Determine Particle Precipitation at Synthetic Nonwoven Electrets: Experimental study and DNS Simulation

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Synthetic nonwoven materials are well-established filter media to separate particles from gases in automotive, cleanroom, ambient air, healthcare and industrial chemical processing applications. An effective way to enhance the filtration efficiency, without thereby increasing the pressure drop, is the introduction of electrostatic charges. In the field of aerosol filtration, electrostatic effects in detail are relatively unexplored but absolutely decisive in many applications (Rengasamy, 2009).

For filtration efficiency experiments regarding electrostatics, adequate sodium chloride aerosols with particle diameters in the range of 10 to 1000 nm are generated. The aerosol charge distribution can be reproducibly adjusted with an aerosol neutralizer. The next step is to measure the particle size distribution with a SMPS (Scanning Mobility Particle Sizer) and OPC (Optical Particle Counter) while particle deposition occurs at a defined filter area using a specimen holder (Schmidt, 2013). In the final analysis the deposition rate is measured for charged and discharged electret fibers to quantify the influence of the electric effect on the filtration efficiency. The general setup for the experiments is shown in figure 1.

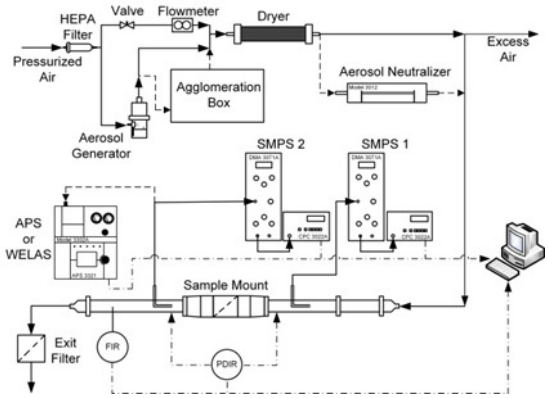

Figure 1. Scheme of the experimental setup.

The measurement and evaluation of the filtration efficiency for particles in these orders of magnitude (< 1000 nm) is technically extensive, time-consuming, error-prone and complex to transfer to different fiber geometry, especially with regard to electrostatic charge of microfibers and particles. Therefore, the experiments are supplemented by direct numerical simulations with the self-developed software tool DNSlab. DNSlab is designed for direct numerical simulations with 3D models of porous structures (Schmidt, 2010). By simulation, various charge distributions on the surface of the fibers and the particles can be simulated and linked to the corresponding filtration efficiencies. Furthermore, the amount of electric charge on the fiber surfaces can be estimated by simulation, by comparing the simulated filtration efficiencies to the measurements. In this contribution, the measurement technique and the simulation method are explained in detail, considering recent improvements of the applied techniques. Measured and simulated filtration efficiencies are compared. The amount of electric surface charge on the fibers is estimated by the results.

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Rengasamy, S., Eimer B. and Shaffer R., C*omparison of Nanoparticle Filtration Performance of NIOSH-approved and CE-Marked Particulate Filtering Facepiece Respirators*, Ann. Occup. Hyg., Vol. 53, No. 2, pp. 117–128, 2009

Schmidt, K., Hellmann, A., Pitz, M., Ripperger, S., *Modeling of NaCl aerosol deposition at electrically charged microfibers*: FILTECH 2013, Proceedings, Wiesbaden, 2013

Schmidt, K., Rief, S., Wiegmann, A., Ripperger, S., *Microstructure Modeling and Simulation of Nanoparticle Deposition*, World Congress on Particle Technology 6, Nürnberg, 2010