Production and Characterization of Nonwoven Nanofibers

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Nanofibers based nonwovens are highly potential materials for use in medical application considering their small pores and are therefore already widely applied in different areas such as filter media, tissue engineering, personal protective masks, life science and other medical related applications. Filter media is one of the largest application groups of nanofiber nonwovens due to their small fibers, high surface area, and low filtration pressure drop. One of the key problems in understanding the filtration processes by using nanofiber based filters is no possibility to create representative 3D models of a real nano-porous structure by standard techniques such as Magnetic Resonance Imaging, X-ray microtomography or Digital Volumetric Imaging (DVI) due to their low resolution limit (480 nm/pixel for DVI). Thus, it is not surprising that virtual idealized nanofiber mat structure models are used in filtration modelling for deeper understanding of filtration via nanofiber mats. However, utilization of virtual idealized nanofiber mats in filtration modelling considering constant diameter along the fiber, neglecting their curvature, inhomogeneous features and possible defects may not sufficiently represent real nanofiber mats and thus, predictive capabilities of such models could be significantly reduced. In order to overcome these possible limitations, a realistic SEM image based 3D structure model is proposed and used. In this work, this is demonstrated for a nanofiber based filter composed from polyurethane nanofiber layers prepared by electrospinning process.

Further, full 3D particle filtration modelling using the 3D structure models representing real filter structures has been utilized considering transition/free molecular flow regime, Brownian diffusion, particle-particle interactions, particle-fiber interactions, aerodynamic slip and sieve. The obtained pressure drops as well as the theoretical predictions for the filtration efficiency, pressure drop and quality factor have been compared with the corresponding experimental data in the ultrafine particle size range (20-400 nm).