = {}^{4}/_{3}\,(\beta^2-1)/\left\{\frac{2\beta^2-1}{\sqrt{\beta^2-1}}\cdot ln\left[\beta+\sqrt{\beta^2-1}\right]-\beta\right\}$$

For motion **perpendicular** to the streamlines:

$$\chi^{\perp} = {}^{8}/_{3}\,(\beta^2-1)/\left\{\frac{2\beta^2-3}{\sqrt{\beta^2-1}}\cdot ln\left[\beta+\sqrt{\beta^2-1}\right]+\beta\right\}$$

For **any** motion:

$$\chi = \chi^{\parallel}\cos^2(\theta) + \chi^{\perp}\cos^2(\theta)$$

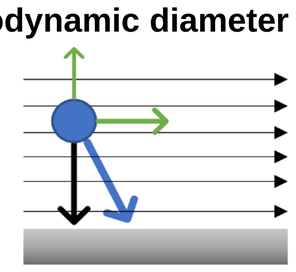
Brownian rotation

$$\boldsymbol{\chi} = \frac{\mathbf{1}}{\mathbf{3}}\boldsymbol{\chi}^{\parallel} + \frac{\mathbf{2}}{\mathbf{3}}\boldsymbol{\chi}^{\perp} \Rightarrow F_D = 3\pi\eta v_{rel}\boldsymbol{\chi} d_f / C_c$$

Particle forces and aerodynamic diameter

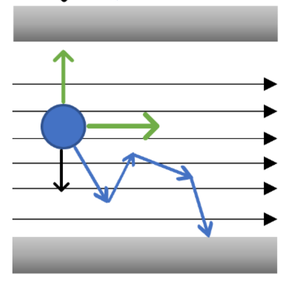
Gravity:

$$\boldsymbol{F_G} = \frac{\pi}{6} d_v^3(\rho_p - \rho_g)g$$



Diffusion:

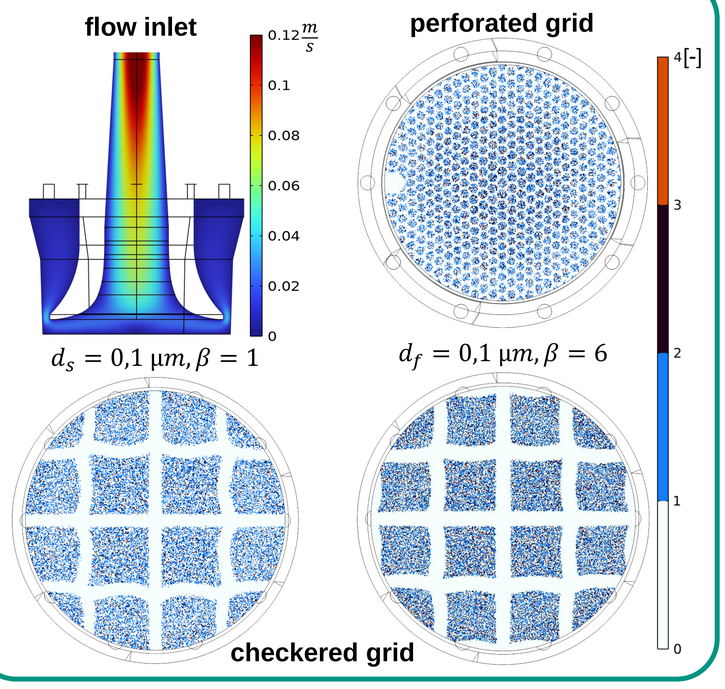
$$\boldsymbol{F_B} = \xi\sqrt{\frac{12\pi k_b \eta T d_v}{\Delta t}}$$



Electric force: $\boldsymbol{F_E} = eZE$

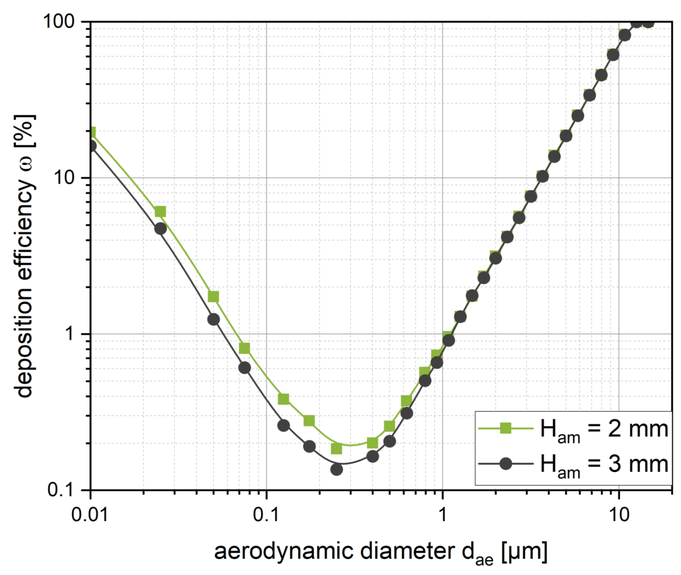
Aerodynamic diameter: $\boldsymbol{d_{ae}} = \boldsymbol{d_f}\sqrt{\frac{\boldsymbol{\rho_p}\,\boldsymbol{\beta}}{\boldsymbol{\rho_0}\,\boldsymbol{\chi}}}$

