# Determining effective density of nanostructured particles by tandem electrical mobility and mass measurement (tandem DMA/APM): application to thermal spraying fumes

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Thermal spraying is a surface treatment process which makes it possible to deposit different types of material on various substrates. This process generates large quantities of fumes, composed mainly of primary particles with diameters below 100 nm (Bémer *et al.*, 2010), as shown in Figure 1.

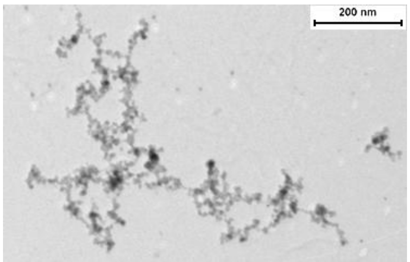


Figure 1. TEM picture of nanostructured particles produced by thermal spraying of a Zn/Al mixture.

To assess occupational exposure, the behaviour of the nanostructured particles produced must be better described and understood. This remains a challenge. Particle effective density is among the parameters of interest, mainly due to its role in particle deposition in the human respiratory tract (ICRP, 1994). In addition, it is required to determine the relationship between equivalent diameters and to convert number distributions to mass distributions (Mc Murry *et al.*, 2002).

Specific instrumentation is required to determine the effective density of airborne nanoparticles as this property cannot be measured directly. Various methods have been proposed to manage this issue, such as measuring electrical mobility and aerodynamic diameters (tandem DMA/ELPI) of the same nanostructured particles (e.g. Van Gulijk *et al.*, 2004; Virtanen *et al.*, 2004).

In this study, we used tandem DMA/APM (e.g. Mc Murry *et al.*, 2002; Ku *et al.*, 2006). Briefly, this setup is based on particle selection according to their electrical mobility using a Differential Mobility Analyzer (DMA, TSI model 3080) and subsequent mass selection in a Particle Mass Analyzer (APM, Kanomax model 3601). The number concentration of airborne particles was monitored by a Condensation Particle Counter (CPC, Grimm model 5.403), while their electrical charge was measured with an aerosol electrometer (TSI, model 3068B).

In addition to particle effective density, the fractal dimension and the number of primary particles making up agglomerates were determined. These data were compared to values calculated based on Lall & Friedlander's theory (Lall & Friedlander, 2006).

Preliminary investigations carried out on airborne silver nanoparticles produced by spark discharge were performed. Results indicated that different rotation speed / optimum voltage doublets give rise to a similar effective density for particles of a given electrical mobility diameter. In addition, the raw curve from which optimal voltage is derived was found to be larger for high rotation speeds.

The protocol was then applied to nanostructured particles emitted during thermal spraying of a Zn/Al mixture onto a surface. How their effective density evolves according to particle size is shown in Figure 2.

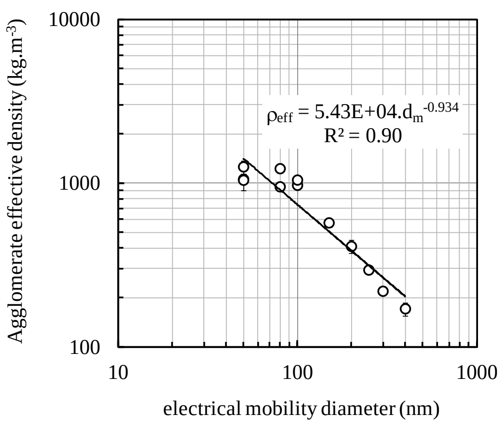


Figure 2. Effective density of nanostructured particles generated by thermal spraying of a Zn/Al mixture as a function of their electrical mobility diameter.

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