Numerical Simulation of Fibre Dose in an Air-Liquid-Interface Exposure System

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Investigating ultrafine particles and airborne nanomaterials regarding their lung toxic potential using Air Liquid Interface (ALI) exposure of lung cell cultures the knowledge of the exact relevant in-vitro dose (RID) is essential to determine the dose-response relationship of the inhalable aerosol.

Due to new materials as carbon fibre reinforced plastics, not only particles are of interest for ALI exposure testing but also inhalable objects of high aspect ratios, like fibres. The aspect ratio β describes the relationship of length l to diameter d of a cylindrical object like a fibre and can be used to calculate the form factor X of a non-spherical particle describing the relationship of the difference in particle behaviour in gas streams (Fuchs, 1964).

For ALI exposure studies carbon fibres were milled and dispersed in air by a segmented belt aerosol generator (Friesen et al., 2023). The same experiments were performed to determine the deposited numbers of particles, fibres and fibres matching the criteria of the World Health Organisation (WHO) for being of concern regarding human health. These so-called WHO-fibres are fulfilling the fibre criterium of $\beta > 3$ and additionally their length $l > 5$ µm and thickness $d < 3$ µm.

The carbon fibre aerosol generated was sampled and analysed by digital light microscopy. The observed objects of the aerosol were classified according to their dimensions and aspect ratio and their aerodynamic equivalent diameter was calculated (Figure 1).

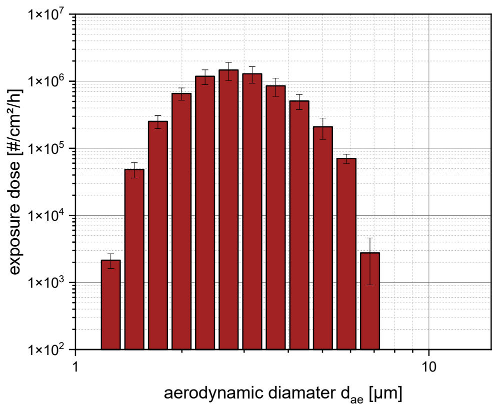

Figure 1. Exposure dose of WHO fibres on the deposition surface in the Air-Liquid-Interface Exposure chamber

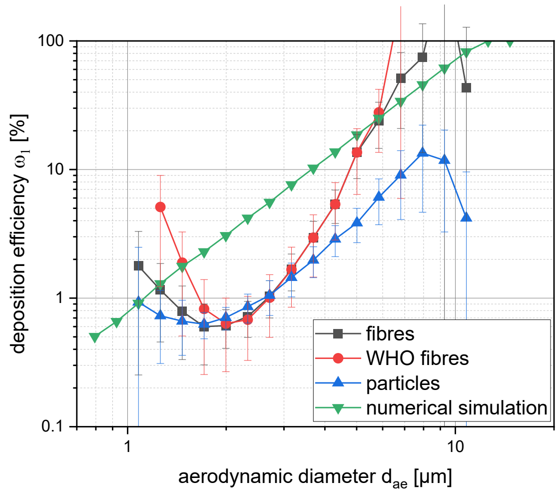

Figure 2. Comparison of experimental and numerical data of deposition efficiencies of fibres, WHO fibres and particles on the deposition surface in the Air-Liquid-Interface Exposure chamber in dependence on the aerodynamic equivalent diameter

The deposition behaviour of these three fractions of the carbon fibre aerosol was measured on the one hand and simulated by numerical methods on the other. All data sets were calculated to the aerodynamic equivalent diameter and classified. The comparison of experimental and simulated data will be shown and discussed (Figure 2).

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