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Impact of Electrostatic Forces on Collection of Charged Nanoparticles Aerosols by Dielectric Wire Screens

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Considering the numerous works that have been carried out for the last few decades, it seems to be unambiguous today that because of Brownian diffusion, penetration of uncharged nanoparticles through wire screens continuously decreases as the aerosol diameter does, and that experimental points can be well represented by the Cheng and Yeh's model (Alonso *et al.*, 1997; Shin *et al.*, 2008). It is no longer the case however with charged aerosols. Indeed, this paper presents results of penetration of nanoparticles aerosols at Boltzmann equilibrium through a plastic wire screen.

The test monodisperse aerosol of copper or carbon nanoparticles, the electrical mobility diameter of which was varied from 4 to 80 nm, was produced from a commercial spark-generator and a nano-DMA for diameter selection. Before challenging the screen in a dummy chamber device (Heim *et al.*, 2005), the aerosols were electrically-neutralized (Boltzmann equilibrium) thanks to a ^{85}Kr radioactive source. Both upstream and downstream concentrations were measured using the same CPC.

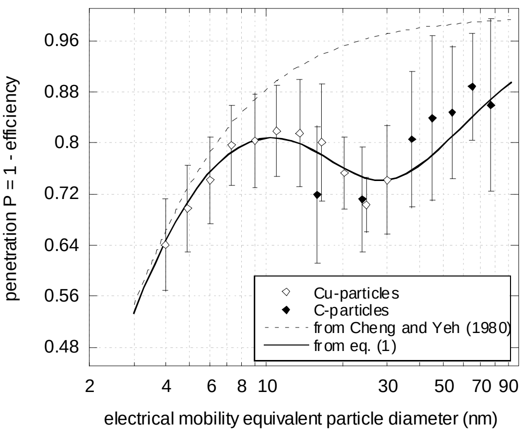

Figure 1 – Penetration of nanoparticles at Boltzmann equilibrium through the wire screen, at 5 cm/s

As it can be seen on figure 1, the experimental points clearly give a "wave-shaped" curve, with a local minimum for P at 25 nm about. This can in fact be well represented taking into account the collection probability of each kind of particles composing the Boltzmann equilibrium aerosol. Such a consideration leads to:

$$P = \sum_i x_i \times P_i \qquad \text{eq. (1)}$$

where x_i is the numeric fraction of particles carrying i elementary charges (i varies from –2 to 2 below 100 nm) and can be estimated from Wiedensohler's equations. P_i is the penetration value of the i-particles through the screen.

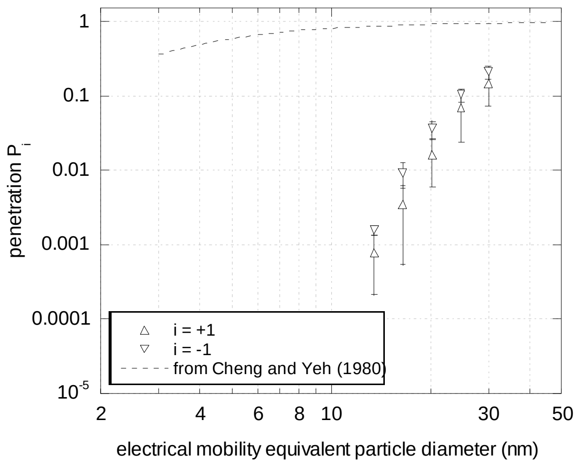

Figure 2 – Penetration of unipolarly charged nanoparticles through the wire screen at 5 cm/s

Figure 2 shows the penetration of unipolarly charged aerosols through the screen. Charged particles are clearly more efficiently captured than uncharged particles, which would only be trapped by Brownian diffusion (theory of Cheng and Yeh). This increased collection efficiency is due to electrostatic forces, the effect of which can be mathematically estimated knowing the electrical charge density carried by the fibers of the screen. Added to the fact that $x_{i \text{ for } i\neq 0}$ increases while x_0 decreases as the particle diameter increases, this leads to the situation reported on figure 1. The same kind of behaviour is currently experimentally-observed at the lab with another wire screen.

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