ALI exposure system geometries

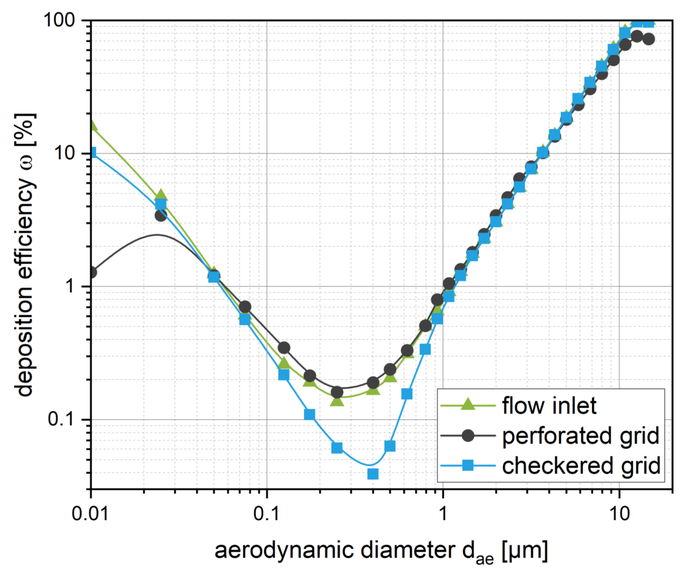


Effect of ALI geometry on deposition efficiency ω

Flow inlet: Deposition efficiencies for different heights above membrane (H_{am})

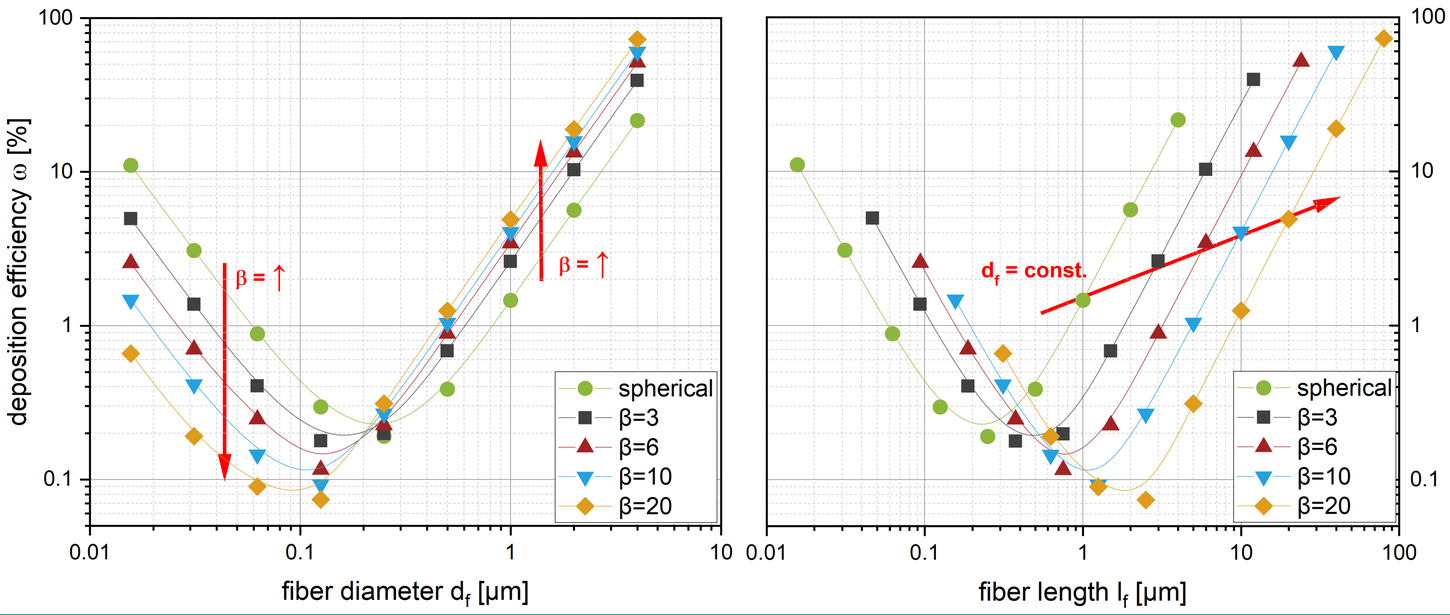


Deposition efficiencies for different exposure system geometries

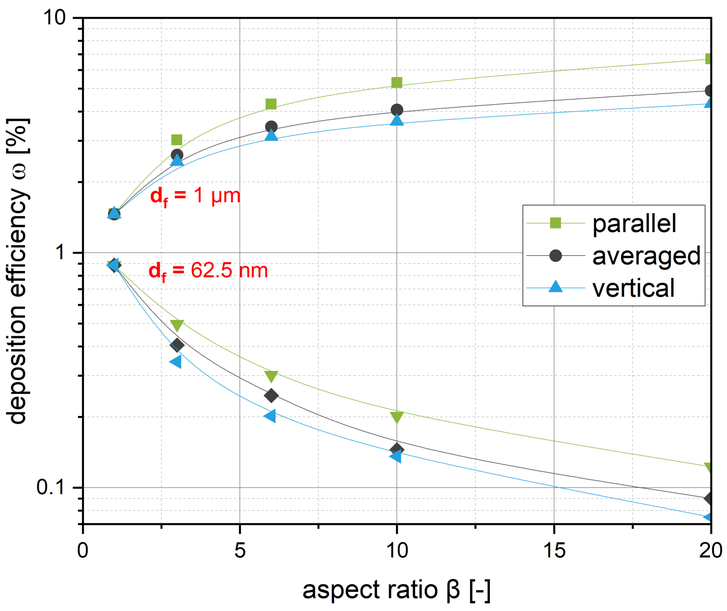


Influence of fiber geometry on deposition efficiency ω

Comparison of deposition efficiencies for spheres and fibers of various aspect ratios



Effect of fiber orientation on deposition efficiencies for nanometer and micrometer fibers



References

1 Fuchs, N.A. (1964). The Mechanics of Aerosols. Pergamon Pr.: Oxford.

More information

Please visit Poster 749:
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