The Use of Nuclepore Filter for Ambient and Workplace Nanoparticle Exposure Assessment

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Filter sampling followed by electron microscopy has long been used for measurement of airborne particles. The method provides direct measurement of the particle geometric size and morphology, which cannot be obtained from real-time instruments. The correlation between the particle concentrations on the filter surface and those in the air deserves careful investigation. In many applications, the collection filters are assumed to be absolute filters and the collected particle concentration is directly converted to the airborne concentration. This assumption is plausible if high efficiency filters are used. On the other hand, usage of high efficiency filters requires strong pumps and power consumption. This poses difficulty for field measurement and increasingly important personal sampling. If the collection filters cannot be assumed to be absolute filters, an accurate filtration model must be established to convert the particle concentration on the filter to the airborne concentration (Cyrs et al. 2010).

In the studies of ambient and workplace airborne particulate matters, the nanoparticles play more and more important roles. They may have specific properties, high local concentrations, and thus more severe effects on the environment and human health. Personal exposure assessment is attracting increasing interests because data under the real work conditions of the workers and that of residents living in the neighborhood of the plant can be obtained. The Nuclepore filters are often used for particle sampling due to their flat surface, which facilitate the microscopic analysis for the collected particles. We investigated the feasibility of Nuclepore filter collection with subsequent electron microscopy analysis to assess the nanoparticle exposure.

The pores of the Nuclepore filter are circular in cross section and the well-known capillary tube models were used for calculating the collection of particles (Spurny et al., 1969; Manton, 1978). We also proposed a modified model based on the Spurny model. We found that the inertia parameter, I (a function of medium and particle densities, filtration face velocity, filter porosity and pore diameter), should be used to determine the applicability of the models.

To search for a proper model, we studied the overall penetrations of three different spherical and cubic nanoparticles (PSL, Ag and NaCl), and three types of fractal particles (Ag open agglomerates and partly sintered aggregates, and soot aggloemrates), covering a wide range of particle sizes (20-800 nm) and densities (1.05-10.5 g/cm3), through Nuclepore filters with two different pore diameters (1 and 3 μm) and different face velocities (2-15 cm/s). The data of the overall penetration were in very good agreement with the properly applied models (Figure 1). A good agreement of filter surface collection between the validated model and the SEM analysis of this study (Figure 2) was obtained, indicating a correct nanoparticle number distribution in the air can be converted from the Nuclepore filter surface collection and this method can be applied for nanoparticle exposure assessment.

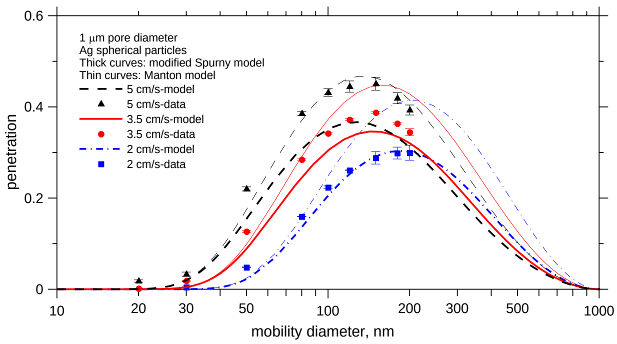

Figure 1. Comparison of Ag penetration in 1 μm filter between experiments and modified Spurny and Manton models at relatively low face velocities, 2-5 cm/s.

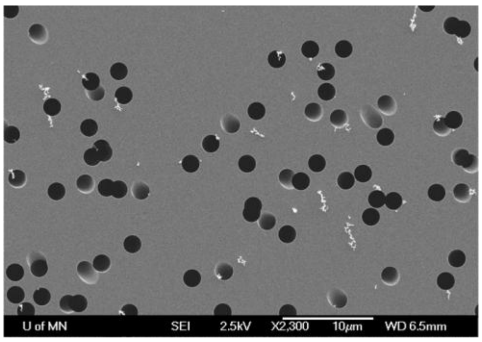

Figure 2. SEM image of soot agglomerates used in the penetration tests.

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