Experimental determination of the response functions of direct-reading instruments for the measurement of surface-area concentration of airborne nanostructured particles

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In the last years, some direct-reading instruments have been designed to provide nanostructured particles (NP) surface-area concentration measurements, based on attachment rate of unipolar ions to NP by diffusion. However, few information are available regarding the performances and the parameters that could affect the responses of these instruments. Consequently, there is a necessity to improve the knowledge on these measuring techniques. In this context, our work aims at studying a selection of instruments allowing the measurement of airborne NP surface-area concentration. The selected instruments are thought to be used for characterizing exposure to NP, since some toxicological studies support the concept that surface-area could be a relevant metric.

A versatile experimental facility (named CAIMAN for 'ChAracterization of Instruments for Measuring Aerosols of Nanoparticles') has been designed and built. In CAIMAN, airborne NP are produced by a spark-discharge generator (PALAS, GFG-1000) in controlled conditions, and can be composed of various substances. To cover a wide range of charge level and morphology, a bipolar ion generator and a high-temperature furnace are included in CAIMAN. Experiments can be performed with either polydisperse or monodisperse aerosols by using a Differential Mobility Analyzer. Test aerosols composed of various substances (C, Cu, Al, Ag) can be obtained with electrical mobility diameters in the range 10 - 500 nm.

The response functions of the selected instruments — (a) NSAM TSI model 3550, (b) LQ1-DC Matter Engineering, and (c) AeroTrak 9000 TSI — were measured for different operating conditions. Response functions correspond to the ratio of the mean instrument indication to the mean particle number concentration, as a function of particle size. Experimental measurements were then compared with the existing theoretical responses: deposited surface-areas in alveolar or tracheobronchial region for instruments (a) and (c), and active surface-area for instrument (b). As an example, fig. A compares the theoretical and experimental responses of the AeroTrak 9000 in alveolar configuration for carbon, copper and aluminium-based aerosols.

The influence of various parameters (size, composition, concentration, shape…) of the NP on the measured responses will be discussed.

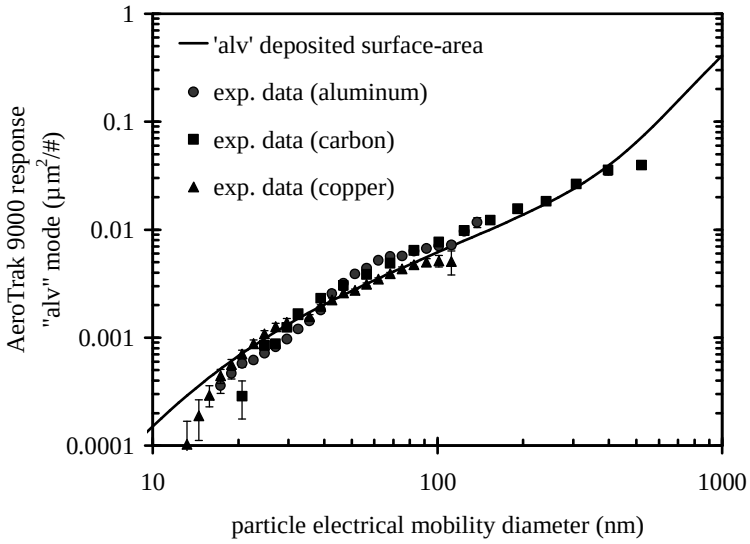

Fig. A. Experimental and theoretical responses of the AeroTrack 9000 instrument in alveolar configuration.